Producing Graphs for Water Quality Reports Using TELL-A-GRAPH

Annette L. Smith

This Report was Prepared under Contract to
Inland Waters and Lands, Conservation and Protection
Environment Canada

Scientific Authority: S.W. Sheehan

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ABSTRACT

This report provides examples of the use of the computer graphics software TELL-A-GRAPH for drawing scientific figures. These examples include the use of error bars with scatter plots and bar graphs. Other types of graphs which have been used in Water Quality reports are also illustrated.

RESUME

Le présent rapport illustre au moyen d'exemples l'usage du logiciel TELL-A-GRAPH destiné à la confection de graphes et figures scientifiques. Sont présentés des exemples de diagrammes en bâton et de diagrammes de dispersion avec marges d'erreur, ainsi que d'autres types de graphes qui ont été inclus dans des rapports de la Direction de la qualité des eaux.

ACKNOWLEDGEMENTS

I thank Taina Tuominen and Stephen Sheehan for their support throughout this work. Their editorial comments have been most helpful.

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INTRODUCTION

TELL-A-GRAF, the computer graphics software, can be used to produce figures for water quality reports and other publications. Since the examples in the TELL-A-GRAF User's Manual are of business applications, this document has been written to illustrate the use of TELL-A-GRAF for drawing scientific figures, particularly graphs with error bars.

The examples which follow are figures which were drawn for the Akamina-Kishinena interpretative report (Smith et al. 1985) and the Columbia River Algal Assay data report (Tuominen et al. 1987). Each example is presented in three parts:

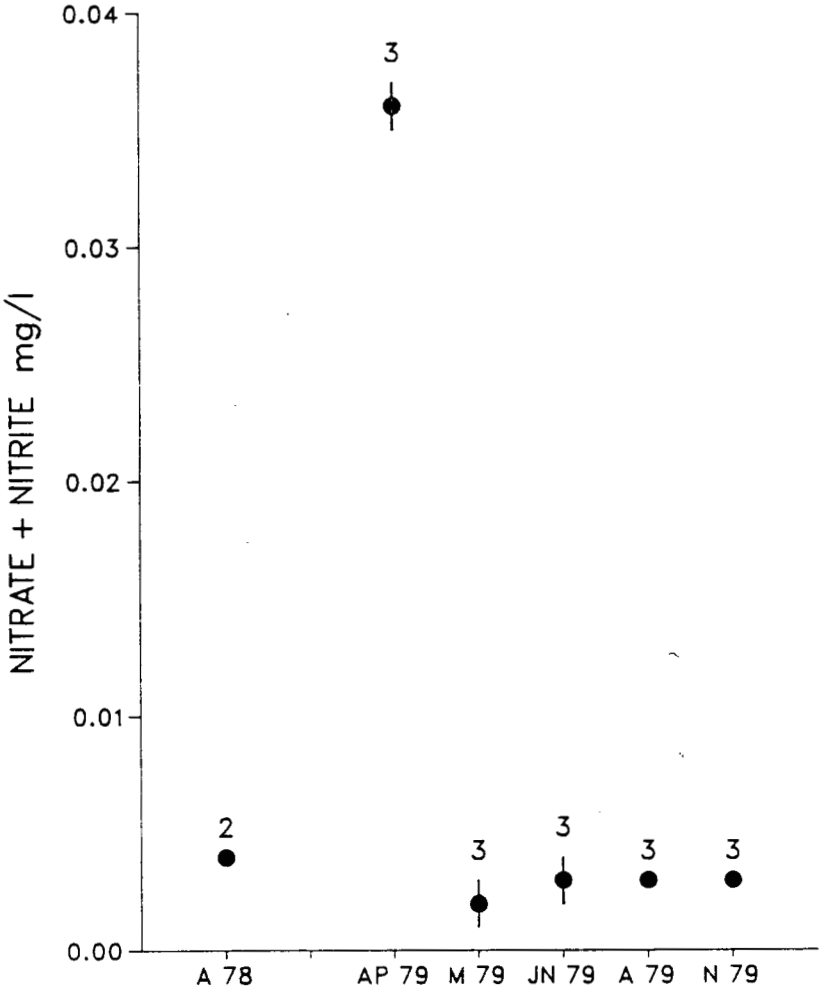
1. The graph
2. The layout description of the graph
3. A more detailed explanation of specific TELL-A-GRAF commands used in the example.

This document is intended to supplement the TELL-A-GRAF User's Manual. For a basic description of the use of TELL-A-GRAF, please refer to the Manual.

EXAMPLE 1 (NITRATE)

APPLICATION: Drawing error bars on points.

ELDER CREEK


0.04
0.03
0.02
0.01
0.00
NITRATE + NITRITE mg/l
3
2
3
3
3
3
A 78
AP 79
M 79
JN 79
A 79
N 79

Listing of NITRATE at 08:34:29 on OCT 1, 1984 for CCid=WQB3

```
**FILE**
 GEN A PLOT.
PAGE BORDER IS OFF.
 X AXIS SCALE MAXIMUM IS  7.
 X AXIS SCALE MINIMUM IS  0.
 X AXIS SCALE STEP-SIZE IS  1.
Y AXIS MINIMUM 0, MAXIMUM 0.04 STEP SIZE 0.01.
 X AXIS DIVISION-LABELS IS 'A 78' ' ' 'AP 79' 'M 79'
  'JN 79' 'A 79' 'N 79'.
 INPUT DATA.
 'CURVE 1'
  1 0.004 3 0.036 4 0.002 5 0.003 6 0.003 7 0.003
 END OF DATA.
 CURVE 1.
 CURVE SYMBOL-TYPE IS  16.
 CURVE 1 IS SCATTERED.
 CURVE 1 COLOR IS BLACK.
X AXIS EXISTENCE IS OFF.
Y AXIS EXISTENCE IS OFF.
X AXIS SHIFT IS ON.
SUBPLOT 1.
 **FILE**
 GEN A STACKED BAR.
PAGE BORDER IS 0.
X AXIS MINIMUM 0, MAXIMUM 7, STEP SIZE 1.
DEPENDENT AXIS MINIMUM 0, MAXIMUM 0.04, STEP SIZE 0.01.
 X AXIS DIVISION-LABELS IS 'A 78' ' ' 'AP 79' 'M 79'
  'JN 79' 'A 79' 'N 79'.
DEPENDENT AXIS LABEL IS 'NITRATE + NITRITE  mg/l'.
X ROOM IS 0.3.
TITLE IS 'ELDER CREEK'.
 INPUT DATA.
 'LOW'
1 0.004 3 0.035 4 0.001 5 0.002 6 0.003 7 0.003
 'HIGH'
1 0 3 0.002 4 0.002 5 0.002 6 0 7 0
 END OF DATA.
 DISTRIBUTION 1.
 DISTRIBUTION WIDTH IS  0.
 DISTRIBUTION COLOR IS BLACK.
 DISTRIBUTION LEGEND ENTRY EXISTENCE IS  0.
 DISTRIBUTION 2.
 DISTRIBUTION WIDTH IS  1.
 DISTRIBUTION COLOR IS BLACK.
DISTRIBUTION LEGEND ENTRY EXISTENCE IS  0.
DIST 2 DOC CONTENT IS USER-TEXT.
DIST 2 DOC IS EXTERNAL.
DIST 2 DOC TEXT '2' '3' '3' '3' '3' '3'.
SUBPLOT 2.
**FILE**
```

TELL-A-GRAF has no option for requesting error bars. The only way to draw error bars is to overlay a stacked bar graph on each point of a curve as shown in the file NITRATE. This procedure requires two subplots:

Lines 2-20 include the information required to produce subplot 1. Mean values are plotted as points by this subplot. Lines 23-48 include the commands necessary to draw the error bars. Subplot 2 is drawn over subplot 1 when the command

Draw 1 2.

is given.

