

Long Term Monitoring of the Coral Reef Organisms of Biscayne National Park

Final Report: 1989-1990 Field Seasons

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Subagreement no. 25,
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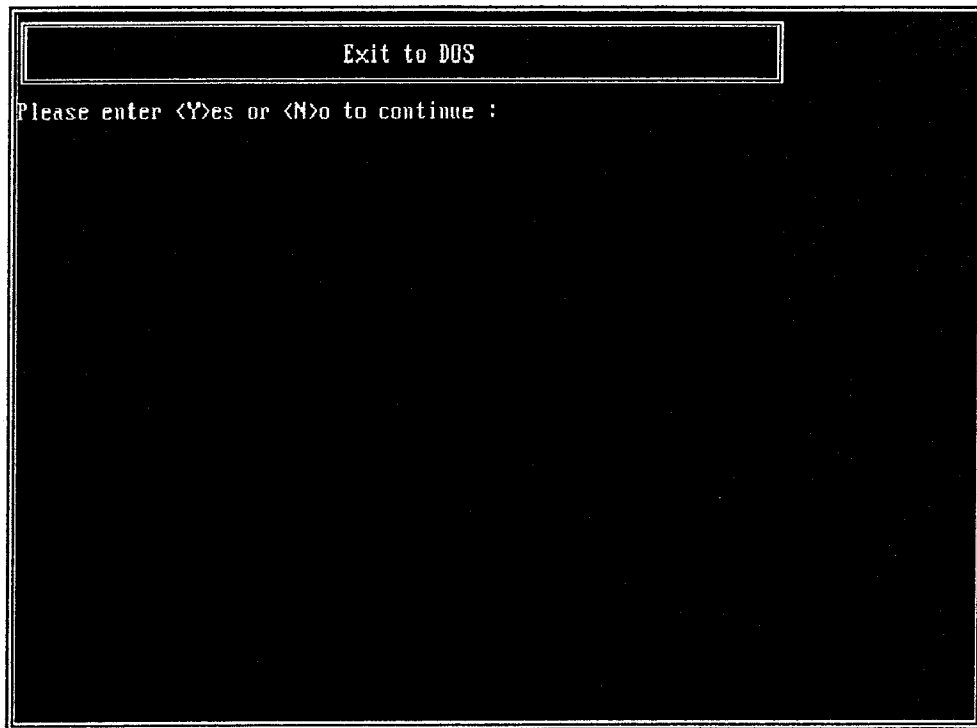
Between USDI, NPS, & UGA Research Foundation Inc.

Volume 7 (of 8)

Deliverable: Sampling Protocol Handbook 1:

Line Transect Methods & Software Analysis

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Screen 6.2

METHODS FOR THE ANALYSIS OF CORAL REEF COMMUNITY STRUCTURE

I. CHAIN TRANSECT

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1993

Option 6

Back to DOS

When you wish to leave the system, choose Option 6. Screens 6.1 and 6.2 will direct you back to DOS.

Editing/Correcting an existing data file?

Please enter <Y>es or <N>o to continue :

Screen 6.1

These two manuals describe two methods for quantifying change on coral reefs: the line transect method (Part I) developed with Dr. Caroline Rogers, and the photostation method (Part II). The study was conceived to detect change in marine benthic communities. Therefore, while these methods can be used for one-time-only surveys, the methods are most powerful when used to compare between censuses taken in the same location on different dates.

Section A of Part I describes the field techniques for establishing "permanent" line transects; Section A of Part II describes the protocol for establishing "permanent" photostations. Section B of both parts describes computer software available for analyzing the data acquired by these methods.

These manuals and computer programs accompanying them are not copy written. They can be obtained at cost from the following address. These will be supplied as 3 1/2" HD discs. This manual and the associated programs will be updated periodically. Any corrections or suggestions would be helpful.

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Constant Redefine Screen of Chain Transect Analysis Program

The Chain Transect Analysis program can only analysis the data under the limitation which are meter number ≤ 100 , substrate number ≤ 20 , coral species number ≤ 30 , arraysize ≤ 30 (max. of (sub. no + 1, coral no)). If user needs to change these limitation, user needs to goto the chainana.pas program to change the type of array. If you have any other question, please contact us to resolve your problem. Here, user needs to define the link length.

The default link length is showing below :

* Link length : 1.37

** Do you want to change the link length?(Y/N)y

Link length : 1.58

Screen 5.2

METHODS FOR THE ANALYSIS OF CORAL REEF COMMUNITY STRUCTURE

I. CHAIN TRANSECT:

A. FIELD METHODS

Option 5

Chain Link Size Program

With Screen 0.1 on the Main Manual, choose Option 5, to change the Chain Link Size; Screen 5.1 will appear.

Our chain links are **1.37 cm** long. This module lets you change this value if your local hardware store happens to have a different chain link length. Follow the instructions on the Screen 5.2 and enter your chain length in centimeters. You only need to do this once before you begin entering data.

```
Constant Redefine Screen of Chain Transect Analysis Program

The Chain Transect Analysis program can only analysis the data under the
limitation which are meter number <= 100, substrate number <= 20, coral species
number <= 30, arraysize <= 30 (max. of (sub. no + 1, coral no)). If user needs
to change these limitation, user needs to goto the chainana.pas program to
change the type of array. If you have any other question, please contact us to
resolve your problem. Here, user needs to define the link length.

The default link length is showing below :
* Link length : 1.37

*** Do you want to change the link length?(Y/N)y
```

Screen 5.1

FIELD METHODS

The sampling program described below addresses four goals:

- (1) positioning the transect lines to include common coral reef types,
- (2) marking the transect line end points to allow relocation and resurvey,
- (3) overlapping the transects lines and photostations to allow comparison between the two survey methods,
- (4) replicating the transect line counts to allow statistical treatment of the results.

These surveys and analytical techniques were first utilized in the Florida Keys. Figures 1 & 2 show maps of survey areas in the Biscayne National Park (Porter and Meier, 1992). Circles on the map indicate the placement of end points for the line transects. Transect positions were carefully chosen to keep the transect lines on the reef and out of sand channels. Several line transects were established within each coral reef zone. The length of the lines laid and the number of lines laid must be controlled by the questions being asked and the parameters being measured (Porter, 1972). Our experience indicates that two 25 m transects in each coral zone will accurately sample most coral community parameters except species number (S). Only repeated swim surveys sample S.

The start and stop points for each underwater transect line are permanently fixed by the implantation of stainless steel eye pins cemented into the reef. The pins are similar to mooring buoy attachments described in detail by Halas (1985). Each eye pin is numbered with a stainless steel tag so that future surveys can identify the start and stop points of the survey accurately. Each pair of eye pins serves as the start and stop point for a transect line. Because the eye pins are cemented into the reef, the transect line can be reestablished and resurveyed accurately. Eye pins are located approximately 30 m apart. It is important to designate each pin as either the start point or the stop point for the transect line: resurveys must always be counted from the same origin and in the same direction.

Pins are made of 1 cm stainless steel bar cut into half meter lengths. One end is bent at the top and welded into a loop 15 cm in diameter. The other end of the bar has a 5 cm long piece of the steel bar welded perpendicularly to the shaft. This cross piece helps the underwater hydraulic cement (Portland Type II) retain the pin in the hole drilled to accommodate the eye pin. Bending the rod at the end will achieve the same goal as welding a small piece perpendicularly to the shaft.

Between these two end points, eight more stainless steel stakes are cemented vertically into the reef to serve as guide posts for a photostation (photostation methodology is described in Part II A). In the surveys diagrammed in Figures 3 & 4, three line transects cross the photostation. Overlapping the surveys like this allows the two methods to be compared.

For any comparison between surveys, it is critical that all transect counters read and understand thoroughly all of the counting instructions listed below.

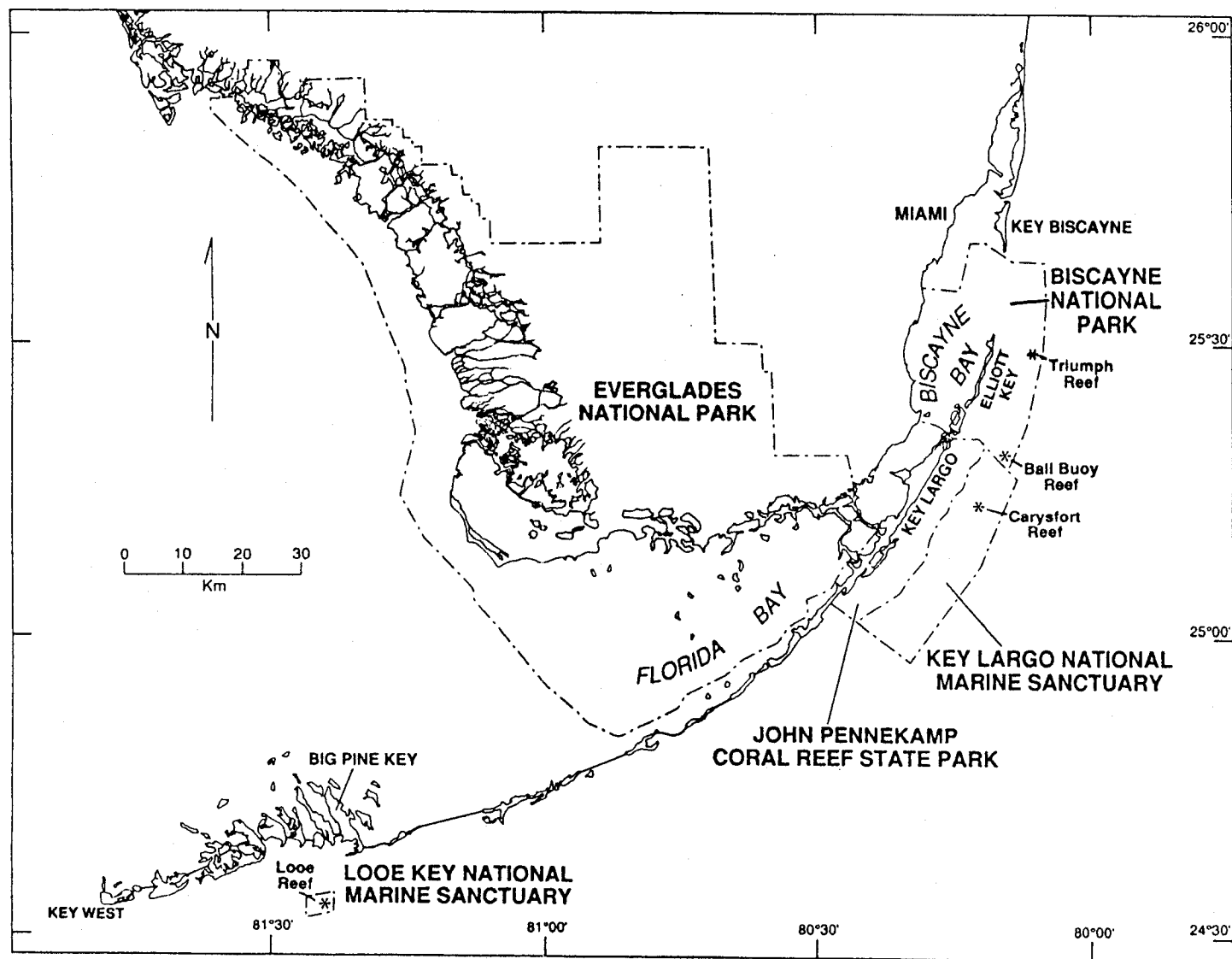
Files Combination Menu

Enter the filename that you want to combin :
(for XXXXXXXRA, XXXXXXXPS files only)

- 1 : t2c189ra
- 2 : t2c289ra
- 3 : t2c389ra

Screen 4.2

Figure 1.



Option 4

Transect Combination Program

This program is a tool program used for statistical analysis of replicate counts of the same transect. Once the files from replicate counts of the same transect are combined and averaged, one can calculate the mean, standard deviation, or other statistical value, for any of the five community parameters.

When Option 4 is chosen from Screen 0.1, Screen 4.1 appears. According to which analysis files you intend to combine, the user will choose either Option 1 (for PS or RA files) or Option 2 (for CH, CS, or CP files). Having done this, Screen 4.2 appears to request the filename for final processing.

Note that this program creates a new .ANA file by combining replicate counts from the same transect, *i.e.* T1C189PS.ANA, T1C289PS.ANA, and T1C389PS.ANA, into a new count total file relabeled as T1CT89PS.ANA.



```
1. Combine XXXXXXRA or XXXXXXPS files.
2. Combine XXXXXXCP, XXXXXXCH or XXXXXXCS files.

Choose # -> 1
```

Screen 4.1

*** Print Analysis Data File Menu ***

1. Print Substrate % Cover Data File.(XXXXXXPS)
2. Print Different Coral % Cover Data File.(XXXXXXPC)
3. Print Coral Species Cumulative Data File.(XXXXXXCS)
4. Print Species Diversity H' Analysis Data File.(XXXXXXCH)
5. Print Coral % Cover Cumulative Data File.(XXXXXXCP)
6. Go Back to the Main Menu.

Choose number(1,2,3,4,5,6), then hit <ENTER> to continue ... 1

Choose file name, then hit <ENTER> to continue >>> t2c189ps

<Ctrl><Break> Exit to DOS

Screen 3.14

Counting begins by stretching a yellow polypropylene transect line between the two eye pins. The line is marked at 1 m intervals from 0, attached to the origin eye pin, to 25, just before the terminal eye pin. Polypropylene line is used as this type of rope floats over the reef as the line is uncoiled. The line is then stretched straight between the two eye pins bringing the rope down to and in contact with the substratum directly underneath it. After stretching, the height of the transect line above the reef is determined by bottom topography.

