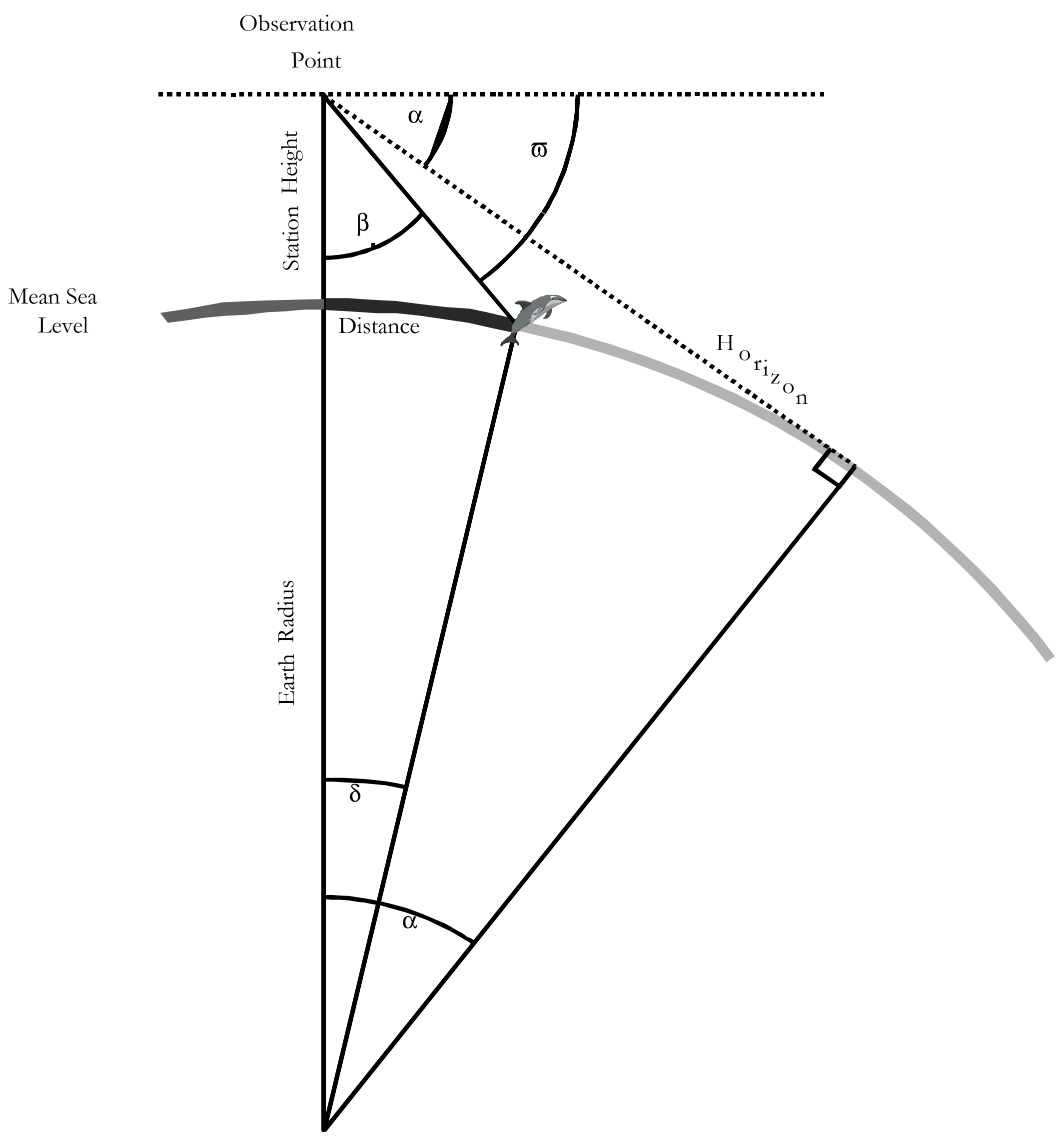
PYTHAGORAS

Theodolite Cetacean Tracking



MARINE MAMMAL RESEARCH PROGRAM

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Introduction

A theodolite is a surveyor's instrument which, when placed on an elevated shore-based vantage point, can be successfully used as a research tool to obtain data on cetacean movement, behavior, distribution, and habitat use. These data are collected in a non-invasive manner, as described by Würsig *et al*. (1991). Both cetaceans and other objects, for instance boats, can be tracked, and interactions between them can be continually monitored. Theodolites allow researchers to determine "fixed" positions by measuring horizontal angles from some arbitrary reference azimuth and vertical angles relative to a gravity-referenced level vector. Although this technique has been used for more than 20 years, and despite the increase in digital theodolite use for cetacean studies, relatively few computer-based theodolite programs exist to assist researchers in collecting, managing, and analyzing theodolite data. A computer-based system benefits theodolite-based studies in many ways. Vertical and horizontal angles to an object can be recorded accurately and efficiently. Real-time calculations of distance and location can be performed, and trackline(s) can be visually displayed, allowing for rapid corrections of possible tracking errors. Once data are collected, a computer-based system reduces time to manage and analyze data.