The error bars themselves are drawn with the commands in lines 32-45. The data entered for distribution 1 (line 34) are

$\bar{X}$ - (error).

Since the width of distribution 1 is 0 (line 39), nothing is actually drawn. The data for distribution 2 (line 36) are

2*(error).

Distribution 2 is stacked on top of distribution 1. The width = 1 (line 43) produces a thin line. Thus a line is drawn from

$\bar{X}$-(error) to $\bar{X}$+(error).

Several steps must be taken to insure that error bars and points align properly:

1. Identical scales must be specified for both subplots. Lines 4-7 provide the same specifications as lines 25 and 26. (Note three different ways of entering the same information.)

2. Since the X-axis is labelled rather than numbered, identical labels must be specified for both subplots, even though they may not be drawn twice (see below). Lines 8 and 9 are identical to lines 27 and 28.

3. It is unnecessary and may be undesirable to draw and label the X and Y axes twice. Lines 18 and 19 have been entered to suppress drawing and labelling these axes in subplot 1. These commands could instead have been entered in subplot 2, but in that case, the Y-axis label (line 29) would have to have been entered in subplot 1.

   Note that the title (line 31) is only entered once. This entry may be in either subplot.

4. By default, the lowest X value plotted is aligned on the Y axis for plots but is shifted one unit to the right of the Y axis for bar graphs. Line 20 causes the first point to be shifted off the Y axis to align with the bars.

Other points illustrated by NITRATE:

- Line 30 determines the size of print used for the X-axis division labels. Omitting this command (using the default character sizes) causes the labels (in this example) to be printed at an angle rather than parallel with the X-axis.

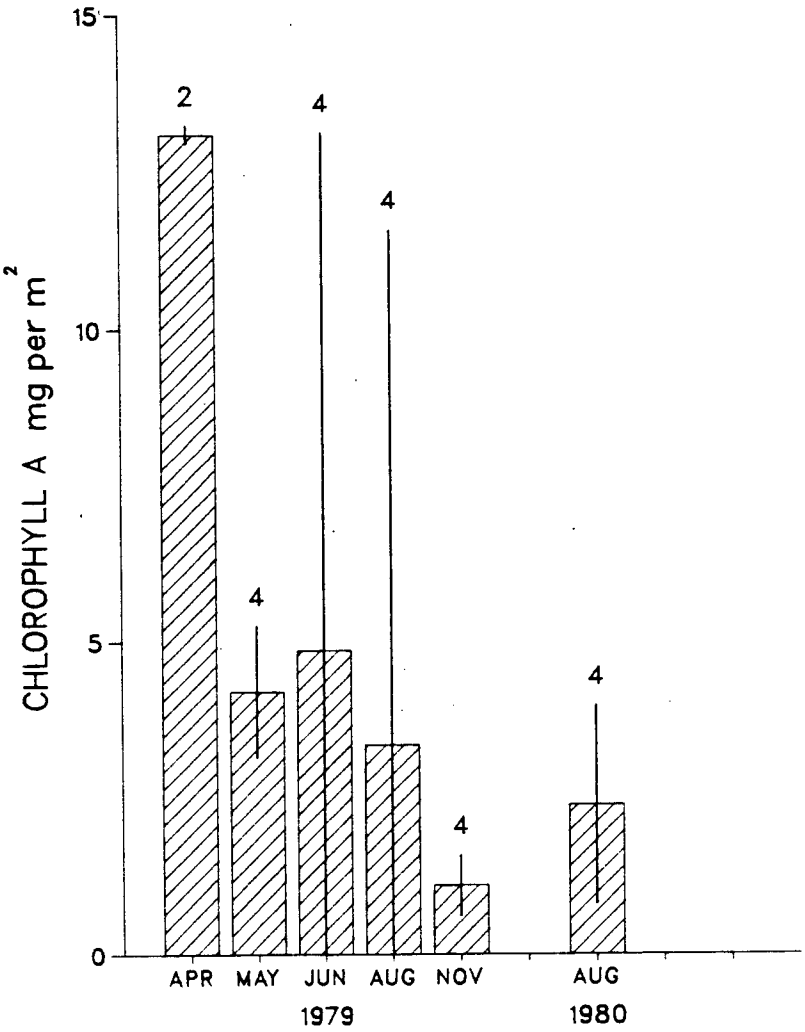
- Lines 46-48 cause the number of samples to be printed at the top of each error bar.

- A legend is printed by default when a graph includes two or more distributions. Since a legend of the distributions used to produce the error bars would be meaningless, the legend is suppressed by lines 41 and 45.

EXAMPLE 2 (CHLORO)

APPLICATION: Drawing error bars on bar graphs.

AKAMINA CREEK



Listing of CHLORO at 09:26:54 on OCT 2, 1984 for CCid=WQB3

```
 1      **FILE**
 2       GEN A BAR.
 3      PAGE BORDER IS 0.
 4      Y AXIS MINIMUM 0, MAXIMUM 15, STEP SIZE 5.
 5      X AXIS MINIMUM 0, MAXIMUM 9, STEP SIZE 1.
 6       INDEPENDENT DIVISION-LABELS IS 'APR ' 'MAY'                    --
 7        'JUN' 'AUG' 'NOV' ' ' 'AUG' ' ' ' ' '.
 8      X ROOM IS .3.
 9       DEPENDENT LABEL TEXT IS 'CHLOROPHYLL A  mg per m<E1.2H.5)2'.
10       TITLE TEXT IS 'AKAMINA CREEK' .
11       INPUT DATA.
12      'CHLOROPHYLL'
13       1 13.1 2 4.2 3 4.86 4 3.34 5 1.09 7 2.38
14       END OF DATA.
15      EVERY DIST LEGEND ENTRY 0.
16       DISTRIBUTION 1.
17       DISTRIBUTION COLOR IS BLACK.
18       DISTRIBUTION SHADE PATTERN IS  1.
19      MESSAGE 1 TEXT '1979',CONNECT TC, X=3, Y=-.7, COORDINATE UNITS.
20      MESSAGE 2 TEXT '1980',CONNECT TC, X=7, Y=-.7, COORDINATE UNITS.
21      SUBPLOT 1.
22       **FILE**
23       GEN A STACKED BAR.
24      PAGE BORDER IS 0.
25      DEPENDENT AXIS MINIMUM 0, MAXIMUM 15, STEP SIZE 5.
26      X AXIS MINIMUM 0, MAXIMUM 9, STEP SIZE 1.
27       INDEPENDENT DIVISION-LABELS IS 'APR ' 'MAY'                    --
28        'JUN' 'AUG' 'NOV' ' ' 'AUG' ' ' ' ' ' .
29       INPUT DATA.
30       'LOW'
31        1 12.96 2 3.15 3 0 4 0 5 .61 7 .8
32       'HIGH'
33      1 .28 2 2.10 3 13.12 4 11.58 5 .96 7 3.16
34       END OF DATA.
35       DISTRIBUTION 1.
36       DISTRIBUTION WIDTH IS  0.
37       DISTRIBUTION COLOR IS BLACK.
38       DISTRIBUTION LEGEND ENTRY EXISTENCE IS  0.
39       DISTRIBUTION 2.
40       DISTRIBUTION WIDTH IS  1.
41       DISTRIBUTION COLOR IS BLACK.
42      DISTRIBUTION LEGEND ENTRY EXISTENCE IS  0.
43      DIST 2 DOC IS USER-TEXT.
44      DIST 2 DOC TEXT  '2' '4' '4' '4' '4' '4'.
45      DIST 2 DOC IS EXTERNAL.
46      Y AXIS EXISTENCE IS OFF.
47      X AXIS EXISTENCE IS OFF.
48      SUBPLOT 2.
49      **FILE**
```

This procedure is identical to placing error bars on point graphs, except that since the default is the same for both subplots, no statement about "AXIS SHIFT" is necessary.