Counts are accomplished using a metal transect chain. Although the exact length of the transect chain link is not critical, we used a standard hardware chain with links 1.37 cm in diameter. Smaller links took too long to count, and larger links missed juveniles and other important biotic features. We number every tenth link with a small 1 cm square plastic tag attached to the link using a small key ring. The tag is made of black-on-white plastic sheet stock with numbers engraved on both sides of the tag. Every fiftieth link is numbered with a larger 2.5 cm square tag of the same material. The link numbering sequence is therefore: 10, 20, 30 40, **50**, 60, etc. The link numbering system allows for quicker, more accurate counts, and prevents losing count. For reefs with complex topography, the counting chains need to be 3 or 4 m long. Data are recorded on a slate or in an underwater writing book (plasticized paper note books are available from Nalgene, Inc.). Underwater tape recorders and computers would speed data collection and improve counting accuracy

The first chain link is attached to the polypropylene line at the line's zero mark, and the remainder of the chain is laid directly under the stretched polypropylene line to the next meter mark along the polypropylene line. The meter mark where the chain **ENDS** is recorded in the book. Note that in this protocol, the first meter counted (from 0 to 1) is recorded as **Meter Number 1**, from Meter mark Number 1 to Meter mark Number 2 is 2, etc. The chain drops directly to the sea floor under the line. The number of links between the polypropylene line and the sea floor below is recorded in the notebook as "fall." This number is an important indicator of the three-dimensional complexity of the reef.

The diver now wraps the chain carefully around all substrata directly beneath the yellow polypropylene line. The diver counts the links covering different substrata until the chain rises directly back up to the next meter mark on the polypropylene line above. Between the meter marks, the chain goes up, down, around, over, and under all objects on the reef according to the bottom topography directly under the line.

Gorgonians are the only exception to this rule. Since no consistent method could be found to measure gorgonian abundance using a transect line, a compromise convention was adopted to have the line follow the substratum under the gorgonian. If the chain touches the base of a gorgonian, then and only then, is the gorgonian counted, and only for the number of links that cross its base. Obviously the line transect method does not quantify gorgonian biomass!

For an overhanging coral branch jutting under the polypropylene transect line (remember that nothing will be above the line given the way in which the line polypropylene line is laid),

Option 7, Screen 3.1. Print data file analysis menu.

Choosing this option brings up Screen 3.13. With this menu, type the proper analysis filename (Screen 3.14) to print the contents of any analysis file.

```
*** Print Analysis Data File Menu ***

1. Print Substrate % Cover Data File.(XXXXXXPS)
2. Print Different Coral % Cover Data File.(XXXXXXPC)
3. Print Coral Species Cumulative Data File.(XXXXXXCS)
4. Print Species Diversity H' Analysis Data File.(XXXXXXCH)
5. Print Coral % Cover Cumulative Data File.(XXXXXXCP)
6. Go Back to the Main Menu.

Choose number(1,2,3,4,5,6), then hit <ENTER> to continue ... 1

<Cntl><Break> Exit to DOS
```

Screen 3.13

Biscayne National Park Ball Buoy Reef

Photostation 1 Line Transects 1-5

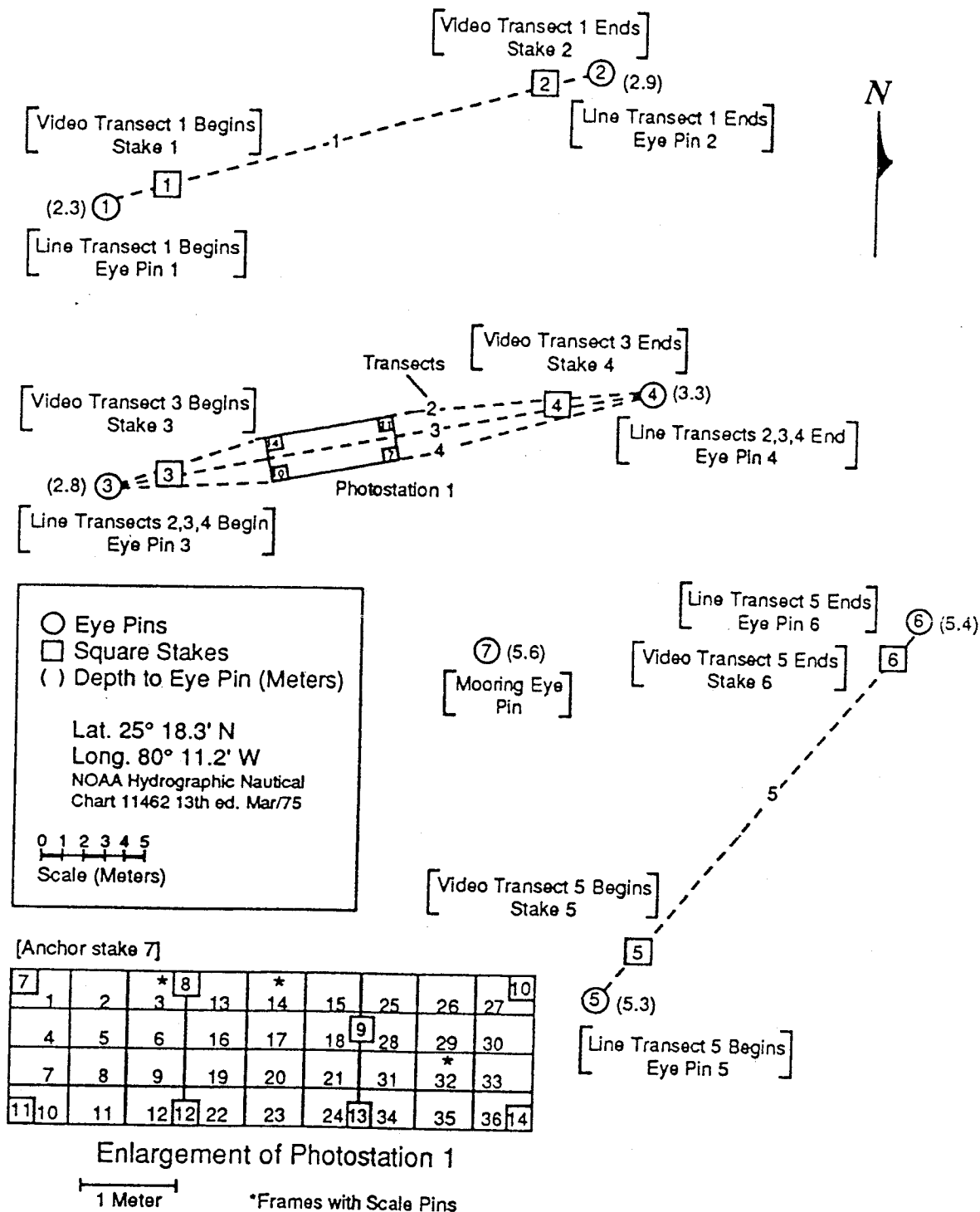


Figure 3

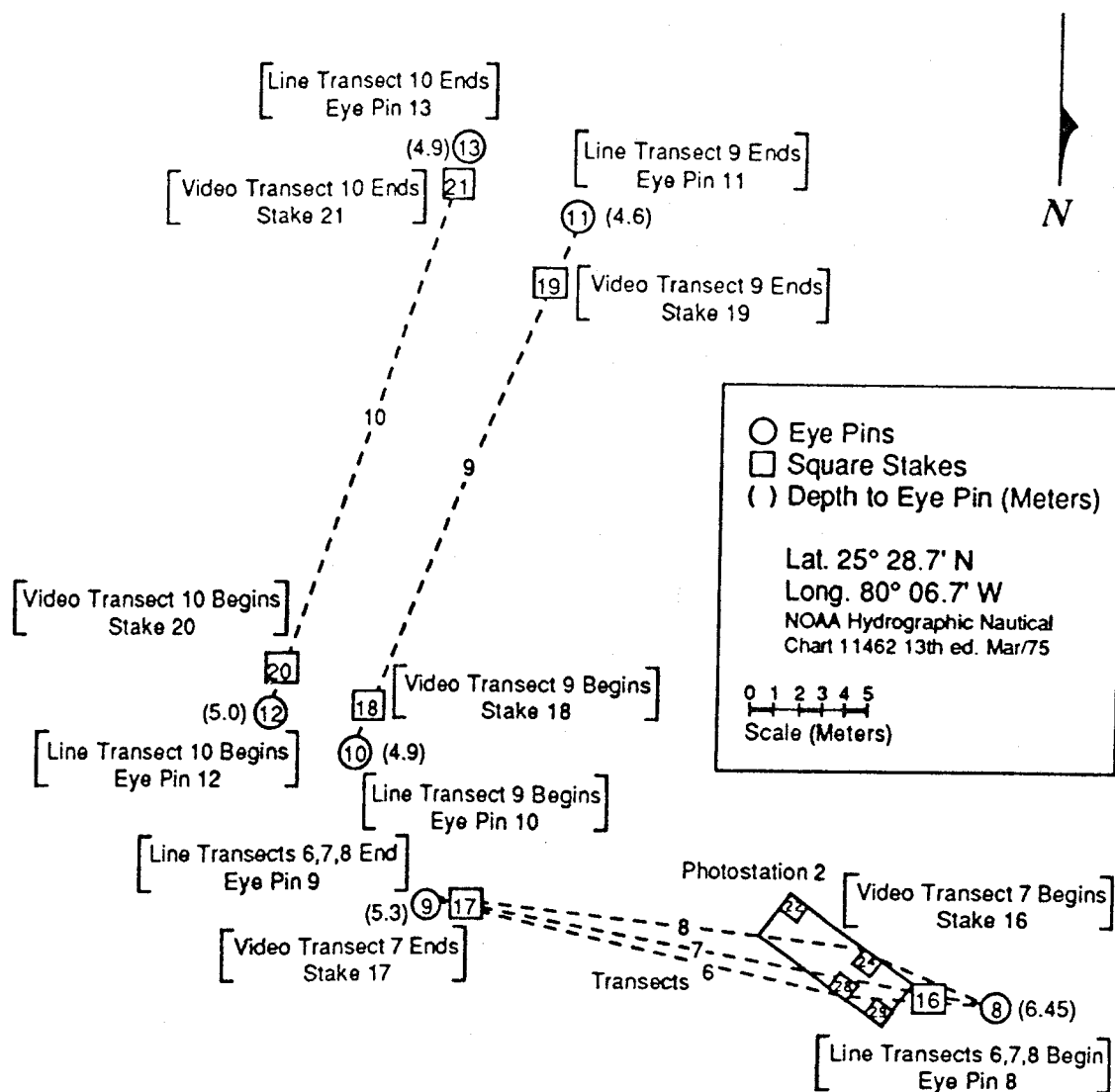
created and will be a new raw data file for a "new" 75 m transect. Do this for counts 2 and 3 to give three replicate counts of the "new" 75 m transect.

```
Please put data diskette in Drive A.  
  
Enter 6-character raw data filename. Use the same count but on different  
transects, then hit <ENTER> to continue ...  
  
Transect 1 : t1c189  
Transect 2 : t2c189  
Transect 3 : t3c189  
  
** Please do not take out diskette from Drive A  
until the process is finished.  
  
                                <Ctrl><Break> Exit to DOS
```

Screen 3.12

Biscayne National Park Triumph Reef

Photostation 2 Line Transects 6-10



[Anchor stake 22]

22	1	2	3	13	14	15	25	26	27	25
4	5	6	16	17	18	28	29	30		
7	8	9	19	20	21	31	32	33		
26	10	11	12	22	23	24	28	34	35	36

Enlargement of Photostation 2

1 Meter

*Frames with Scale Pins

Figure 4

*** A:t2c189CP.ANA ***

Cumulative % coral cover file has been created.
The CP postscript on the original data filename indicates Cumulative Percent coral cover. To view the numerical results, return to the main menu, choose menu option 6, and use the 8-character filename from the top of this screen.
To print or view graphs or statistics, load STATGRAPHICS, and import this 8-character filename.

Press <ENTER> to return to Chain Transect Analysis Menu.

Screen 3.11

Option 6 of Screen 3.1. Stringing transects together

When you choose this Option, Screen 3.12 appears. This Option allows you to string several different transects together to create a longer transect for analysis. It is inappropriate to string together recounts of the same transect. You may only string different transects together. This longer transect is renamed automatically with the first letter as **R**, indicating that the transects have been rearranged. The next number is the same as the first transect in the combination string. For instance, a combination of three 25 m transects, T2C1 plus T3C1, plus T4C1 into one 75 m transect would be labeled **R2C1**. Note that it is simplest to keep the recounts together, that is, string Count 1 of Transect 1, plus Count 1 of Transect 2 plus Count 1 of Transect 3. After rearranging your raw data, you can rerun the analysis program (including Option 2 from Screen 3.1) to get the new analysis data file.

For example, we have three different transects with 25 meters in each one (Figures 1 & 2). Each transect was counted three times. Therefore, we have nine raw data files. (T2C189.DAT, T2C289.DAT, T2C389.DAT; T3C189.DAT, T3C289.DAT, and T3C389.DAT; and T4C189.DAT, T4C289.DAT, T4C389.DAT). To concatenate the files into one 75 m transect, we key in T2C189, T3C189, and T4C189 in response to Option 3 to string these three raw data files together into a new data file. It will automatically be renamed **R2C189.DAT**. This new file name is automatically assigned by the program according to the input file numbers. It only changes the first letter of the file name - **R** means rearrange. **R2C189.DAT** will be

the chain rises from the sea floor and these links are recorded as "rise." The chain links wrapping around the coral branch are recorded using the appropriate coral designator. The chain then falls back to the sea floor; these links are recorded in the data book as "fall." The computer program to be described in Section B, retains this "rise" and "fall" information as gaps in the data, but does not treat it as a substratum type to be analyzed.

For all other structures, the chain hugs the substratum in the plane directly beneath the polypropylene line. The chain must touch solid structure at all times, even if this means that the chain has to be held up against the underside of a coral branch or ledge.

Count the number of links covering each substratum in the following manner. Simply record the link number where each new substratum ends, and, using the four-letter descriptors listed in Table 1, identify the ownership of that space. There is no reason to record the number of the link where a substratum starts, as this value is, by definition, always the link number of the previous substratum stop plus one. Every link is counted as covering some kind of substratum as defined in Table 1. You may add new substratum types at will to Table 1 to suit your own transecting needs. Just be sure to use a four letter moniker.

The "rise" at the end of the chain count, from the sea floor back up to the polypropylene line above, is not recorded since this value will be identical to the "fall" at the start of the next meter mark down to the sea floor.