Other points illustrated:

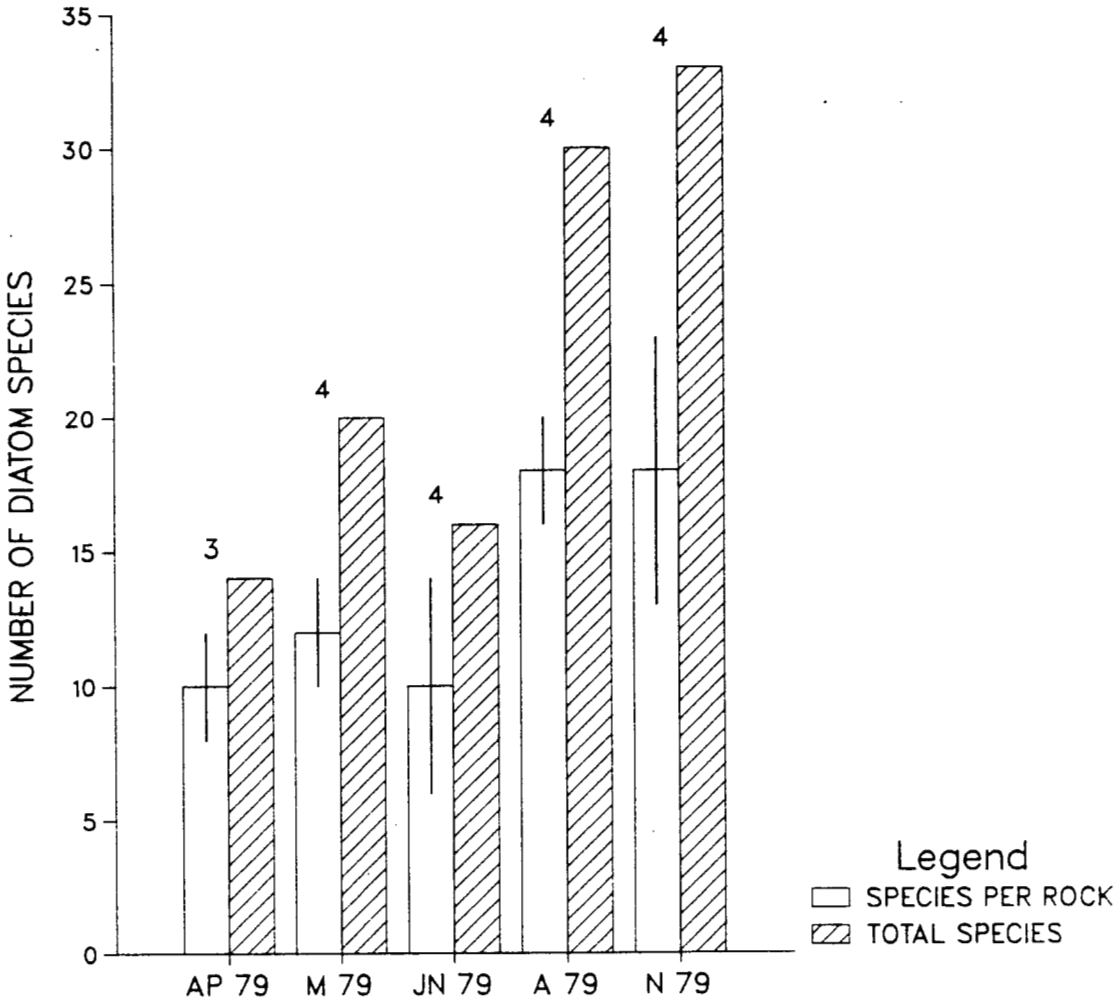
- A superscript is included in the Y-axis label (line 9).

- Years are placed below months for the X-axis labels using the MESSAGE command (lines 19 and 20). There are several methods of specifying the positioning of messages. The one which requires the least trial and error is COORDINATE UNITS (positioning in relation to X and Y points).

EXAMPLE 3 (SPECIES)

APPLICATION: Drawing error bars on clustered bar graphs.

ELDER CREEK


NUMBER OF DIATOM SPECIES
35
30
25
20
15
10
5
0
3
4
4
4
4
AP 79
M 79
JN 79
A 79
N 79
Legend
SPECIES PER ROCK
TOTAL SPECIES

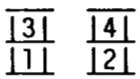
Listing of SPECIES at 08:39:50 on SEP 25, 1984 for CCid=WQB3

```
**FILE**
 GEN A CLUSTERED BAR.
PAGE BORDER=0.
X AXIS MINIMUM 0, MAXIMUM 5, STEP SIZE 1.
 DEPENDENT SCALE MAXIMUM IS  35.
 DEPENDENT SCALE MINIMUM IS  0.
 DEPENDENT SCALE STEP-SIZE IS  5.
 INDEPENDENT DIVISION-LABELS IS 'AP 79' 'M 79'                    --
  'JN 79' 'A 79' 'N 79'.
 X ROOM IS  0.30.
 DEPENDENT LABEL TEXT IS 'NUMBER OF DIATOM SPECIES' .
 TITLE TEXT IS 'ELDER CREEK' .
 INPUT DATA.
 'SPECIES PER ROCK'
1 10 2 12 3 10 4 18 5 18
 'TOTAL SPECIES'
  1 14 2 20 3 16 4 30 5 33
 END OF DATA.
 EVERY DISTRIBUTION.
 DISTRIBUTION COLOR IS BLACK.
 DISTRIBUTION 1.
 DISTRIBUTION COLOR IS BLACK.
 DISTRIBUTION SHADE PATTERN IS  4.
 DISTRIBUTION 2.
 DISTRIBUTION COLOR IS BLACK.
 DISTRIBUTION SHADE PATTERN IS  1.
DIST 2 DOC IS USER-TEXT.
DIST 2 DOC TEXT  '3' '4' '4' '4' '4'.
DIST 2 DOC IS EXTERNAL.
DIST 2 DOC CONNECT=TL.
LEGEND X ORIGIN 6,Y ORIGIN 0, COORDINATE UNITS.
SUBPLOT 1.
 **FILE**
 GEN A STACKED BAR.
CLUSTERING=2.
PAGE BORDER=0.
X AXIS MINIMUM 0, MAXIMUM 5, STEP SIZE 1.
 DEPENDENT SCALE MAXIMUM IS  35.
 DEPENDENT SCALE MINIMUM IS  0.
 DEPENDENT SCALE STEP-SIZE IS  5.
 INDEPENDENT DIVISION-LABELS IS 'AP 79' 'M 79'                    --
  'JN 79' 'A 79' 'N 79'.
 INPUT DATA.
 'LOW'
  1 8 2 10 3 6 4 16 5 13
'DUMMY'
1 35 2 35 3 35 4 35 5 35
 'HIGH'
  1 4 2 4 3 8 4 4 5 10
'DDUM'
1 0 2 0 3 0 4 0 5 0
 END OF DATA.
 DISTRIBUTION 1.
 DISTRIBUTION WIDTH IS  0.
 DISTRIBUTION COLOR IS BLACK.
 DISTRIBUTION LEGEND ENTRY EXISTENCE IS  0.
 DISTRIBUTION 2.
 DISTRIBUTION WIDTH IS  0.
```