Table 1 lists and defines the different substrata. All substrata are identified with a different four letter name. Coral species are labeled as a combination of the **first letter of the genus name (always capitalized)** and the **first three letters of the species name (always lower case)**. Thus *Agaricia agaricites* becomes Aaga. Non-coral substrata are always identified with four **lower case letters**. Coral species are thus distinguished from non-coral substrata by capitalization of the first letter. This is an important feature of the computer program and allows the program to distinguish between coral and non-coral substrata in all subsequent analyses.

Mobile organisms are not entered into the computer as substratum types. The spiny sea urchin, *Diadema*, however, is counted when under the line and recorded in the data book.

The line transect method described above contributes several important pieces of information about coral reef community structure that the photographic method described in Part II does not. By following the contours of the reef, the chain transect method gives information on the topographic complexity of the reef. Further, despite the difficulty in applying the method on complex substrata, the line transect method does give you a direct measure of living coral surface area: by following the surface of living coral under the line, the line transect method quantifies three-dimensional surface area whereas projected surface areas from photographs do not. For these two reasons, the line transect method is useful for answering some questions that the photographic method can not.

A final advantage of the line transect method is that you emerge from the water with data

Option 5, Screen 3.1.

Cumulative Percent of live coral cover encountered along the transect (CP).

Choosing Option 5, brings up Screen 3.10. This program allows you to compute the cumulative coral cover. After the program stops running, Screen 3.11 appears, giving you the filename of the newly created analysis file.

```
Please put data diskette in Drive A.  
  
Enter original 6-character raw data filename,  
then hit <ENTER> to continue... t2c189  
  
** Please do not take out diskette from Drive A  
until the whole processing is finished.  
  
<Ctrl><Break> Exit to DOS
```

Screen 3.10

acquisition complete. Despite the smaller sample size of the line transect method relative to the photostation method, rapid data analysis can sometimes be an advantage. This is especially true when large changes in substratum ownership have occurred: both methods document dramatic changes well. The photostation, however, documents subtle change, whereas the line transect does not.

REFERENCES

- Halas, J.C. 1985. A unique mooring system for reef management in the Key Largo National Marine Sanctuary. *Proc. Fifth Internat. Coral Reef Congr. (Papete, Tahiti)* 4:237-242.
- Porter, J.W. 1972. Patterns of species diversity in Caribbean reef corals. *Ecology* 53:745-748.
- Porter, J.W., and O.W. Meier. 1992. Quantification of loss and change in Floridian reef coral populations. *Amer. Zool.* 32:625-640.

*** A:t2c189CH.ANA ***

A cumulative species diversity (H') file has been created.
The CH postscript on the original data filename indicates Cumulative species diversity. To view the numerical results, return to the main menu, choose menu option 7, and enter the 8-character filename from the top of this screen.
To print or view graphs or statistics, load STATGRAPHICS, and import this 8-character filename.

Press <ENTER> to return to Chain Transect Analysis Menu.

Screen 3.9

After the program is finished, Screen 3.9 appears, giving you the filename of this newly created analysis file.

Table 1. Substrate and coral identification protocol.

Computer Id	Name	Brief Definition	
rock	rock	Non-living:	Newly bare substrate. This designation is indicative of recent scarring or breakage. In practice this is quite rare on a healthy reef; none of this substrate type was found in our survey. Newly bare substrata is quickly colonized by algae.
sand	sand	Non-living:	Sand must be more than 2 cm thick. As our surveys specifically avoided sand channels, this substrate type was also very rare.
alga	algae	Living:	Macroalgae, fist size or larger. Not all the fist-size algae need be under the chain, but only the part that is under the chain is counted. <i>Halimeda</i> is included in this category.
dcwa	dead coral with algae	Living:	If a recent scar on an otherwise living coral surface is covered with algae, use this designation. Like "rock" above, this category is a measure of disturbance.
pave	pavement	Living:	Includes long-dead coral covered by turf and calcareous red algae (not <i>Halimeda</i> which is scored as a fleshy alga). This is one of the commonest surfaces on Caribbean reefs.
spen	sponge	Living:	An erect sponge; boring sponges are not scored.

Option 4, Screen 3.1. Cumulative species diversity ($H' \ln$) of the transect (CH)

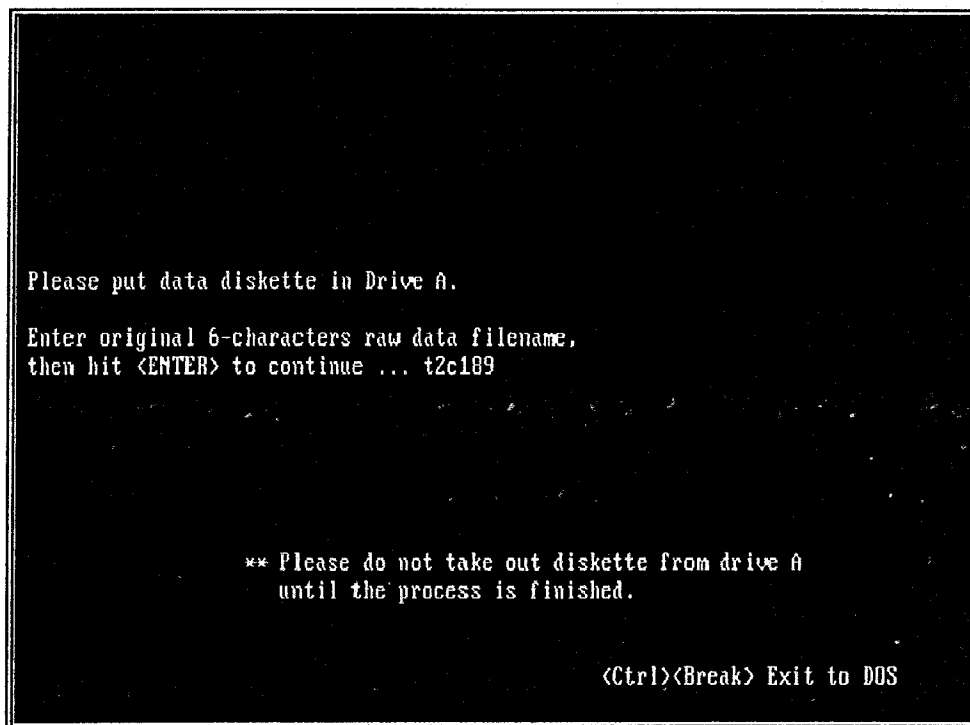
Choosing Option 4, brings up Screen 3.8. This program calculates species diversity of a transect according to the following formula:

$$H' = -\sum p_i \log_b p_i \approx \frac{C}{N} \{N \log_{10} N - \sum n_i \log_{10} n_i\}$$

where N = the total number of centimeters of living coral, and

n_i = the number of centimeters belonging to each species, $i = 1, 2, \dots, s$.

b = natural log base 2.718



Screen 3.8

Table 1, continued

Computer Id	Name	Brief Definition	
gorg	gorgonian	Living:	Count only the base. Be sure to distinguish between the gorgonian <i>Rhodopoda</i> and zoanthids (next category). The chain must cross the base of the gorgonian, not just lie under a frond.
zoan	zoanthid	Living:	Zoantharia including <i>Zoanthus</i> and <i>Palythoa</i> . Be sure to distinguish between these and the gorgonian <i>Rhodopoda</i> .
anem	anemone	Living:	Sea anemones.
cora	coral	Living:	All stony corals including fire coral. The computer assigns all species of coral (designated by an upper case first letter of the genus name) to this category.
tuni	tunicate	Living:	Tunicates.
othe	other	Living:	This category includes other benthic invertebrates such as bivalves or sessile polychaetes. In practice, we did not encounter this category under our lines.

Please put data diskette in Drive A.

Enter original 6-character raw data filename,
then hit <ENTER> to continue ... t2c189

** Please do not take out diskette from Drive A
until the process is finished.

<Ctrl><Break> Exit to DOS

Screen 3.6

*** A:t2c189CS.ANA ***

A cumulative species number (S) file has been created.
The CS postscript indicates Cumulative Species. To view the numerical
results, return to the main menu and choose menu option 7. Enter the
8-character filename from the top of this screen.

To print or view graphs or statistics, load STATGRAPHICS, and import
this 8-character file.

Press <ENTER> to return to Chain Transect Analysis Menu.

Screen 3.7

Figure Legends

- Figure 1. Reef study sites in the Florida Keys. Biscayne National Park coral reef sites are Ball Buoy Reef (see Figure 3) and Triumph Reef (see Figure 4).
- Figure 2. Reef Study sites in the Upper Keys. Biscayne National Park coral reef sites are Ball Buoy Reef (see Figure 3) and Triumph Reef (see Figure 4).
- Figure 3. The Biscayne National Park Ball Buoy Reef transect area showing the positions of the five line transects and the photostation. Line transect start and stop positions (circles) and their depth (in meters) are also shown. Line transect 1 is landward behind the reef crest; line transects 2 - 4 are on the reef crest; and line transect 5 is seaward of the reef crest. Time-delay Loran positioning puts Ball Buoy at 25° 19.108' N, and 80° 11.025' W. Transects 2 - 4 were placed over the photostation to allow for a cross comparison between the line transect and photostation methods.
- Figure 4. The Biscayne National Park Triumph Reef transect area showing the positions of the five line transects and the photostation. Line transect start and stop positions (circles) and their depth (in meters) are also shown. Time-delay Loran positioning puts Triumph Reef at 25° 28.325' N, and 80° 06.715' W. Transects 6 - 8 were placed over the photostation to allow for a cross comparison between the line transect and the photostation methods.
- Figure 5. The percent cover of different substratum types (computer file designation PS) under combined line transects on Biscayne National Park coral reefs. Table 1 defines the different substratum types.
- Figure 5a. Transects 2 - 4, Ball Buoy Reef, 1989.
- Figure 5b. Transects 6 - 8, Triumph Reef, 1989.
- Figure 6. The relative abundance of each coral species (computer file designation RA) under combined line transects on Biscayne National Park coral reefs.
- Figure 6a. Transects 2 - 4, Ball Buoy Reef, 1989.
- Figure 6b. Transects 6 - 8, Triumph Reef, 1989.
- Figure 7. The cumulative number of coral species (computer file designation CS) under combined line transects on Biscayne National Park coral reefs.
- Figure 7a. Transects 2 - 4, Ball Buoy Reef, 1989.
- Figure 7b. Transects 6 - 8, Triumph Reef, 1989.
- Figure 8. The cumulative coral species diversity (H' , based on the natural log of the length, in centimeters, occupied by each species) (computer file designation CH) under combined line transects on Biscayne National Park coral reefs.
- Figure 8a. Transects 2 - 4, Ball Buoy Reef, 1989.
- Figure 8b. Transects 6 - 8, Triumph Reef, 1989.
- Figure 9. The cumulative percent of live coral cover (computer file designation CP) under combined line transects on Biscayne National Park coral reefs.
- Figure 9a. Transects 2 - 4, Ball Buoy Reef, 1989.
- Figure 9b. Transects 6 - 8, Triumph Reef, 1989.

►Explanation

This program resorts the data so that recounts of the same transect can be compared. For instance, if the first time Transect 1 was counted, one link covered Aaga, but the second time, the line move a hair and no Aaga was found, this program creates an Aaga slot in the the second count file and insert a 0.0 length. Without matching entries, two files can not be compared. Likewise if Mann were encountered first in Count 1 of Transect 1 but Apal was encountered first in Count 2, these two variables would have to be resorted to be sure that their values appeared and were summed in the same order.

The two analysis data files which you enter must be on the same transect but have different count number. Otherwise, the result will be nonsensical.

Enter analysis datafile name 1 (XXXXXXRA or XXXXXXTPS): t2c189ra
Enter analysis datafile name 2 (XXXXXXRA or XXXXXXTPS): t2c289ra

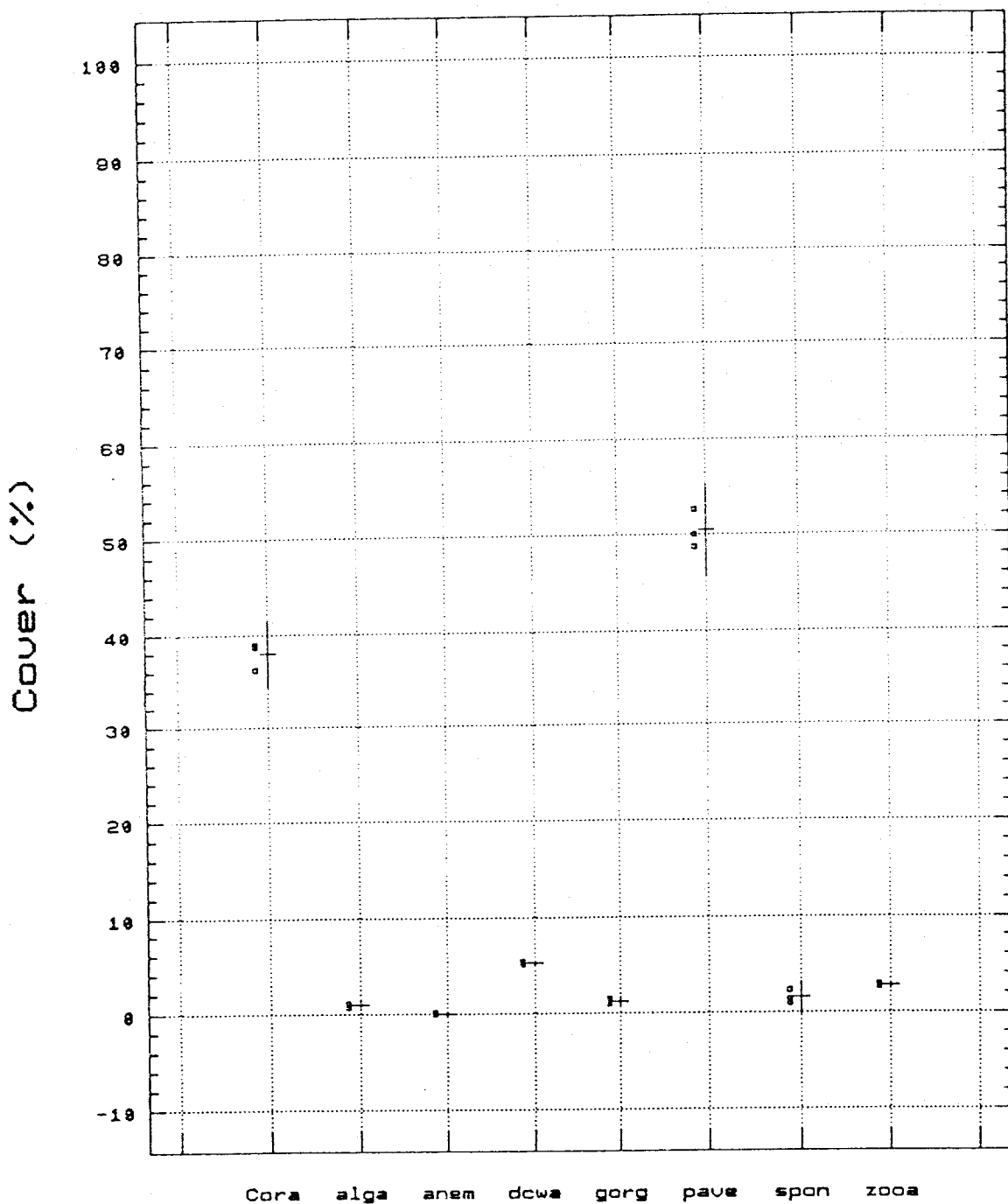
<Ctrl><Break> Exit to DOS

Screen 3.5

Option 3, Screen 3.1. Cumulative number of coral species encountered along the transect (CS).

When Option 3 is chosen, Screen 3.6 appears. This program counts up the total number of different coral species contained in the raw data file. After running the program, Screen 3.7 appears to tell you the new .ANA filename created by this analysis.

Biscayne National Park
Reef I, Trs. 2-4 Comb., 1989



Substrate Types (N = 3; 95% C.I.)

Figure 5a.

In this example, N is the number of counts and therefore is 3, and n is the number of counts to be compared at one time, and is therefore 2. Following the rule, therefore C is equal to 3. This means that Option 2 needs to be run 3 times, once for each of the three possible combinations. The order in which these are run does not influence the result. So, run T2C189PS.ANA and T2C289PS.ANA, T2C189PS.ANA and T2C389PS.ANA, and T2C289PS.ANA and T2C389PS.ANA. You will note that the new files have the same names, but are slightly larger than before. This is because the missing species and substratum types have been added, even though the newly added substrate types have only 0.0 cm in them.

►Explanation

This program resorts the data so that recounts of the same transect can be compared. For instance, if the first time Transect 1 was counted, one link covered Aaga, but the second time, the line move a hair and no Aaga was found, this program creates an Aaga slot in the the second count file and insert a 0.0 length. Without matching entries, two files can not be compared. Likewise if Mann were encountered first in Count 1 of Transect 1 but Apal was encountered first in Count 2, these two variables would have to be resorted to be sure that their values appeared and were summed in the same order.

This program will sort 2 analysis datafiles to assure that each has the same number of variables and that all variables appear in the same order. This program will also alphabetize the corals and substrate types. These modifications will help the graphic and statistical analysis.

..... hit <ENTER> to continue

Screen 3.4

Biscayne National Park
Reef II, Trs. 6-8 Comb., 1989

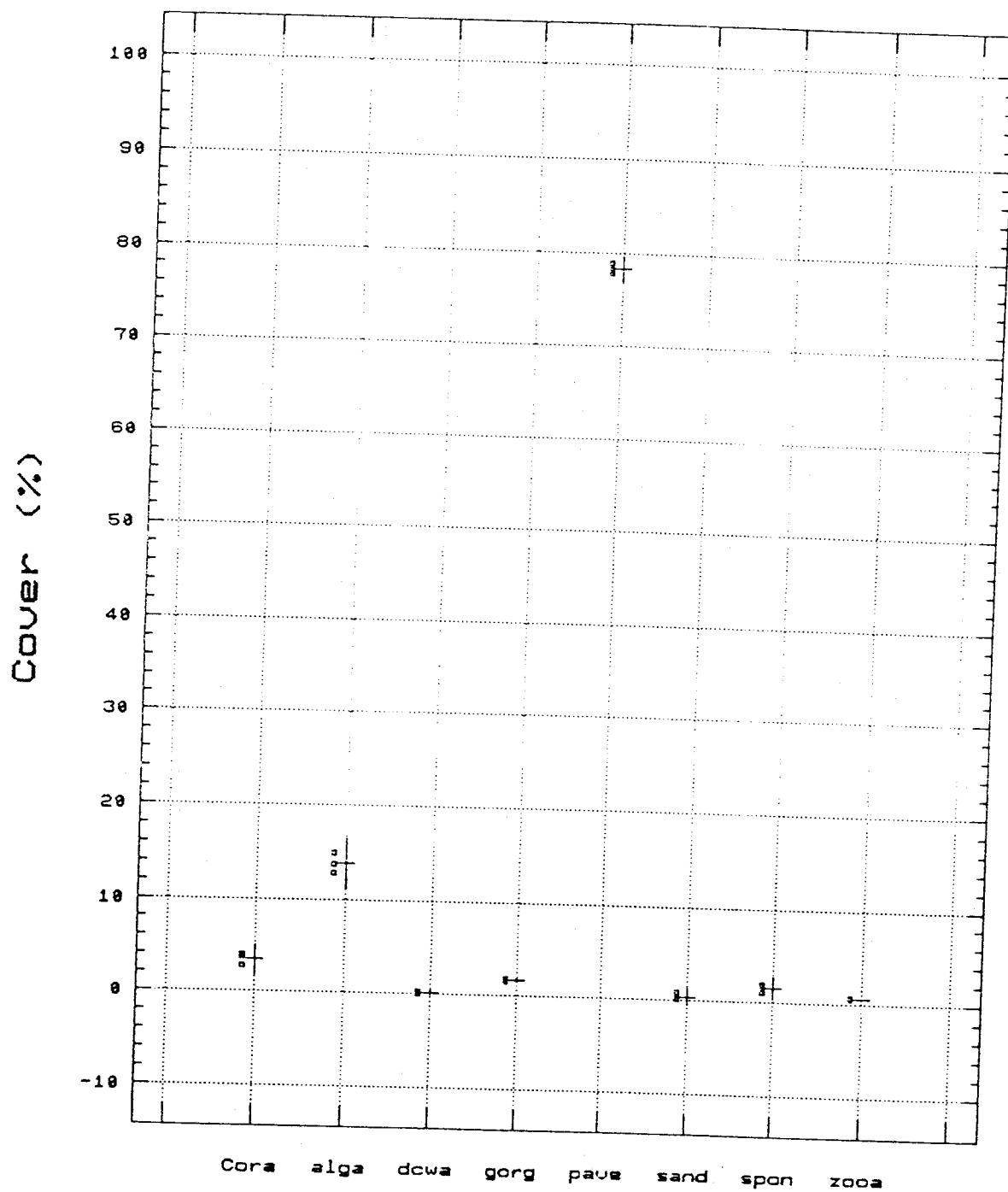


Figure 5b.

Option 2 of Screen 3.1. Sort % cover analysis data.

This option does not create new files, but is necessary to allow the user to statistically analyze or graph data contained in .ANA files. The problem is solved by this analysis is that all files which are going to be compared statistically or graphed on the same axes must have the same variables. While this may sound straightforward, in practice it is not. For instance, a small colony of Aaga might be counted on the first count, but not on the second count because the line had moved a bit. This situation happens frequently with rare corals and uncommon substrates. This program solves the "absentee" data problem by "adding" Aaga to the second transect and assigning a 0.0 cm value as its "length" in the second count.

Another common problem is that while Aaga may appear first on the first count, Apal may appear first on the second count of the same transect line. By alphabetizing the entries, this program assures that the graphics and statistical packages will plot and compute values from the same variables from each count. Aaga values from count one will be compared to Aaga values from count two, regardless of the order in which Aaga appeared in the original data entry.

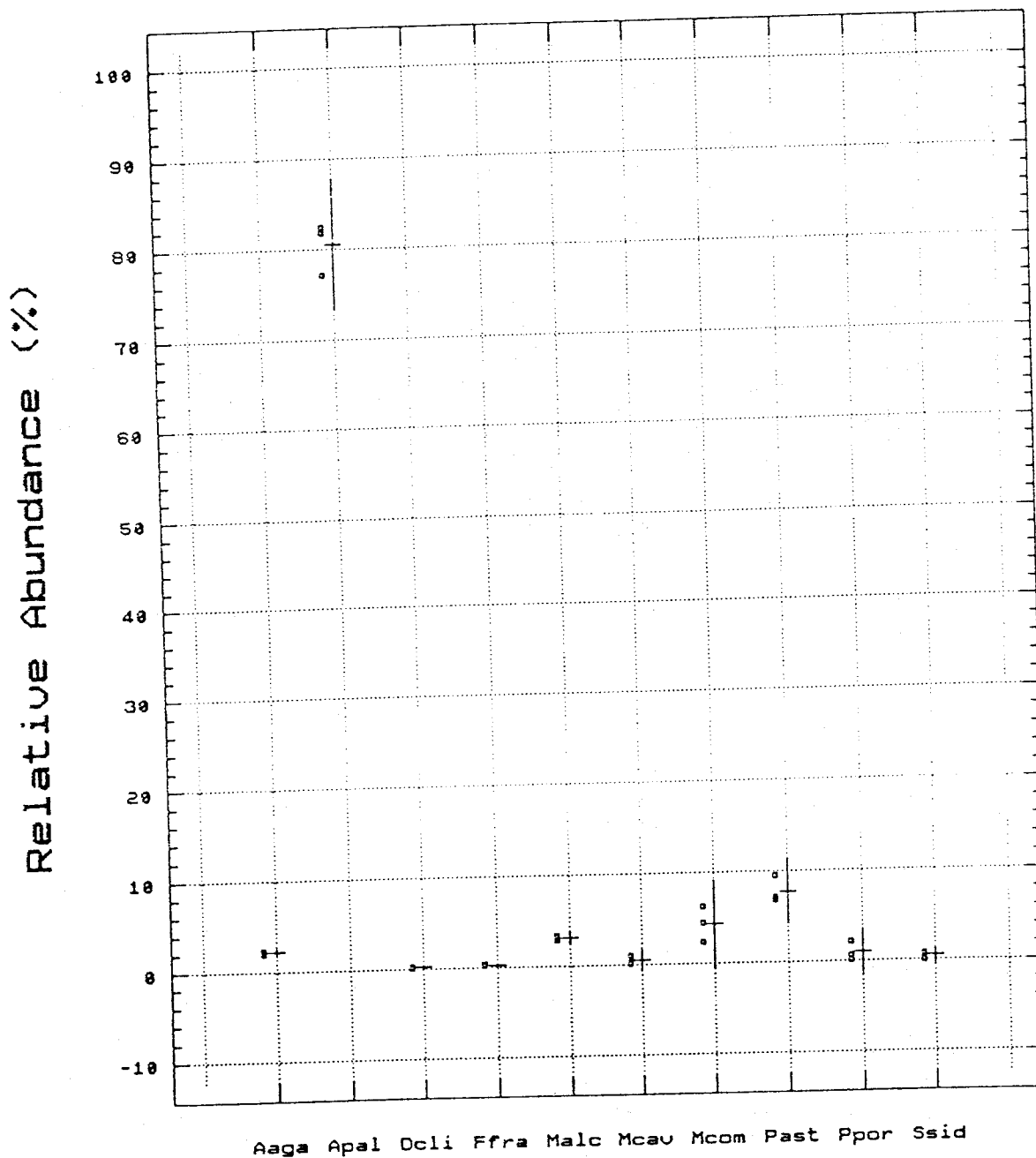
Choose Option 2 from Screen 3.1 only after all the transect data have been entered. When the user chooses Option 2, Screens 3.4 and 3.5 appear. Read the explanation first! The program will entirely rewrite the .ANA file that you enter. It will not delete data, but it will add data in the form of coral species and substrates, and the appropriate 0.0 cm lengths, that were missing from any recount of the same line.

The following example explains how this task is to be accomplished on multiple recounts of the same transect. For example, we count the same transect three times. The appropriate file names given to the recounts at the time of data analysis are: **T2C189PS.ANA**, **T2C289PS.ANA**, and **T2C389PS.ANA**. For purposes of discussion, let us assume that one very rare coral showed up only in the first count of transect 2 (T2C1), and that another rare coral appeared only in recount number 2 of transect 2 (T2C2). These three files can not, without modification, be compared: if we try, the statistical analysis program will give an error message [variable or group number differs] between these three files. To avoid this kind of problem, we need to run Option 2 of Screen 3.1. The number of times that we need to run this option to assure that all recounts have a parallel presentation of all groups is determined by the Combination Rule:

$$c \binom{N}{n} = \frac{N!}{n! (N-n)!}$$

where N = Number of counts
 n = Number of counts to be compared at one time
 c = the combination symbol

Biscayne National Park
Reef I, Trs. 2-4 Comb., 1989



Coral Species (N = 3; 95% C.I.)

Figure 6a.

```
*** A:t2c189PS.ANA ***  
*** A:t2c189RA.ANA ***
```

Percent substrate type and coral species relative abundance files have been created.

The PS indicates on the original data filename indicates Percent Substrate; the RA indicates the relative abundance of different coral species. To view the numerical results, return to the main menu, choose menu option 7, and enter the 8-character filename from the top of this screen.

To print or view graphs or statistics, load STATGRAPHICS, and import this 8-character filename.

Press <ENTER> to back to Chain Transect Analysis Menu.

Screen 3.3

As can be seen on Screen 3.3, Option 1 actually creates two different analysis files. **TxCxyyPS.ANA** calculates Percent cover of different Substrate types. All different substrate types listed in the original data entry file are included. Although corals are identified to species, for the purposes of this particular substrate analysis, they are all lumped under the substrate type "cora." Any raw data entry with an upper case first letter is lumped in this analysis as "cora." Abundances are based on the number of chain links covered by each substrate type.

TxCxyyRA.ANA computes the Relative Abundance of each coral species. This file will include the abundance of any coral species listed in the data entry file. As above, the computer recognizes which entries of the raw data are coral versus other kinds of substrate by the fact that all coral species entries have the first letter capitalized.