Listing of SPECIES at 08:39:50 on SEP 25, 1984 for CCid=WQB3

```
     59       DISTRIBUTION COLOR IS BLACK.
     60       DISTRIBUTION LEGEND ENTRY IS ZERO.
     61       DISTRIBUTION 3.
     62       DISTRIBUTION WIDTH IS  1.
     63       DISTRIBUTION COLOR IS BLACK.
     64       DISTRIBUTION LEGEND ENTRY EXISTENCE IS  0.
     65      DISTRIBUTION 4 WIDTH IS 0.
     66      DISTRIBUTION 4 COLOR IS BLACK.
     67      DISTRIBUTION 4 LEGEND ENTRY IS ZERO.
     68       INDEPENDENT ANNOTATION IS  0.
     69       DEPENDENT ANNOTATION IS  0.
     70      SUBPLOT 2.
     71       **FILE**
```

Error bars are placed on clustered bar graphs using subplots as previously described. The major differences between the present example and example 2 are the statement on line 35 (causing the error bars to be both stacked and clustered) and the need for dummy data (lines 46-47 and 50-51). The dummy data are required because the distributions stack and cluster in the following order:



Since in the example illustrated by SPECIES, only the first bar graph in each pair has an error bar, distributions 2 and 4 must contain dummy data. If both bar graphs were to have error bars, the data for errors associated with the first bar would be entered as distributions 1 and 3 and data for the error of the second bar would be entered as distributions 2 and 4.

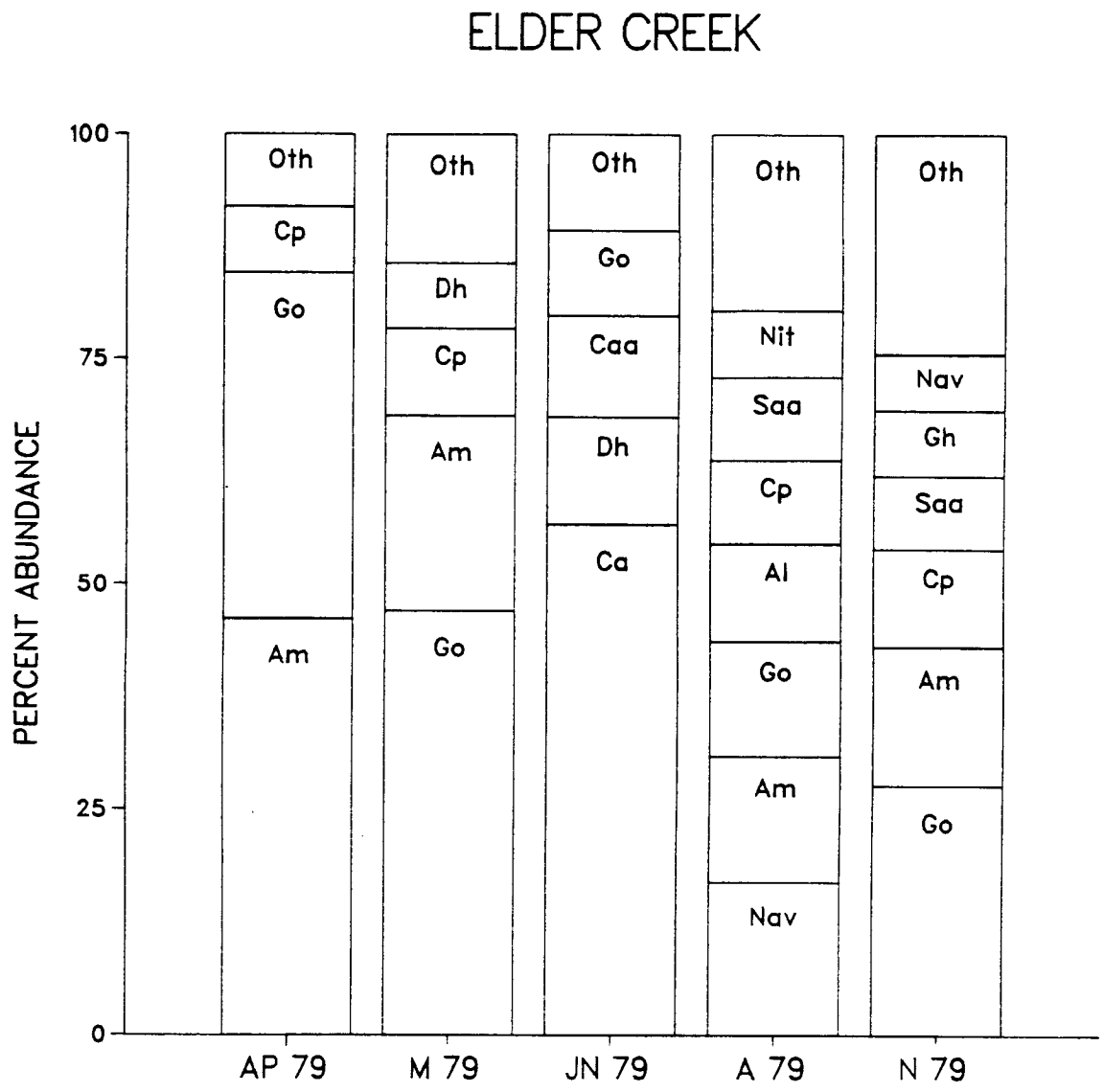
Additional points illustrated:

- The number of samples is centered above the two bars in each cluster by lines 29 and 30.

- The legend for subplot 1 is not suppressed. Line 31 describes the position of the legend.

EXAMPLE 4 (DRAW.COMP)

APPLICATION: Use of hidden bar graph.


ELDER CREEK
PERCENT ABUNDANCE
100
75
50
25
0
Oth
Cp
Go
Am
Oth
Dh
Cp
Am
Go
Oth
Go
Caa
Dh
Ca
Oth
Nit
Saa
Cp
Al
Go
Am
Nav
Oth
Nav
Gh
Saa
Cp
Am
Go
AP 79
M 79
JN 79
A 79
N 79

Listing of DRAW.COMP at 08:40:10 on SEP 25, 1984 for CCid=WQB3

```
      GEN A HIDDEN BAR.
     PAGE-BORDER IS  0.
     INDEPENDENT SCALE MAXIMUM IS  5.
     INDEPENDENT SCALE MINIMUM IS  0.
     INDEPENDENT SCALE STEP-SIZE IS  1.
     DEPENDENT SCALE MAXIMUM IS  100.
     DEPENDENT SCALE MINIMUM IS  0.
     DEPENDENT SCALE STEP-SIZE IS  25.
     DEPENDENT LABEL TEXT IS 'PERCENT ABUNDANCE' .
     INDEPENDENT DIVISION-LABELS IS 'AP 79' 'M 79' 'JN 79'
      'A 79' 'N 79'.
     X ROOM IS  0.3.
     X AXIS LENGTH IS  7.5.
     TITLE TEXT IS 'ELDER CREEK' .
     INPUT DATA.
    'CA'
    3 56.7
    'CAA'
    3 79.83
    'DHQ'
    2 85.62 3 68.65
    'SAA'
    4 72.98 5 62.08
    'AL'
    4 54.57
    'AM'
    1 46.20 2 68.77 4 30.93 5 43.06
    'CP'
    1 91.93 2 78.42 4 63.83 5 53.95
    'GH'
    5 69.32
    'GO'
    1 84.55 2 47.05 3 89.23 4 43.67 5 27.63
    'NAV'
    4 17.00 5 75.60
    'NP'
    4 80.38
    'OTHER'
    1 100 2 100 3 100 4 100 5 100
     END OF DATA.
     EVERY DISTRIBUTION.
     DISTRIBUTION COLOR IS BLACK.
    DISTRIBUTION SHADE PATTERN IS 4.
    DISTRIBUTION LEGEND ENTRY EXISTENCE IS 0.
    EVERY DISTRIBUTION DOCUMENTATION IS USER-TEXT.
    DISTRIBUTION 1 DOC TEXT 'Ca'.
    DISTRIBUTION 2 DOC TEXT 'Caa'.
    DISTRIBUTION 3 DOC TEXT 'Dh' 'Dh'.
    DISTRIBUTION 4 DOC TEXT 'Saa' 'Saa'.
    DISTRIBUTION 5 DOC TEXT 'Al'.
    DISTRIBUTION 6 DOC TEXT 'Am' 'Am' 'Am' 'Am'.
    DISTRIBUTION 7 DOC TEXT 'Cp' 'Cp' 'Cp' 'Cp'.
    DISTRIBUTION 8 DOC TEXT 'Gh'.
    DISTRIBUTION 9 DOC TEXT 'Go' 'Go' 'Go' 'Go' 'Go'.
    DISTRIBUTION 10 DOC TEXT 'Nav' 'Nav'.
    DISTRIBUTION 11 DOC TEXT 'Nit'.
    DISTRIBUTION 12 DOC TEXT 'Oth' 'Oth' 'Oth' 'Oth' 'Oth'.
    EVERY DISTRIBUTION DOC IS INTERNAL.
```

```
Listing of DRAW.COMP at 08:40:10 on SEP 25, 1984 for CCid=WQB3

    59      **FILE**
```

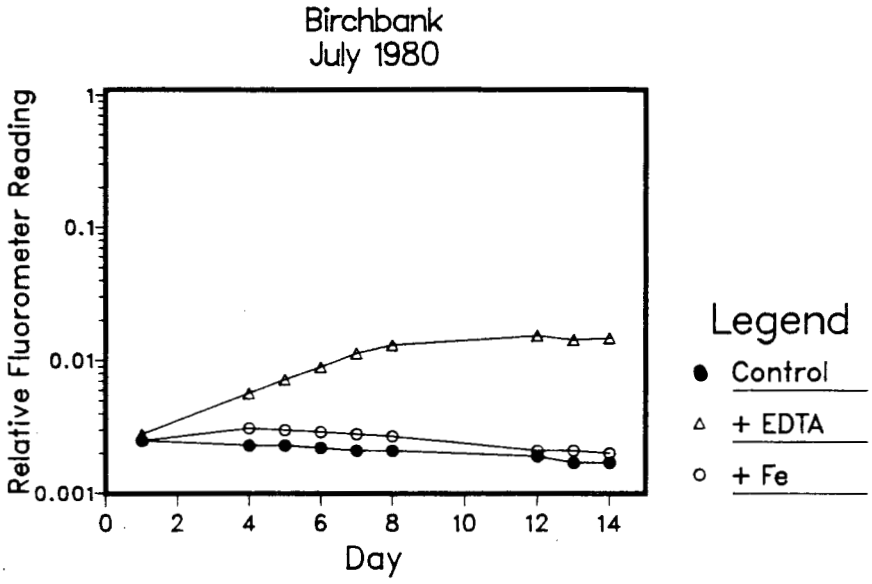
In this example, the hidden bar graph has been used to plot percentage abundance of diatom species. The graphs are arranged so that the most abundant species forms the base of each bar and other species are stacked on top in decreasing order of abundance.

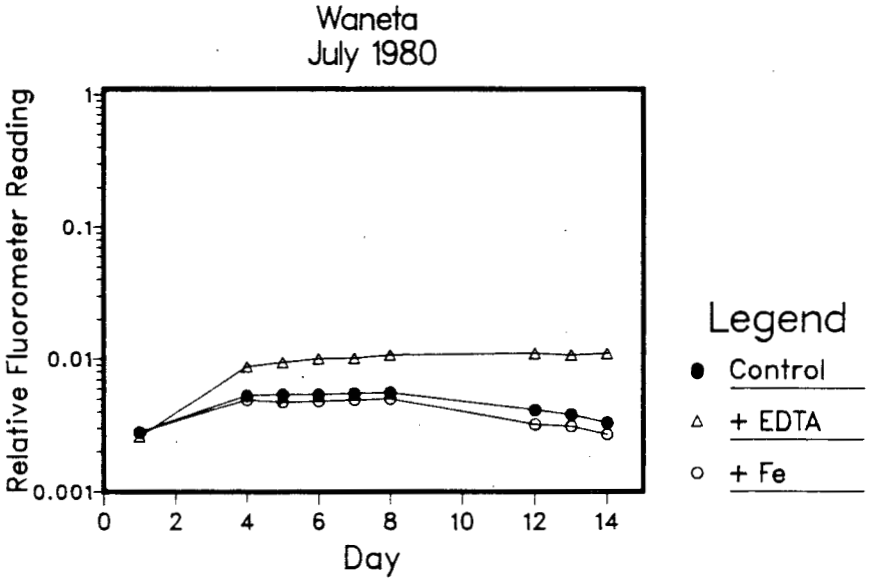
To achieve this pattern, the data are entered as cumulative percent abundances (lines 16-39).

The DISTRIBUTION DOCUMENTATION commands are used to place abbreviations of species names inside each bar (lines 45-58).

EXAMPLE 5 (DRAW.JUL)

APPLICATION 1: Plotting two graphs on one page.


Birchbank
July 1980
Relative Fluorometer Reading
1
0.1
0.01
0.001
0
2
4
6
8
10
12
14
Day
Legend
Control
+ EDTA
+ Fe


Waneta
July 1980
Relative Fluorometer Reading
1
0.1
0.01
0.001
0
2
4
6
8
10
12
14
Day
Legend
Control
+ EDTA
+ Fe

Listing of DRAW.JUL at 10:46:33 on SEP 17, 1984 for CCid=WQB3

```
**FILE**
GEN A PLOT.
PAGE BORDER IS OFF.
DEPENDENT AXIS LABEL IS 'Relative Fluorometer Reading'.
INDEPENDENT AXIS LABEL IS 'Day'.
X AXIS SCALE MINIMUM 0, MAXIMUM 15, STEP-SIZE 2.
Y AXIS TYPE IS LOG.
Y AXIS SCALE MINIMUM .001, MAXIMUM 1.1.
X AXIS ORIGIN 2.25, LENGTH 4.0.
Y AXIS ORIGIN 7.35, LENGTH 3.0.
LEGEND X ORIGIN 16,Y ORIGIN 0.001, COORDINATE UNITS.
EVERY CURVE SYMBOL COUNT=1.
EVERY CURVE SYMBOL SIZE=1.
EVERY CURVE COLOR IS BLACK.
CURVE 1 SYMBOL TYPE IS 16.
CURVE 2 SYMBOL TYPE IS 2.
CURVE 3 SYMBOL TYPE IS 17.
bank data.
'BCON'
'BEDTA'
'BFE'
EOD.
curve 1 legend 'Control'.
curve 2 legend '+ EDTA'.
CURVE 3 LEGEND '+ Fe'.
title is 'Birchbank' 'July 1980'.
AXIS FRAME IS ON.
SUBPLOT 1.
**FILE**
GEN A PLOT.
PAGE BORDER IS OFF.
DEPENDENT AXIS LABEL IS 'Relative Fluorometer Reading'.
INDEPENDENT AXIS LABEL IS 'Day'.
X AXIS SCALE MINIMUM 0, MAXIMUM 15, STEP-SIZE 2.
Y AXIS TYPE IS LOG.
Y AXIS SCALE MINIMUM .001, MAXIMUM 1.1.
EVERY CURVE SYMBOL COUNT=1.
EVERY CURVE SYMBOL SIZE=1.
EVERY CURVE COLOR IS BLACK.
CURVE 1 SYMBOL TYPE IS 16.
CURVE 2 SYMBOL TYPE IS 2.
CURVE 3 SYMBOL TYPE IS 17.
bank data.
'WCON'
'WEDTA'
'WFE'
EOD.
curve 1 legend 'Control'.
curve 2 legend '+ EDTA'.
curve 3 legend '+ Fe'.
title is 'Waneta ' 'July 1980'.
X AXIS ORIGIN 2.25, LENGTH 4.0.
Y AXIS ORIGIN 2.6, LENGTH 3.0.
AXIS FRAME IS ON.
LEGEND X ORIGIN 16,Y ORIGIN 0.001, COORDINATE UNITS.
SUBPLOT 2.
```