Biscayne National Park
Reef II, Trs. 6-8 Comb., 1989

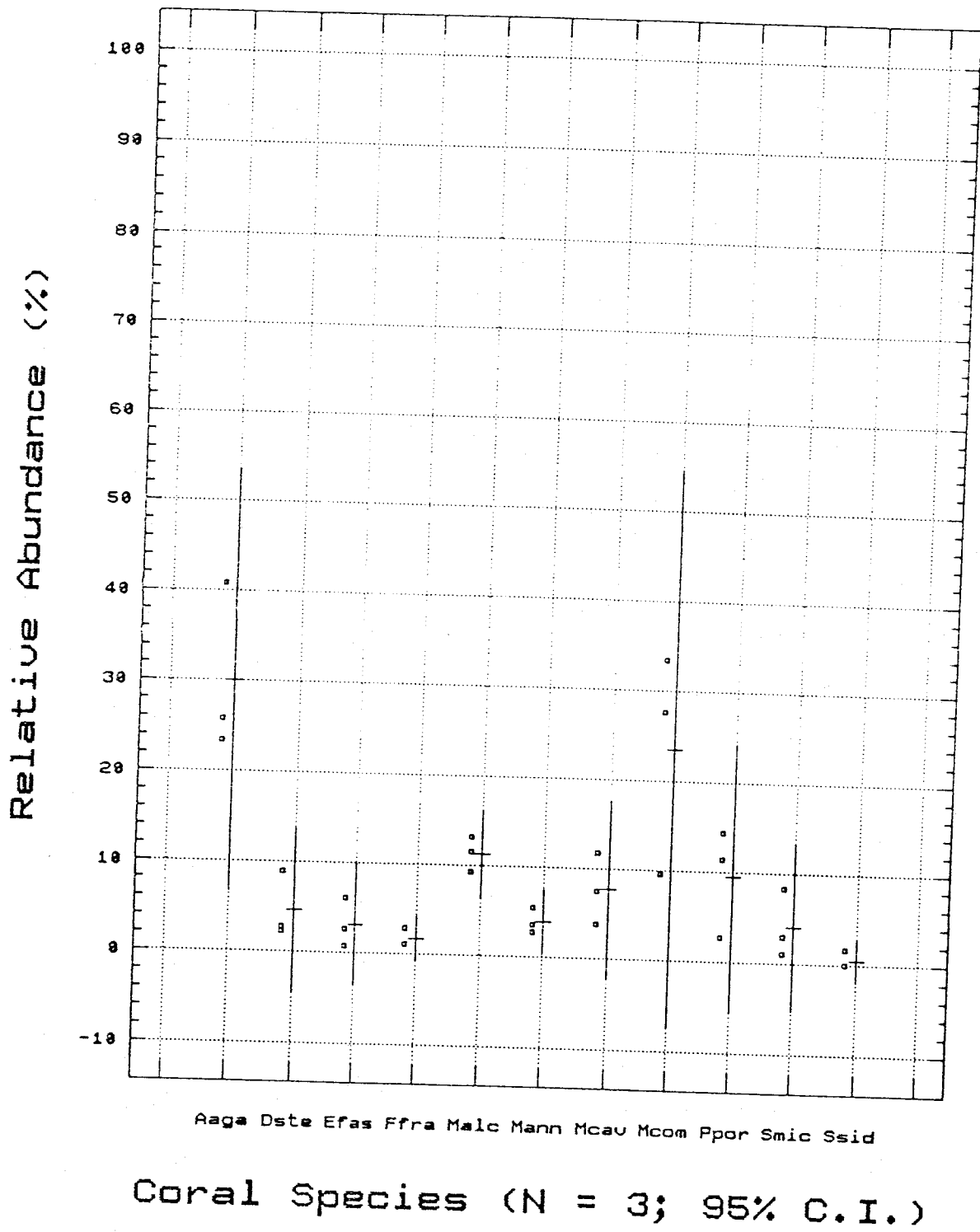


Figure 6b.

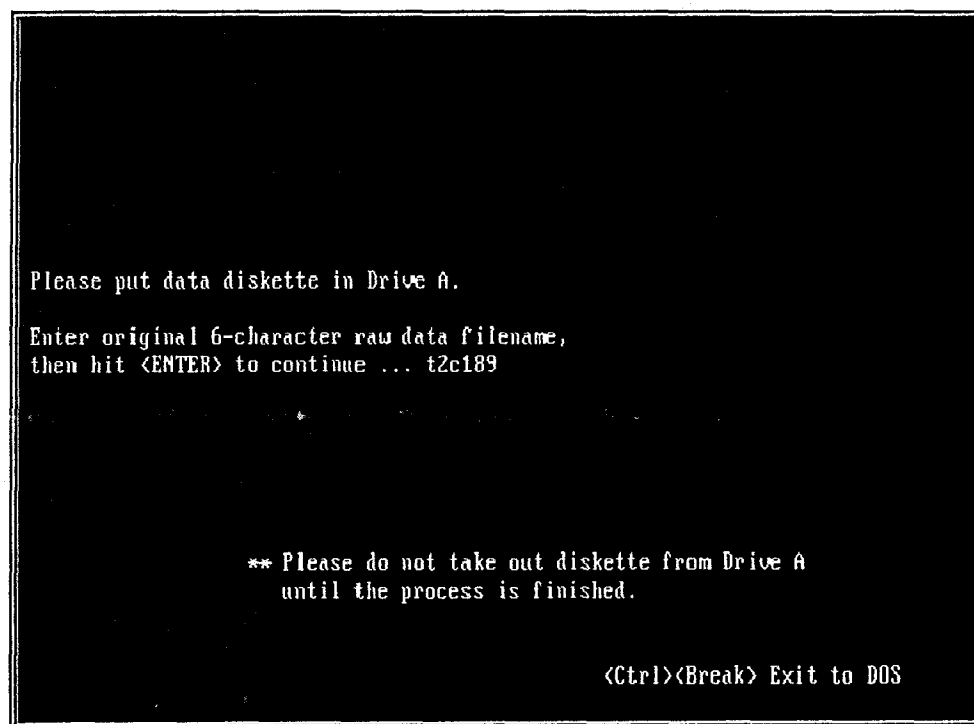
If you have chosen to rearrange several transects by stringing them together, **R** rather than **T** will begin the file name.

Option 1 of Screen 3.1. Percent cover analyses:

The % cover of different substrate types.

The relative abundance of different coral species.

When you choose this option, Screen 3.2 will appear. After you enter the raw data file name, without any extension, the program creates two new files on Drive A called: **TxCxyyPS.ANA** and **TxCxyyRA.ANA**. Note that the first six characters are the same as the raw data file name, and that two additional letters have been added to the end of this name to designate what kind of analyses were done to the data. Finally the extension **.ANA** is added to these analysis files. Screen 3.3 will now appear, giving you the names of the new Percent Substrate and Relative Abundance analysis files just created.



Screen 3.2

Biscayne National Park
Reef I, Trs. 2-4 Comb., 1989

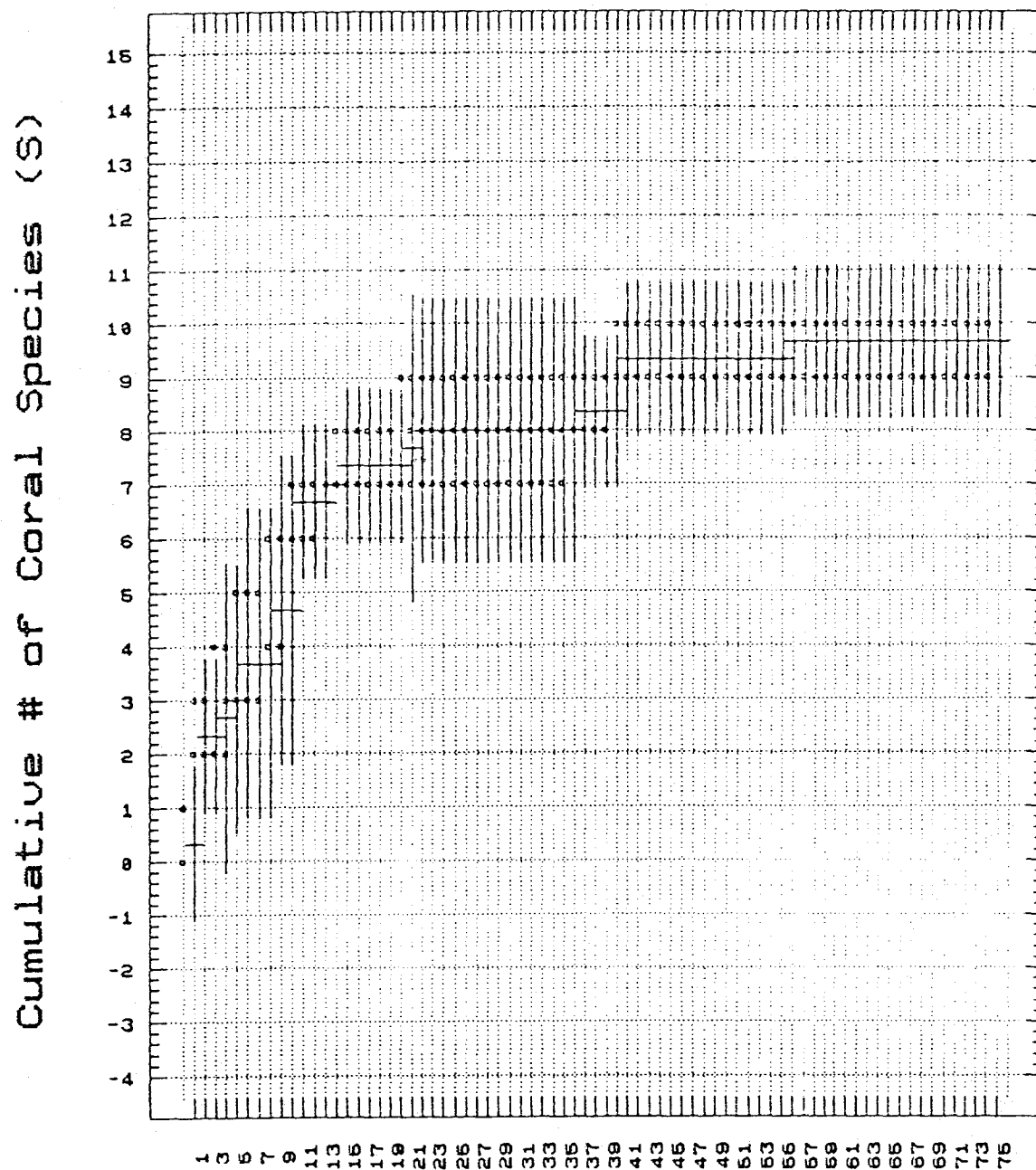
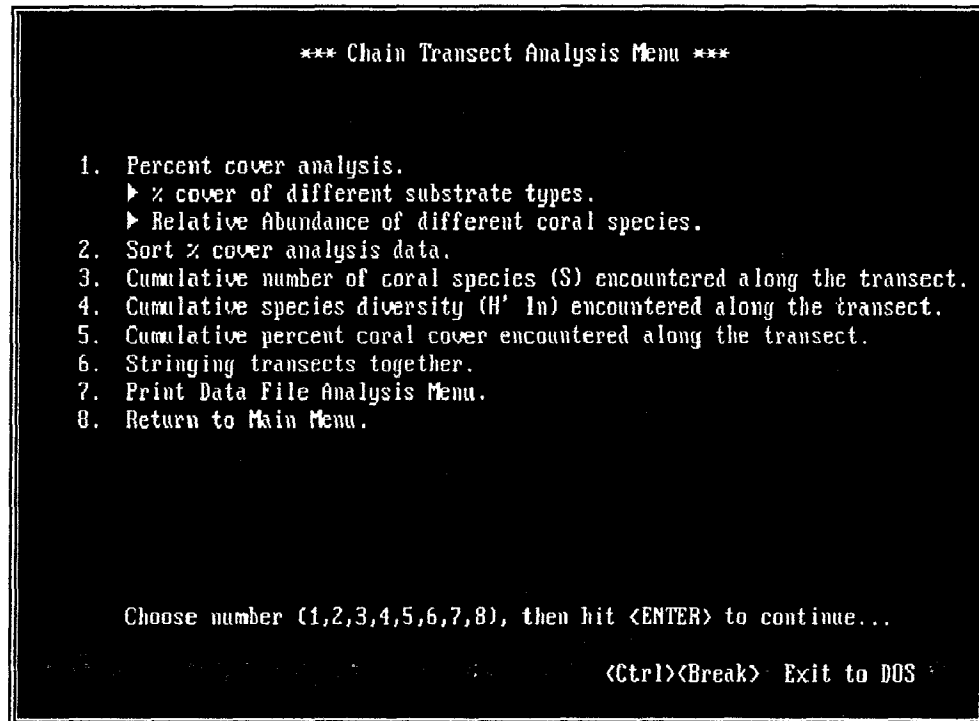


Figure 7a.

Option 3

Chain Transect Data Analysis Program

When you choose Option 3 from the Main Menu Screen 0.1, the main chain transect analysis menu (Screen 3.1) appears.



Screen 3.1

This program calculates: (1) the Percent cover of different Substrate types, (2) the Relative Abundance of different coral species, (3) the Cumulative number of coral Species encountered along the transect, (4) the Cumulative species diversity (H' natural log of the length, in centimeters, of each species) encountered along the transect, and (5) the Cumulative Percent of live coral cover.

The chain transect analysis program also allows you to string raw data files together to make longer, "continuous," transects. For instance, it will combine any three different 25 m transects into one 75 m transect (or five 20 m transects into one 100 m line). Reanalysis of this rearranged raw data may improve the forecasting ability of the data.

Regardless of which option you run, the analyzed data will be stored on Drive A of your working diskette with new filenames like **TxCxyyPS.ANA**, **TxCxyyRA.ANA**, **TxCxyyCS.ANA**, **TxCxyyCH.ANA** or **TxCxyyCP.ANA**.