Listing of JULY.80 at 13:33:27 on OCT 18, 1984 for CCid=WQB3

1	July 24 - August 7, 1980					
2	Birchbank					
3	Control					
4		Replicates			Mean	S. D.
5	Day 1	.0026	.0025	.0024	.0025	.0001
6	Day 4	.0025	.0021	.0023	.0023	.0002
7	Day 5	.0027	.0021	.0022	.0023	.00032
8	Day 6	.0024	.0021	.002	.0022	.00021
9	Day 7	.0022	.0022	.002	.0021	.00012
10	Day 8	.0024	.002	.002	.0021	.00023
11	Day 12	.0019	.0019	.0019	.0019	0
12	Day 13	.002	.0016	.0016	.0017	.00023
13	Day 14	.002	.0016	.0016	.0017	.00023
14	Control + EDTA					
15	Day 1	.0028	.0028	.0028	.0028	0
16	Day 4	.0049	.0066	.0055	.0057	.00086
17	Day 5	.0066	.0089	.006	.0072	.00153
18	Day 6	.0074	.012	.0073	.0089	.00269
19	Day 7	.01	.015	.0088	.0113	.00329
20	Day 8	.011	.017	.011	.013	.00346
21	Day 12	.013	.019	.014	.0153	.00321
22	Day 13	.012	.017	.014	.0143	.00252
23	Day 14	.014	.016	.014	.0147	.00115
24	Control + 200ug Fe/L					
25	Day 1	.0025	.0025	.0024	.0025	.00006
26	Day 4	.0032	.0032	.0029	.0031	.00017
27	Day 5	.0032	.0029	.0028	.0030	.00021
28	Day 6	.0031	.0028	.0028	.0029	.00017
29	Day 7	.0032	.0026	.0026	.0028	.00035
30	Day 8	.0029	.0027	.0024	.0027	.00025
31	Day 12	.0021	.0022	.0019	.0021	.00015
32	Day 13	.0021	.0022	.0019	.0021	.00015
33	Day 14	.0020	.0022	.0018	.0020	.0002
34	Waneta					
35	Control					
36	Day 1	.0028	.0028	.0029	.0028	.00006
37	Day 4	.005	.0055	.0053	.0053	.00025
38	Day 5	.0046	.0059	.0056	.0054	.00068
39	Day 6	.0048	.0058	.0057	.0054	.00055
40	Day 7	.0051	.0059	.0056	.0055	.00040
41	Day 8	.005	.0059	.0059	.0056	.00052
42	Day 12	.0026	.0052	.0046	.0041	.00136
43	Day 13	.0024	.0047	.0042	.0038	.00121
44	Day 14	.0022	.004	.0036	.0033	.00095
45	Control + EDTA					
46	Day 1	.0026	.0026	.0026	.0026	0
47	Day 4	.0093	.008	.0087	.0087	.00065
48	Day 5	.01	.0085	.0096	.0094	.00078
49	Day 6	.011	.0091	.01	.0100	.00095
50	Day 7	.011	.0093	.01	.0101	.00085
51	Day 8	.012	.01	.01	.0107	.00115
52	Day 12	.013	.01	.01	.011	.00173
53	Day 13	.012	.01	.01	.0107	.00115
54	Day 14	.013	.01	.01	.011	.00173
55	Control + 200ug Fe/L					
56	Day 1	.0028	.0028	.0027	.0028	.00006
57	Day 4	.0048	.0046	.0053	.0049	.00036
58	Day 5	.0045	.0045	.0051	.0047	.00035

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59	Day	6	.0047	.0048	.0049	.0048	.0001
60	Day	7	.0049	.0049	.005	.0049	.00006
61	Day	8	.0052	.0049	.005	.0050	.00015
62	Day	12	.0031	.0035	.003	.0032	.00026
63	Day	13	.003	.0034	.0029	.0031	.00026
64	Day	14	.0026	.0029	.0027	.0027	.00015
65	Control + P						
66	Day	1	.0029	.0028	.0029	.0029	.00006
67	Day	4	.0086	.0064	.0092	.0081	.00147
68	Day	5	.0089	.0077	.011	.0092	.00167
69	Day	6	.01	.0089	.012	.0103	.00157
70	Day	7	.011	.011	.013	.0117	.00115
71	Day	8	.013	.013	.016	.014	.00173
72	Day	12	.023	.021	.028	.024	.00361
73	Day	13	.026	.023	.03	.0263	.00351
74	Day	14	.03	.026	.032	.0293	.00306
75	Control + N						
76	Day	1	.0028	.0028	.0028	.0028	0
77	Day	4	.0054	.006	.0055	.0056	.00032
78	Day	5	.0059	.0066	.0055	.006	.00056
79	Day	6	.0054	.0065	.0054	.0058	.00064
80	Day	7	.0056	.0065	.0058	.0060	.00047
81	Day	8	.0059	.0067	.0064	.0063	.00040
82	Day	12	.0059	.0059	.0057	.0058	.00012
83	Day	13	.0054	.0052	.0058	.0055	.00031
84	Day	14	.0046	.0046	.0054	.0049	.00046
85	Control + P + N						
86	Day	1	.003	.0029	.0029	.0029	.00006
87	Day	4	.0089	.0084	.008	.0084	.00045
88	Day	5	.01	.0093	.0089	.0094	.00056
89	Day	6	.013	.01	.0095	.0108	.00189
90	Day	7	.017	.011	.012	.0133	.00321
91	Day	8	.022	.011	.013	.0153	.00586
92	Day	12	.077	.019	.024	.04	.03214
93	Day	13	.11	.022	.029	.0537	.04891
94	Day	14	.17	.029	.039	.0793	.07868
95	Control + EDTA + P						
96	Day	1	.0025	.0027	.0028	.0027	.00015
97	Day	4	.0039	.004	.0083	.0054	.00251
98	Day	5	.0045	.0051	.012	.0072	.00417
99	Day	6	.0038	.0055	.022	.0104	.01005
100	Day	7	.0045	.0057	.035	.0151	.01727
101	Day	8	.0042	.0065	.052	.0209	.02696
102	Day	12	.0039	.0082	.08	.0307	.04275
103	Day	13	.004	.0087	.083	.0319	.04432
104	Day	14	.0046	.0082	.081	.0313	.04311
105	Control + EDTA + N						
106	Day	1	.0028	.0029	.0026	.0028	.00015
107	Day	4	.0089	.0075	.0061	.0075	.0014
108	Day	5	.013	.012	.0081	.0110	.00259
109	Day	6	.019	.017	.012	.016	.00361
110	Day	7	.026	.019	.014	.0197	.00603
111	Day	8	.032	.022	.014	.0227	.00902
112	Day	12	.03	.026	.014	.0233	.00833
113	Day	13	.028	.029	.013	.0233	.00896
114	Day	14	.024	.028	.014	.022	.00721
115	Control + EDTA + P + N						
116	Day	1	.0029	.0028	.0027	.0028	.0001

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117	Day	4	.0082	.0069	.009	.0080	.00106
118	Day	5	.012	.01	.016	.0127	.00306
119	Day	6	.019	.013	.027	.0197	.00702
120	Day	7	.029	.017	.04	.0287	.01150
121	Day	8	.044	.023	.056	.041	.01670
122	Day	12	.1	.045	.12	.0883	.03884
123	Day	13	.12	.044	.13	.098	.04703
124	Day	14	.12	.05	.13	.1	.04359
125	Control (using polycarbonate culture						
126	Day	1	.0027	.0028	.0026	.0027	.0001
127	Day	4	.003	.0032	.0033	.0032	.00015
128	Day	5	.0031	.0039	.0041	.0037	.00053
129	Day	6	.003	.0036	.0035	.0034	.00032
130	Day	7	.003	.0035	.0036	.0034	.00032
131	Day	8	.0032	.0035	.0037	.0035	.00025
132	Day	12	.0031	.003	.0034	.0032	.00021
133	Day	13	.0031	.0029	.0038	.0033	.00047
134	Day	14	.0031	.0029	.0038	.0033	.00047
135	Control + EDTA (using polycarbonate c						
136	Day	1	.0029	.0028	.0029	.0029	.00006
137	Day	4	.0061	.0055	.0058	.0058	.0003
138	Day	5	.0076	.0067	.0067	.007	.00052
139	Day	6	.0094	.0074	.0076	.0081	.00110
140	Day	7	.012	.0084	.0088	.0097	.00197
141	Day	8	.016	.009	.01	.0117	.00379
142	Day	12	.03	.013	.014	.019	.00954
143	Day	13	.028	.013	.017	.0193	.00777
144	Day	14	.028	.014	.018	.02	.00721
145	TED-135ug Zn/L						
146	Control						
147	Day	1	.0025	.0026	.0028	.0026	.00015
148	Day	4	.0044	.0042	.0045	.0044	.00015
149	Day	5	.0055	.0045	.005	.005	.0005
150	Day	6	.0065	.0046	.0055	.0055	.00095
151	Day	7	.0074	.005	.0059	.0061	.00121
152	Day	8	.0078	.0048	.0072	.0066	.00159
153	Day	12	.0087	.0042	.0067	.0065	.00225
154	Day	13	.0086	.0049	.0074	.0070	.00189
155	Day	14	.0086	.0048	.0076	.007	.00197
156	Control + EDTA						
157	Day	1	.0028	.0027	.0028	.0028	.00006
158	Day	4	.019	.036	.034	.0297	.00929
159	Day	5	.033	.046	.044	.041	.007
160	Day	6	.049	.053	.049	.0503	.00231
161	Day	7	.055	.058	.054	.0557	.00208
162	Day	8	.058	.063	.055	.0587	.00404
163	Day	12	.068	.057	.053	.0593	.00777
164	Day	13	.072	.06	.055	.0623	.00874
165	Day	14	.07	.057	.053	.06	.00889
166	Control + P						
167	Day	1	.0026	.0026	.0028	.0027	.00012
168	Day	4	.0046	.0046	.0047	.0046	.00006
169	Day	5	.0049	.0053	.0054	.0052	.00026
170	Day	6	.0056	.006	.0061	.0059	.00026
171	Day	7	.0063	.0058	.0063	.0061	.00029
172	Day	8	.0071	.0065	.0066	.0067	.00032
173	Day	12	.0086	.0067	.0074	.0076	.00096
174	Day	13	.0094	.007	.0072	.0079	.00133

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175	Day	14	.0096	.0068	.0072	.0079	.00151
176	Control + EDTA + P						
177	Day	1	.0029	.0027	.0027	.0028	.00012
178	Day	4	.044	.058	.029	.0437	.01450
179	Day	5	.073	.078	.068	.073	.005
180	Day	6	.076	.076	.071	.0743	.00289
181	Day	7	.077	.073	.071	.0737	.00306
182	Day	8	.075	.074	.066	.0717	.00493
183	Day	12	.074	.067	.058	.0663	.00802
184	Day	13	.066	.063	.054	.061	.00624
185	Day	14	.064	.06	.052	.0587	.00611
186	Control + 200ug Fe/L						
187	Day	1	.0027	.0027	.0027	.0027	0
188	Day	4	.0044	.0056	.006	.0053	.00083
189	Day	5	.005	.0065	.007	.0062	.00104
190	Day	6	.0053	.0065	.0078	.0065	.00125
191	Day	7	.0057	.0072	.0078	.0069	.00108
192	Day	8	.0057	.0075	.008	.0071	.00121
193	Day	12	.0043	.0065	.0065	.0058	.00127
194	Day	13	.004	.0067	.0065	.0057	.00150
195	Day	14	.0038	.0056	.0056	.005	.00104

Two graphs may be placed on the same page using subplots. The axis lengths and placements must be specified (lines 9-10 and 52-53).

By default the legend is printed in the lower right hand corner of the page. If legend placements are not specified, the legends for both plots will be printed on top of each other. It is easiest to specify legend placement in coordinate units for each graph (lines 11 and 55).

APPLICATION 2: Use of TELLABANK and bank data

Data can be read from a data file and stored in a second file (bank file) as variable pairs which can be used by TELL-A-GRAF. To create a bank file type

```
$RUN *TELLABANK
```

This program is documented in Appendix D of the TELL-A-GRAF User's Manual.

In the present example, algal growth curves for several treatments are to be plotted. The data (given as relative fluorometer readings) are stored in the file JULY.80. For each treatment "mean" is to be the dependent variable and "day" the independent variable. By giving appropriate responses to TELLABANK's prompts, one can extract the desired variable pairs and store them in a file which will be used by TELL-A-GRAF.

The data set for each curve is stored in a separate "bank file". Each bank file has a unique name. Thus, the bank file 'BCON' (line 19 of DRAW.JUL) contains the X,Y coordinates extracted from lines 5-13 of JULY.80, while 'BEDTA' (line 20 of DRAW.JUL) contains the data from lines 15-23 of JULY.80.

The inclusion of bank data among the TELLAGRAF commands is illustrated in lines 18-22 and 43-47 of DRAW.JUL. The TELLABANK names (BCON, etc.) will appear in the legend unless alternate legend entries are specified, as in lines 23-25 and 48-50.

CAUTION 1: The number of characters allowed in a bank file name is limited (currently 12). TELLABANK will truncate longer names to 12 characters. Thus, a file named 'CONTROL+EDTA+P' will be truncated to 'CONTROL+EDTA'. If a file named 'CONTROL+EDTA' already exists, the data in that file will be replaced by the data in 'CONTROL+EDTA+P' without warning.

CAUTION 2: TELLABANK stores all bank files in the temporary file -TAGPRM. Since TELLABANK is tedious to run on large data sets (eg. JULY.80), you may wish to rename -TAGPRM as a permanent file at the end of the TELLABANK session. Since TELL-A-GRAF reads bank data from the PRM file, you must COPY the bank data to -TAGPRM when you run TELL-A-GRAF. Do not RENAME a permanent file -TAGPRM or TAGPRM if the TELL-A-GRAF

layout description contains subplots. TELL-A-GRAF creates subplot files which it stores in the PRM file. Thus, the PRM file can become long (50-100 pages or more). Subplot files cannot be accessed by TELLABANK, and therefore are impossible to delete once they have been attached to a permanent file containing bank data.

Other points illustrated by DRAW.JUL:

- Line 7 specifies a log scale. Remember that zero's cannot be plotted on a log scale. If zero's are accidentally included, TELL-A-GRAF will not give a warning. Instead, when you attempt to plot the graph, the FORTRAN monitor will give an error message whose meaning may not immediately be obvious.