Biscayne National Park
Reef II, Trs. 6-8 Comb., 1989

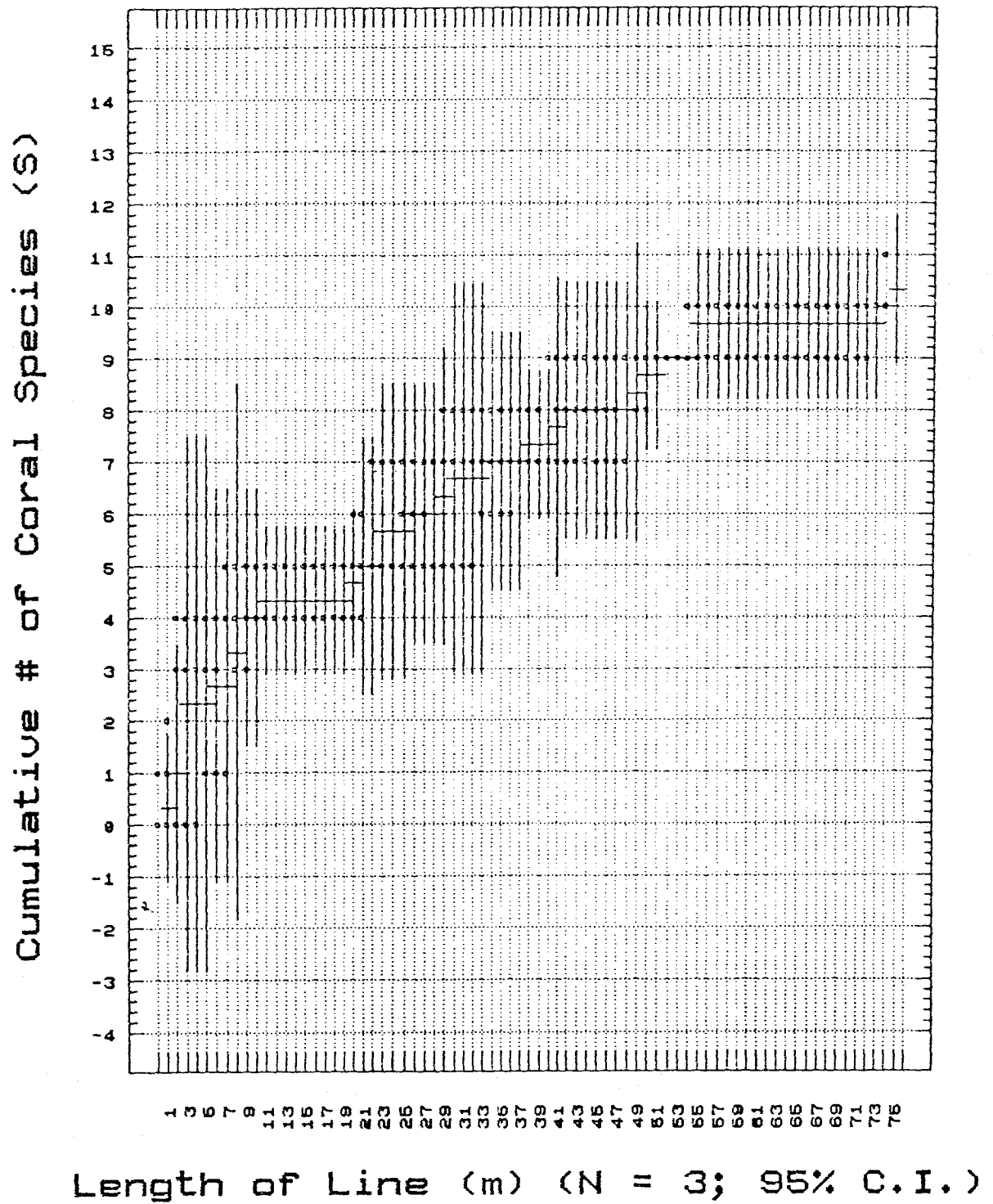
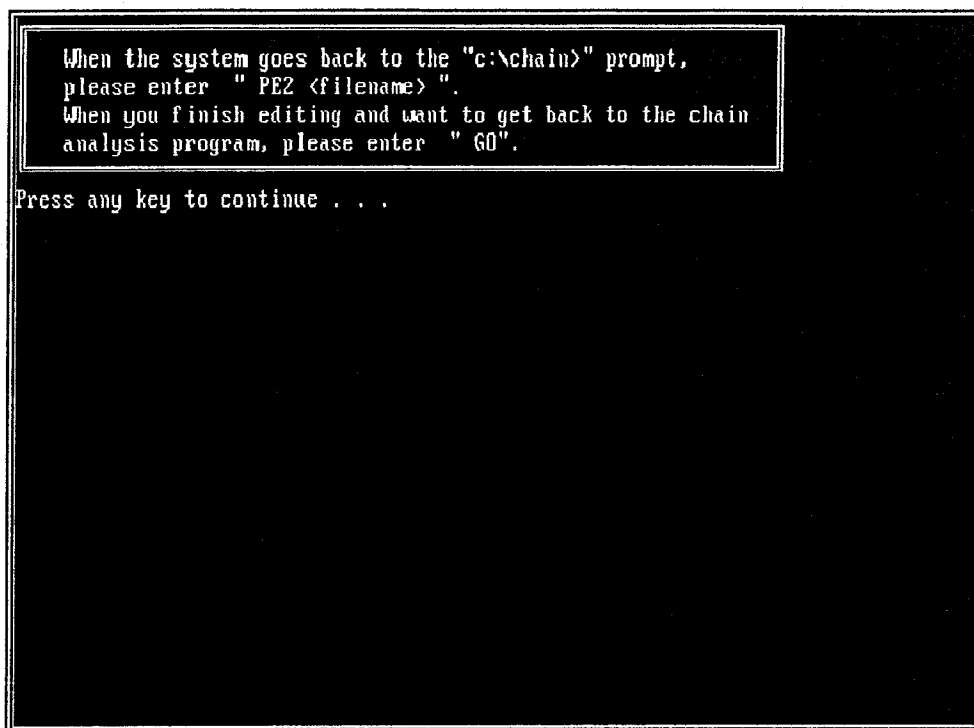
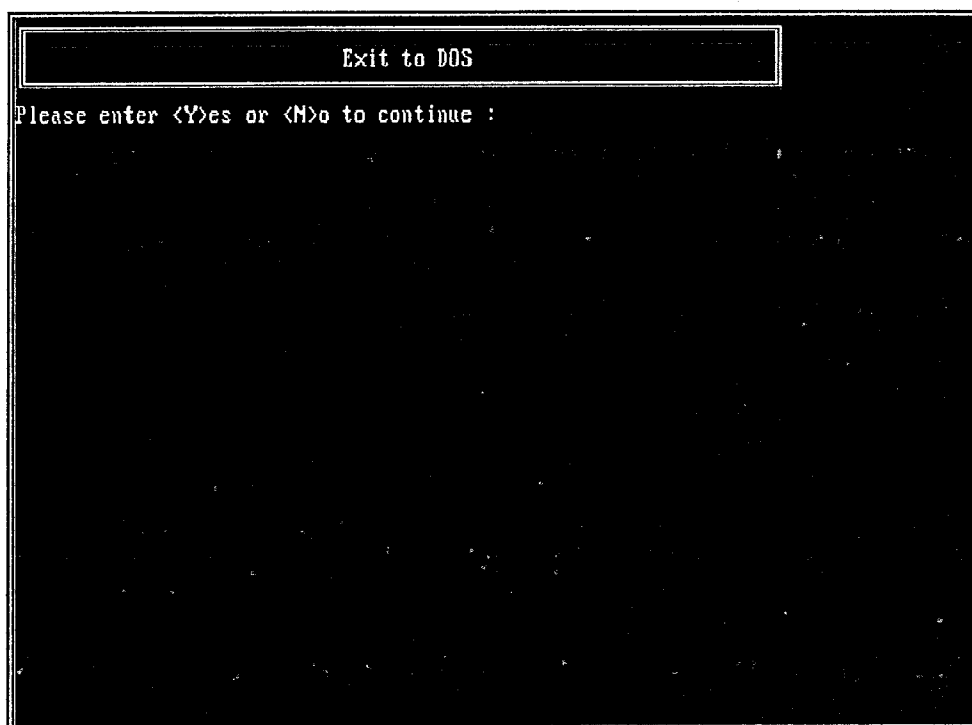


Figure 7b.



Screen 2.3



Screen 2.4

Biscayne National Park
Reef I, Trs. 2-4 Comb., 1989

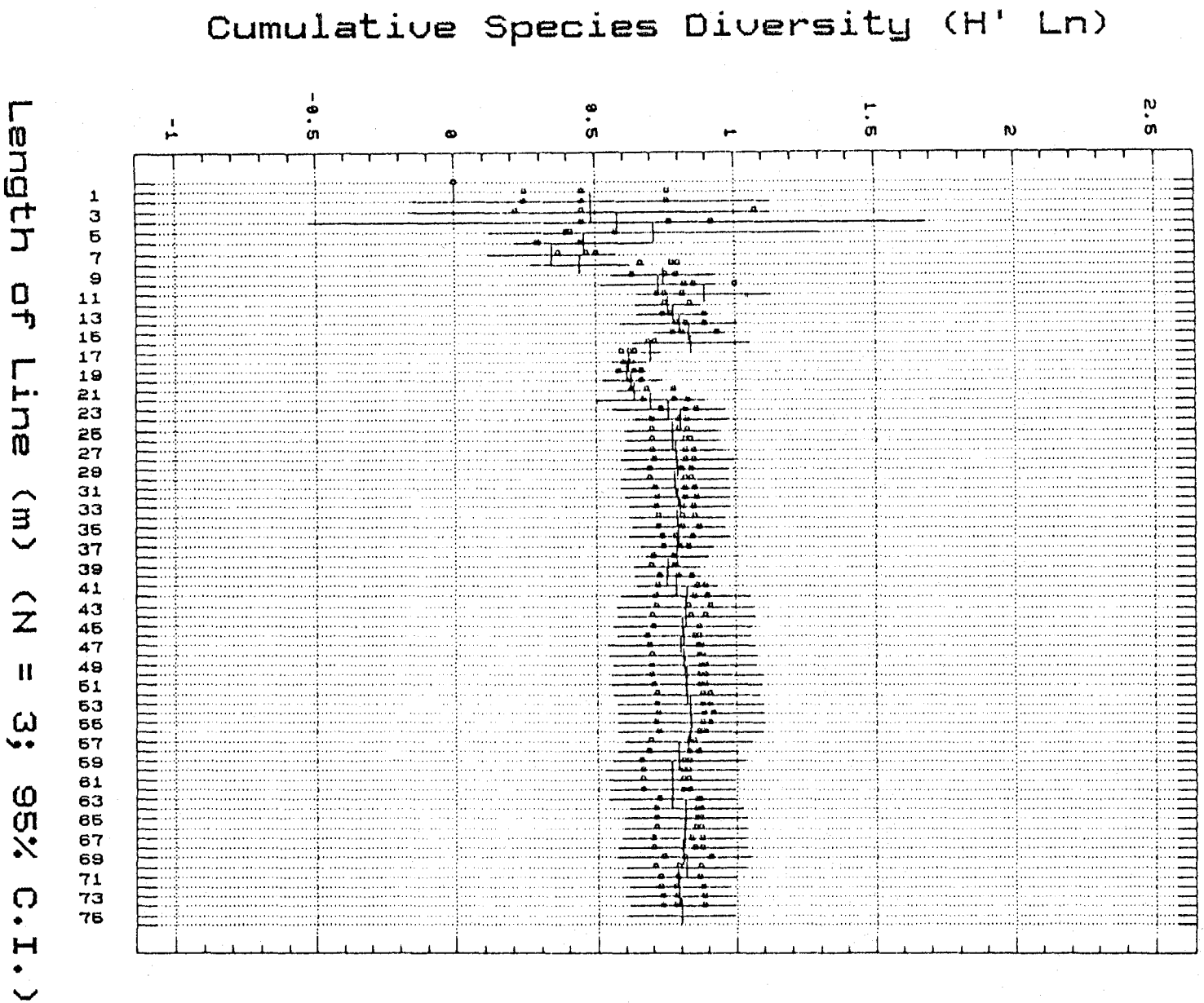


Figure 8a.

programs can not translate code symbols, such as [TAB].

Editing/Correcting an existing data file?

Please enter <Y>es or <N>o to continue :

Screen 2.2

Biscayne National Park
Reef II, Trs. 6-8 Comb., 1989

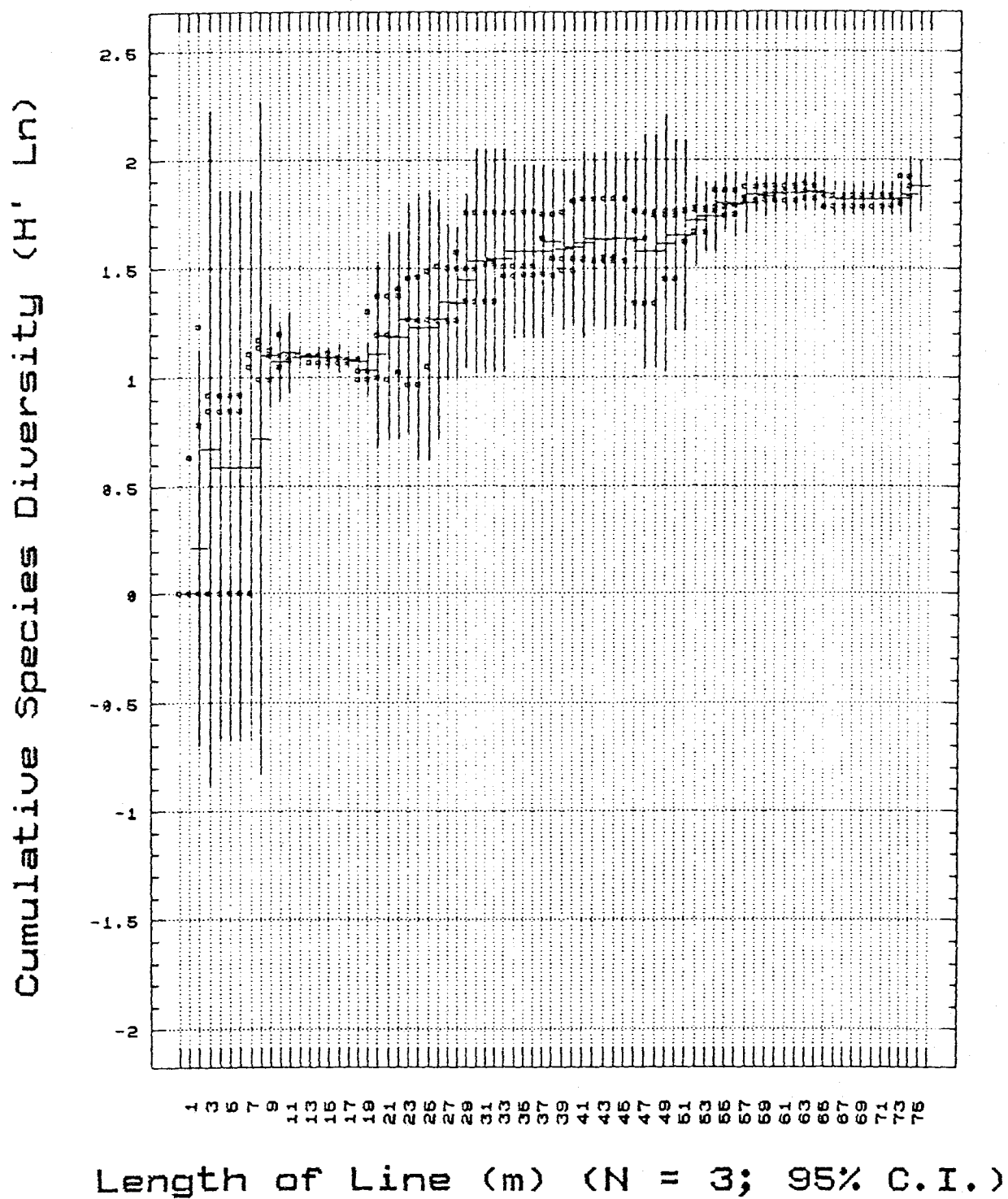


Figure 8b.