- In order to have all of the points on the curve drawn, it is necessary to specify SYMBOL COUNT=1 (lines 12 and 37). The default condition draws the entire curve but only draws symbols for the first and last points.

- The graphs in this example are framed (lines 27 and 54). Sometimes the axes do not reproduce well because the lines are too thin. Framing the axis is a way of avoiding this problem.

DRAWING PUBLICATION-QUALITY GRAPHS

To obtain publication-quality graphs you should

1. Draw graphs on the Calcomp plotter at SFU rather than on the HP7470A plotter.

   When you are satisfied with the layout of your graph, use the TELL-A-GRAF SEND statement to send the graph to a plotfile. TELL-A-GRAF sends all graphs plotted in one session to the same file. If you wish to have each graph in a separate file, specify -P as the plotfile and after each graph has been sent, type

   ```
   $RENAME -P PLOTFILE
   ```

   where PLOTFILE is a unique name for each graph. (MTS will not confirm that the file has been renamed, but it will carry out the operation.) Note that the next step requires permanent files. At the end of the TELL-A-GRAF session type

   ```
   $RUN *CCQUEUE PAR=PLOTFILE
   ```

   The graph will be drawn at SFU.

   Since the quality of drawings varies (pens run low on ink), you may need to have the graph drawn more than once. Be sure to save your plot file until you have a drawing which satisfies you.

2. Draw the graph as close as possible to the size it will appear in the report.

   If you draw a full page sized graph and allow TELL-A-GRAF to select the default size for titles and axis labels, the printing will be too small when the figure is reduced. If you specify reduced axis lengths, TELL-A-GRAF will select the appropriate sized print.

   Alternatively, you can draw a full page graph and specify the size of print that TELL-A-GRAF is to use. You can determine the best size by trial and error:

   Specify the print size and send the graph to a plot file. Run *CCQUEUE and reduce the size of the plot by the desired factor, eg.

   ```
   $R *CCQUEUE
   ```

   When PAR=PLOTFILE has not been specified, the computer will respond

   ```
   ENTER PLOT REQUEST
   ```

   You type

   ```
   PLOTFILE SCALE=.5
   ```

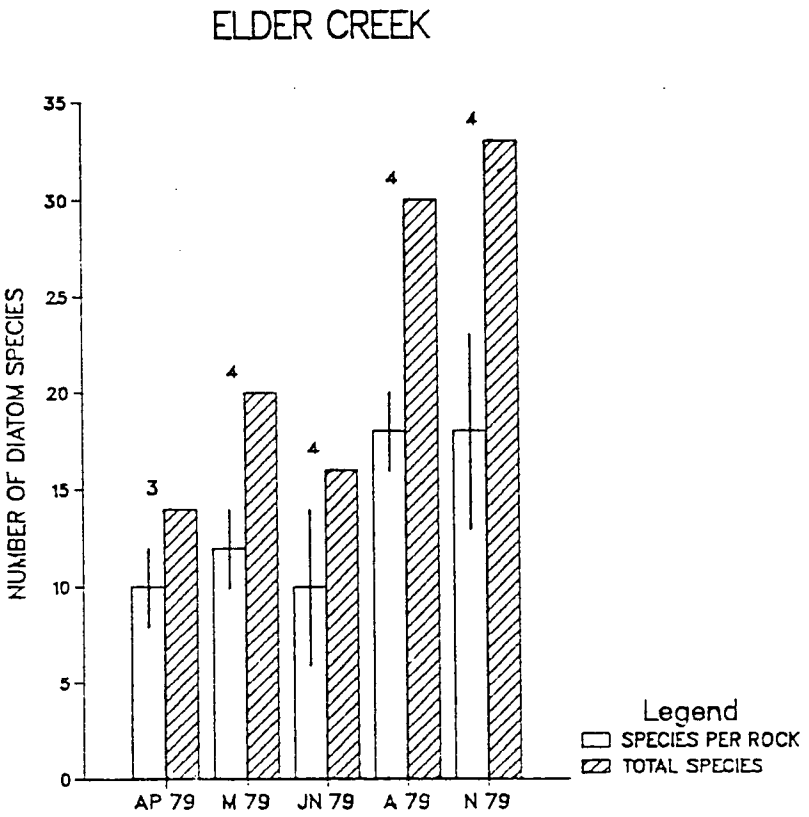
   The computer responds

   ```
   ENTER PLOT REQUEST
   ```

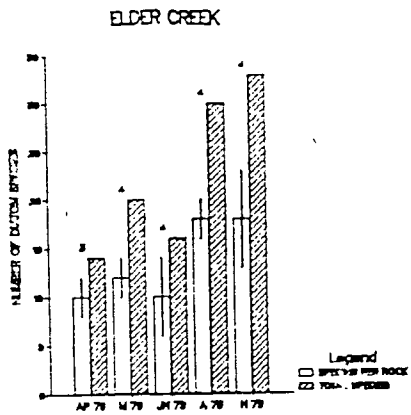
   You may respond with new file names and/or scales as many times as you wish. When finished, respond to the plot request with

   ```
   $endfile
   ```

When you view the plots, you can determine whether you have selected appropriate sizes for the lettering. Note that at SCALE=.25 and below the lettering becomes too small for the pen width. Reductions of this magnitude must be done photographically. Plots at SCALE = .5 and SCALE = .25 are illustrated on the following page. Note all other plots in this report have been reduced to 71% of the original by photoreduction.



SCALE = .5



SCALE = .25

ECONOMICAL USE OF TELL-A-GRAF

TELL-A-GRAF is designed so that the user can easily experiment with different graphic presentations. However, running TELL-A-GRAF is expensive. The most economical use of TELL-A-GRAF can be made when many similar graphs are to be drawn (eg., graphing all of the data in JULY.80, Example 5).

Begin with one graph, and use the interactive feature of TELL-A-GRAF to test different presentations. When you are satisfied with the appearance of the graph, save the layout description using the SAVE command (TELL-A-GRAF User's Manual, Section F). Then exit TELL-A-GRAF and produce layouts for the remaining graphs using MTS:

1) Make as many copies as necessary of the layout instructions either in the same file or in separate files.

2) Edit each set of instructions, changing titles, data, legend entries, etc., as necessary.

To produce the graphs, run TELL-A-GRAF and enter

```
INCLUDE 'FILENAME'.
```

You can now view the graph on the computer screen with the GO command or plot the graph with the SEND command. If each graph is contained in a separate file, you must type

```
INCLUDE 'FILENAME'.
```

each time you wish to view or plot a new graph.

Since TELL-A-GRAF takes time to read and process each file, it is quicker to have all graphs in the same file. However, it may be difficult to select a particular graph from a large file. This problem can be solved by giving each graph a SUBPLOT name or number (but see caution about using subplots with bank data, Example 5). Then each graph to be plotted is specified, eg.

```
SEND 3.
```

sends SUBPLOT 3. To view the graph on the screen, specify

```
DRAW 3.
```

instead of GO.

REFERENCES

Anon, 1981. Tellagraf User's Manual, Version 4.1. Integrated Software Systems Corporation, San Diego, California.

Smith, A.L. G.L. Ennis, S.W. Sheehan and T.M. Tuominen. 1985. A water quality study of the Akamina-Kishinena watershed and other tributaries to the Flathead River in British Columbia subjected to logging. Data report. Available from Inland Waters Directorate, Pacific and Yukon Region, Water Quality Branch, Vancouver, B.C.

Tuominen, T.M., G.L. Ennis and S.W. Sheehan. 1987. An algal assay study on the effects of metals and nutrient discharges on the algal growth potential in the Columbia River, British Columbia. Data report. Available from Inland Waters Directorate, Pacific and Yukon Region, Water Quality Branch, Vancouver, B.C.