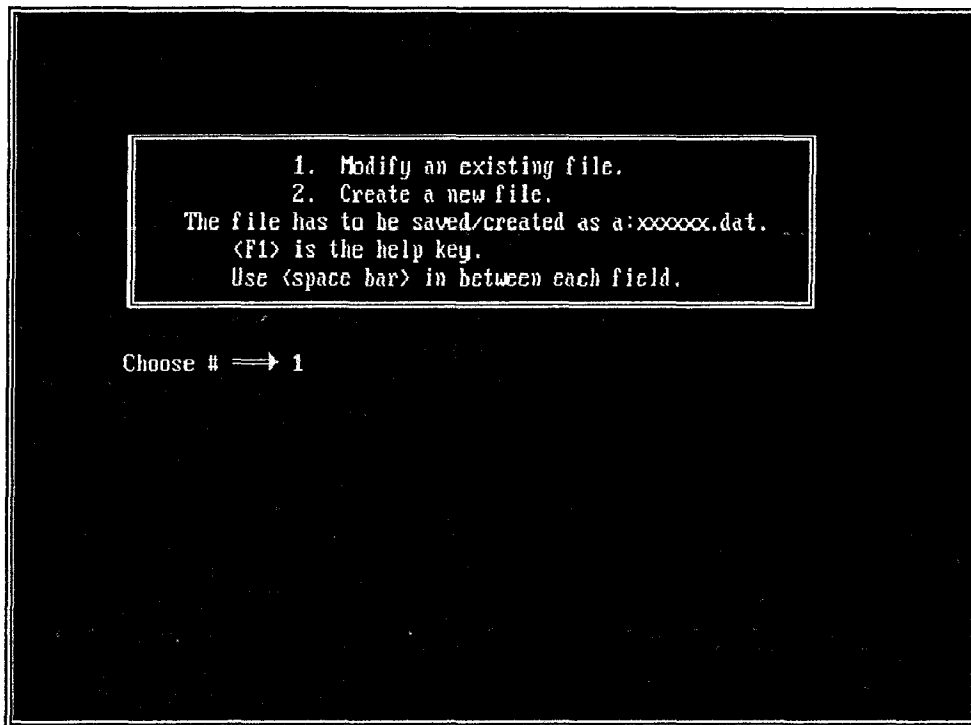
Option 2

Free Formatted Data Entry Program

With Screen 0.1 on the Main Menu, choose Option 2, the Free Format Data Entry Program.

This program is the IBM Personal Editor II software package. When you choose this option, Screen 2.1 appears. The user can either choose to create a new file, or edit an existing file. If Option 1 is chosen, PE2 will appear immediately. If Option 2 is chosen, Screen 2.2 appears. This screen confirms that you want to edit an existing file. After Screen 2.2, Screen 2.3 and Screen 2.4 appear and explain how to key in proper commands to access an existing file. Then, the system exits to DOS to allow you to execute the appropriate commands.

Hit the **Esc** key to begin the Editor. Remember to put at least one space between each field, and put only one record on each line. Follow the same definition as in Option 1 to create the filename. If you have any questions about PE2, hit the **F1** key to get help. You can also print a hardcopy of the PE2.HLP file.



Screen 2.1

If the user prefers some other editor program, use it instead. Any editor should be able to accomplish these tasks. Use only standard ASCII letters and numbers. Our analysis

Biscayne National Park
Reef I, Trs. 2-4 Comb., 1989

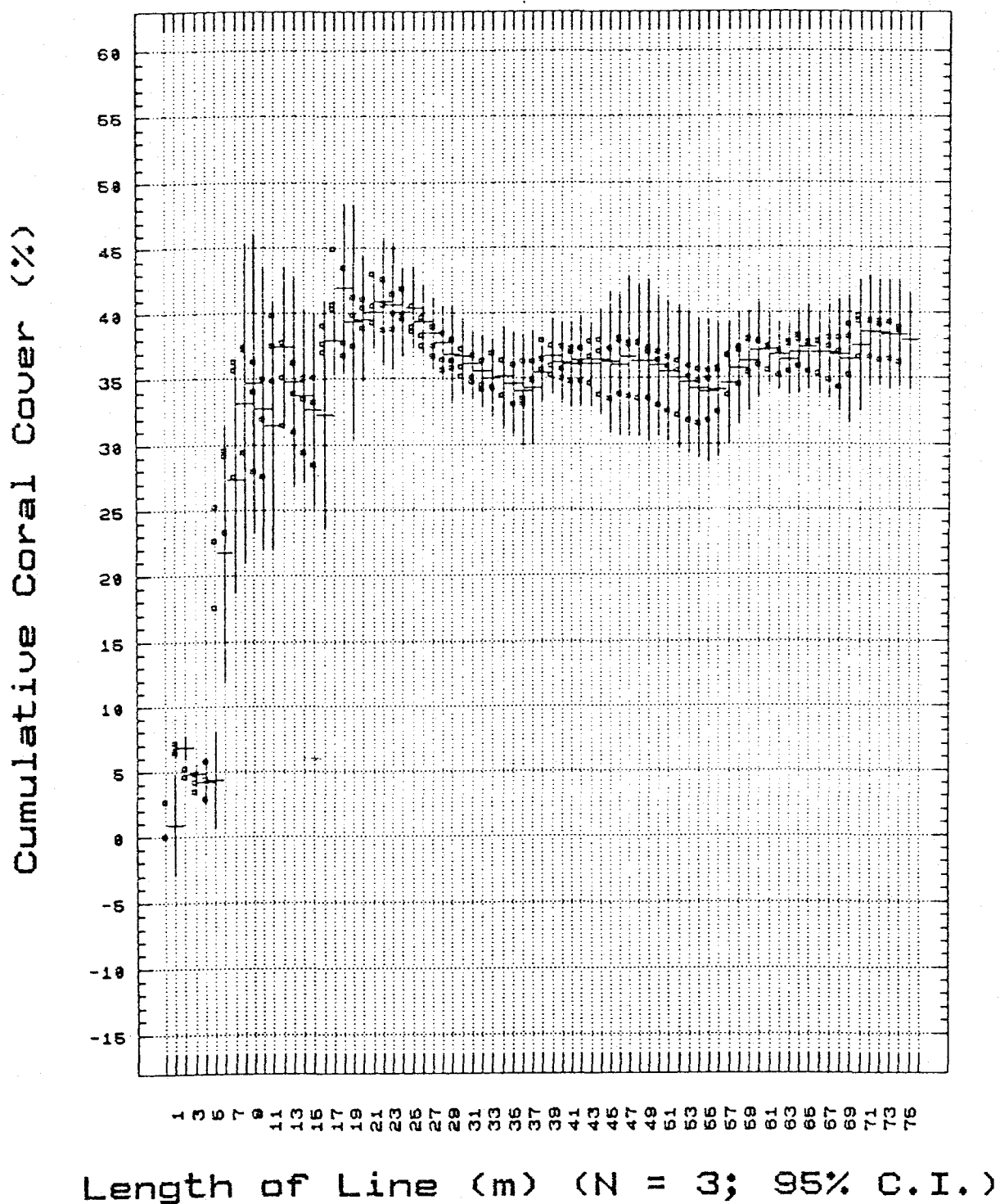


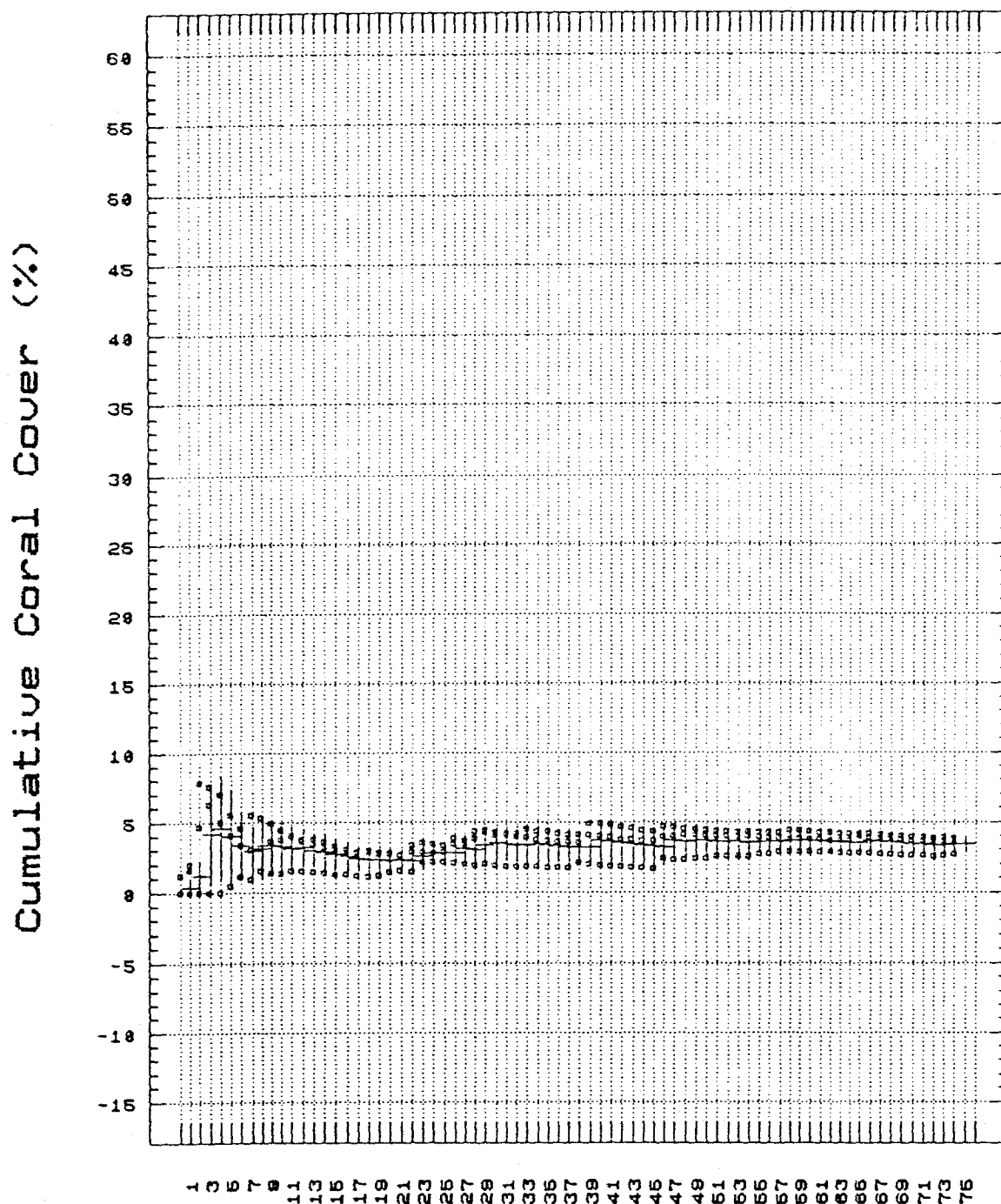
Figure 9a.

1	1	3 gorg
1	4	5 pave
1	6	6 gorg
1	7	10 Aaga

hit <ENTER> to continue

Screen 1.7

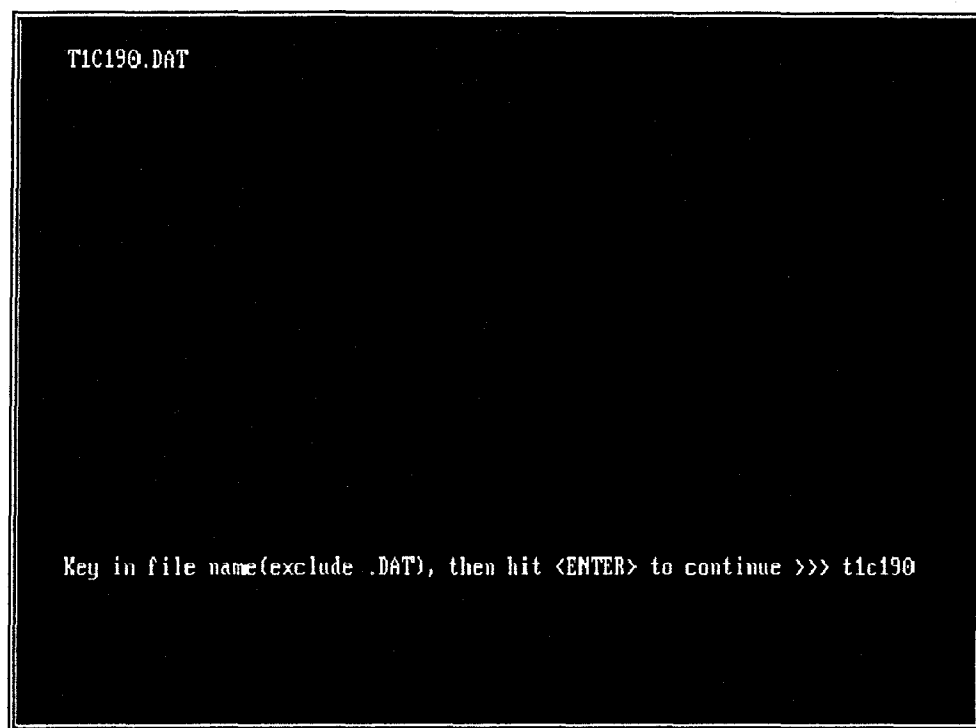
Biscayne National Park
Reef II, Trs. 6-8 Comb., 1989



Length of Line (m) (N = 3; 95% C.I.)

Figure 9b.

the name of the file you want and press <enter>.



Screen 1.6

METHODS FOR THE ANALYSIS OF CORAL REEF COMMUNITY STRUCTURE

I. CHAIN TRANSECT

B. SOFTWARE ANALYSIS

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```

                                DATA ENTRY

                                0 - 0

Meter # (Integer between 1-25) :      1

Link # (Integer between 1-400): Start  1
                                Stop   10

Occupancy(*) :                      Aaga

* Coral : Uppercase 1st letter, lowercase next 3 letters
Non-coral : All 4 letters lowercase

Do you want to correct data on this record?(Y/N) y

-- <F1> exit to Data Entry Menu

```

Screen 1.5

Press the **F1** key when the cursor is on the meter number to request to stop data entry. The user can continue to add to the end of this data set later by choosing Option 2 from Screen 1.3.

Option 2 from Screen 1.2 can be used to add data to the end of an existing file, but it cannot be used to correct mistakes in a preexisting file. You must choose Option 2 - Free format editor from the main menu (Screen 0.1) to correct previously stored files.

If you choose Option 2 from Screen 1.2 to add data to an existing file, the screen that appears looks identical to Screen 1.4, except that, in the upper right hand corner, the screen displays the meter number where you left off. All meter number entries must be values **greater than or equal to** the meter number already entered. All link number entries must be **greater than** the previous **stop** link value. If you attempt to enter a lower number, the computer will beep.

From Screen 1.1, the user may wish to view the contents of a file. Option 2, "Display a data file on the screen", will achieve this goal. Any data file extant on disc A will show on the screen when this option is requested. Just enter the name of the file to be displayed (Screen 1.6) and see the data displayed (Screen 1.7).

The final Option from Screen 1.1 is Option 3, "Print an existing data file". This option will let you get a hardcopy of any data file resident on the floppy disc in Drive A. Just type in

Introduction

Line transects are the commonest ecological survey method. Using the field methods described in the previous section (Part I A), one can characterize coral reef community structure under a line. If the line is counted several times, the statistical accuracy of the survey can be calculated. If the permanently marked line is recounted at a later time, then changes in community structure can be determined by comparison with previous surveys. Multiple counts of each line are absolutely required to establish counting variance. Without multiple counts, no statistical comparison with future counts is possible.

This manual describes our computer software package used to analyze line transect data. Data entry and data analysis are easy. The program is written in Turbo Pascal Version 5.0. It is assumed that your computer has at least the following configuration:

- (1) One C: hard drive (5 meg is sufficient)
- (2) One A: floppy disc drive
- (3) 64K RAM

To install this program, put the Program Disc in Drive A, go to the A>, and type **INSTALL <Enter>**. This command will copy the program onto the hard disc (C: drive) under the subdirectory titled **CHAIN**.

The program is flexible. While all the examples in this manual are from transects on coral reefs, any line transect data could be used. The program is predicated on the belief that (1) the lines will be counted several times during each field session for statistical treatment of the data and (2) the line will be recounted at some time in the future.

At each point in the manual, we present examples of the output from our own work to illustrate and clarify how the program functions. This software is intended to help enter the raw data, calculate basic community parameters, rearrange the calculated data, and simplify statistical analysis and graphic output.

The community parameters computed are as follows. They are illustrated by Biscayne National Park data in the designated figure.

- (1) the percent cover of different substratum types under the line (Figure 5).
- (2) the relative abundance of each coral species (Figure 6).
- (3) the cumulative number of coral species (Figure 7)
- (4) the cumulative coral species diversity (H' natural log, based on the length, in centimeters, occupied by each species) (Figure 8).
- (5) the cumulative percent of live coral cover under the line (Figure 9).

Additional information can be obtained from the line transect data that are not analyzed



in this program. Examples include: the ratio of the total length of chain counted under the line to the length of reef transected and the pattern of substratum ownership along the line.

There are six different options embedded in this program. The user can access each option easily. A brief overview of this software is as follows. Table 1, at the end of this section, lists different data formats.

Call up the **CHAIN** directory, and type **GO**. Screen 0.1 will appear on the monitor. The user can choose any one of these six options. Options 1 and 2 assist in data entry. Option 1 allows you to enter data in response to a user-friendly screen menu (i.e., screen formatted data entry) and Option 2 allows you to create or modify a raw data table (i.e., free formatted data entry). Actually, data entry can be accomplished by direct entry into an ASCII file using any number of commercially available software editing packages. Option 1, however, is the easiest way to enter data from field note books described in Part I A of this manual.

Option 1 (screen formatted data entry program) automatically files raw data in a data file that you will label based on prompting from the menu. The typical file name will be constructed as follows. This labelling scheme is very important and should not be modified. The file name should be: **TxCxyy.DAT**, where **Tx** is the transect number such, as Transect 1 (**T1**); **Cx** is the replicate count number, such as the first count of Transect 1 (**C1**); and **yy** is the year of the survey, such as **91**. Based upon your answers to the screen menu questions (follow Screen 1.3 to see suggested file names) you will create a unique file for each count of each transect, for example **T1C191.DAT**). The **.DAT** is automatically added indicates raw data. Note that this data file name has six characters plus the **.DAT** extension.

Option 2 (free formatted data entry program) is a commercial software package (IBM's Personal Editor 2). If the user is not familiar with this editor, any other editing software package can be used to enter raw data. The data file has to be saved as an ASCII file and named following the labeling rules described in the last paragraph.

Note that if links 1 - 19, for instance, are involved in a vertical fall between the polypropylene line and the seafloor below, the first link number entered for meter # 1 would be 20. After entering the start and stop link numbers for a substratum, name the type of substratum using the four letter name from Table 1 in Part I A. Add data in ascending numerical order for all meters and all links.

```

DATA ENTRY

Meter # (Integer between 1-25) :      1
Link # (Integer between 1-400): Start 1
                                Stop 10
Occupancy(*) :                      0000

* Coral : Uppercase 1st letter, lowercase next 3 letters
Non-coral : All 4 letters lowercase

-- <F1> exit to Data Entry Menu

```

20

Chain Transect Program

=====

1. Data Entry Program.
2. Data Entry/Editor Program (Free Format).
3. Data Analysis Program.
4. Transect Combination Program.
(For STATGRAF Conf. Interval use)
5. Chain Link Size Program.
(The default is a link of 1.37 cm)
6. Exit to DOS.

Enter # to execute the program.

Choose # → 1

Screen 0.1

<Ctrl><Break> Exit to DOS

Option 3 is the principle line transect analysis program. It calculates the five community parameters listed above from the data you have keyed in. It utilizes the unique file name assigned during data entry for each transect, and adds a two-letter analysis descriptor to the file name to make an eight character file name indicative of the kind of analysis performed. The analyses performed and the descriptor added are as follows:

- (1) the Percent cover of different Substrate types (designated **PS**, Percent Substrate).
- (2) the Relative Abundance of each coral species (designated **RA**, Relative Abundance in percent for each coral species).
- (3) the Cumulative number of coral Species (designated **CS**, Cumulative Species).
- (4) the Cumulative coral species diversity, H' (designated **CH**, Cumulative H').
- (5) the Cumulative Percent of live coral cover (designated **CP**, Cumulative Percent).

The data files will be created as either (1) the Percent of each Substrate type, **TxCxyyPS.ANA**, (2) the Relative Abundance of each coral species as a percent totaling 100%, **TxCxyyRA.ANA**, (3) the Cumulative number of coral Species, **TxCxyyCS.ANA**, (4) the Cumulative coral species H' diversity, **TxCxyyCH.ANA**, and (5) the Cumulative Percent of coral cover, **TxCxyyCP.ANA**, . These files are in ASCII format and can be accessed by appropriate statistical or graphics packages. Note that the lower case x in these file names, is either the transect number or count number that you have assigned. If you have more than 9 transects or more than nine recounts of the same transect, you might prefer to use a letter.

Note that the program names these analysis files automatically from your data file. Also note that the file name now has eight characters in its name, plus the extension **.ANA**. In this labelling scheme, C designates a cumulative value.

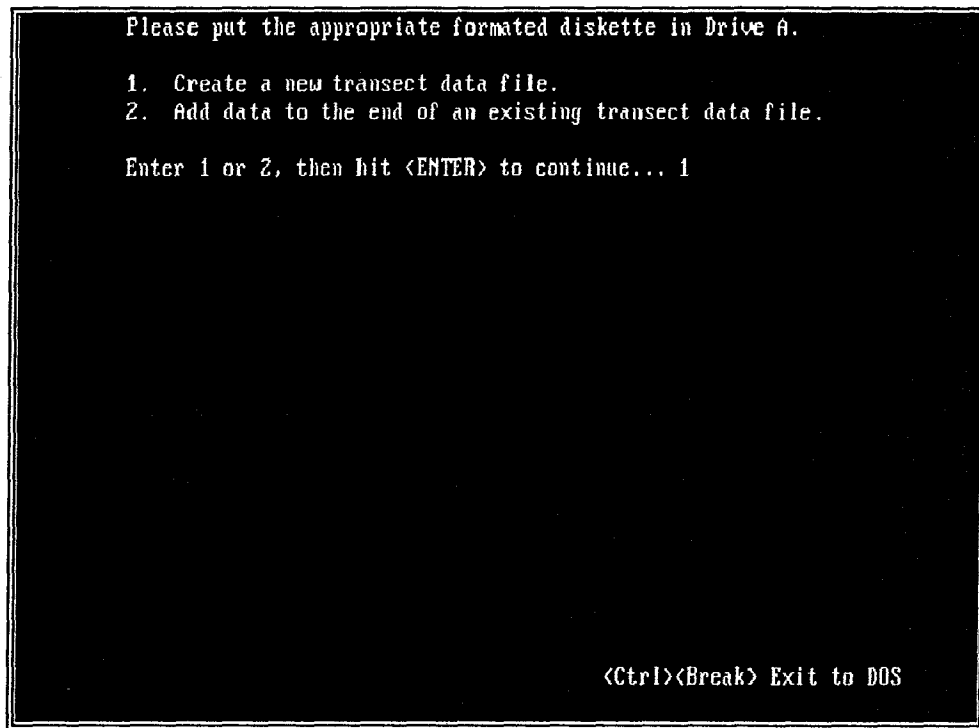
Option 4 - averages replicate counts of the same transect line (Tx). It is a tool program used for statistical analysis of replicate counts of the same transect. Once files are combined, one can calculate the mean, standard deviation, or any other statistical property for any of the five community parameters listed above. The individual count analysis files will be converted to a new single file, named: **TxCTyyPS.ANA**, **TxCTyyRA.ANA**, **TxCTyyCS.ANA**, **TxCTyyCH.ANA** and **TxCTyyCP.ANA**. This new filename translates as Transect x, Count Total of the now combined replicate counts of Transect x for the designated year yy.

Species diversity indices are difficult to treat statistically (Pielou, 1966). We use the mean, however, simply as a reflection of replicate counts of the same transect.

Option 5 - Lets you set the size of the chain link. The default value for our work is 1.37 cm.

Option 6 - exits to DOS.

The software system is flexible. It can handle data sets with different numbers of substrate types, transect lengths, and number of species encountered under the line. There are,



Screen 1.2

If you choose option 1, then Screen 1.3 appears. Insert a formatted diskette into Drive A. The user now needs to enter the data file name. We suggest you follow the rules printed on the screen assign a new file name to your transect data. If you attempt to assign a pre-existing filename found on the disc you inserted in the A: drive, the system will give you an error message, and give you instructions (described below) on what to do next.

however, limits to these "array" sizes. These limits are as follows:

- (1) The number of substrate types can not exceed 20
- (2) The number of coral species can not exceed 40
- (3) The length of each individual transect line can not exceed 99 m. There is no limit to the number of transects that can be combined, but each individual transect is limited to 99 m.
- (4) The number of chain links under each meter is limited to 999.

If the user needs to change these arrays, please pull out the proper Pascal source code for this system, modify the value, and recompile the program.

If more than one survey is conducted in a single year, our labeling system will have to be modified. Substituting the first letter of the month for one number of the year, *i.e.* **TxCxMy** would solve this problem. Remember, different files can not have the same name.

Pielou, E.C. 1966. Shannon's formula as a measure of specific diversity: its use and misuse. Amer. Natur. 100: 463-465.

Option 1

Screen Formatted Data Entry Program

When you type 1 <enter> at the Main Menu (Screen 0.1), the Data Entry Menu (Screen 1.1) appears on the monitor.

```
*** Data Entry Menu ***

1. Entry of chain transect data.
   ▶Screen will show how to set up a datafile name.
   ▶Screen will explain each data entry field. If, however, you
     want to modify an existing data file, you will have to use
     Option 2 on the Main Menu, a free format editor, to change
     your data.

2. Display an existing data file on the screen.

3. Print an existing data file.

4. Return to Main Menu

Choose number (1,2,3,4), then hit <enter> to continue... 1

<Ctrl><Break> Exit to DOS
```

Screen 1.1

This is the user-friendly data entry menu. There are four options on this sub-menu. If you want to create a new transect data file or continue entering data to the end of an existing data file, choose Option 1 <Enter> and Screen 1.2 appears. On Screen 1.2, the user can choose 1 - Create a new transect data file, or 2 - Add to an existing data file.