Pythagoras allows researchers to customize the program interface according to their particular necessities. The user can define the fix type (e.g. dolphins, whales, boats), the behavior associated with the fix, and other data such as group size, species, environmental conditions, etc.

The position of the fixed object is estimated automatically by *Pythagoras* every time a "fix" is entered. The estimated position and all data associated with that fix (fix type, behavior, distance to the station, environmental conditions, species, group size, etc.) are recorded into a Microsoft Access database file. The database can be exported into Microsoft Access, Microsoft Excel, Text (ASCII), or comma delimited files.

Pythagoras can graphically represent the area around your station if the appropriate GIS information is provided. The location of the fixed object is plotted in real-time, allowing the observer to rapidly check data as they are being collected. Analysis modules are included to provide further trackline information by calculating distance, course, linearity, reorientation rate, and leg speed of each track.

Chapter

1

Main Menu

File

- Prints, saves, or opens data

Program

- Start tracking program
- Collect focal behavior data

View

- View and edit existing data for selected station
- Graphically display trackline information

Analysis

- Leg speed, linearity, and reorientation rate
- Trackline distance estimator
- Frequency, occurrence, and intervals of behavioral events

Setup

- Setup parameters for your Station, Theodolite, Options, and various wizards to help you setup parameters for the program and your station.

Help

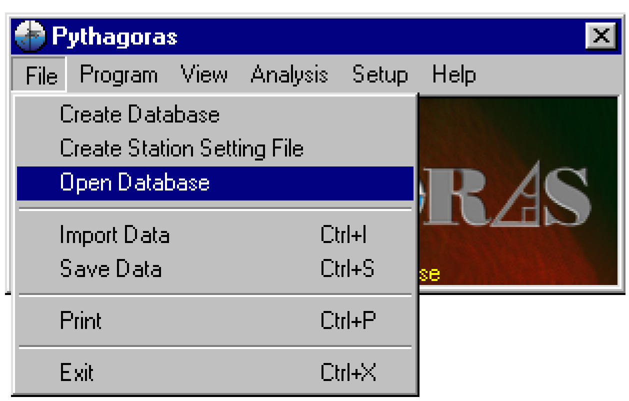
- Information to help you understand more about *Pythagoras*

Pythagoras' Database

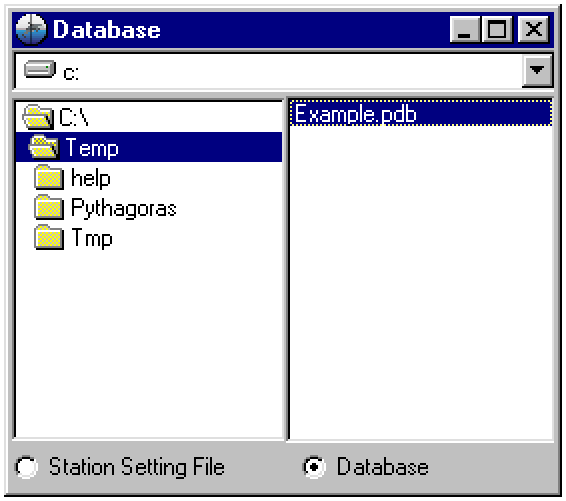
Pythagoras utilizes Microsoft Access for storing information pertaining to your station, preferences, fix data, environmental data, non-fix data, focal behavior data, and the other data specified in your station preferences. The database is continually updated; therefore if your computer "crashes", your data should be saved. All relevant data can be exported into various file formats (Chapter 5).

Pythagoras maintains two separate databases: 1) Station Settings File (contains parameters, variables, and options related to each station) and 2) Database (contains all tracking and behavioral data registered).

Opening Pythagoras*' Database* - Database and Station Settings files of *Pythagoras* contain the extension PDB (*Pythagoras* DataBase) and SDB (Station DataBase), respectively. To open an existing *Pythagoras* database, go to file\open database from the main menu.

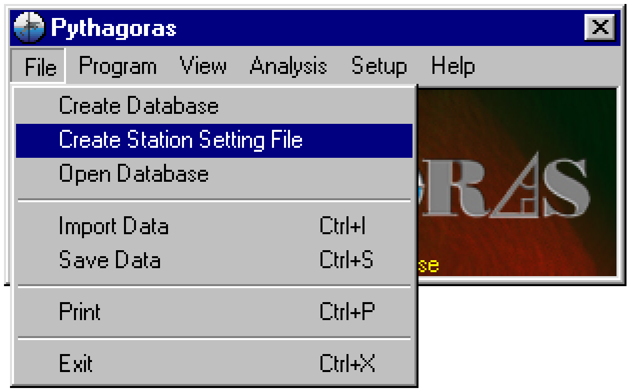


Once at the database open window, simply locate your database file. The top portion of the window contains the current drive, while the left hand portion contains folder information. Once you select the drive and folder containing the database file, your database will be displayed on the right hand portion of the screen. You must also specify the type of database (i.e. Station settings file or Database file).

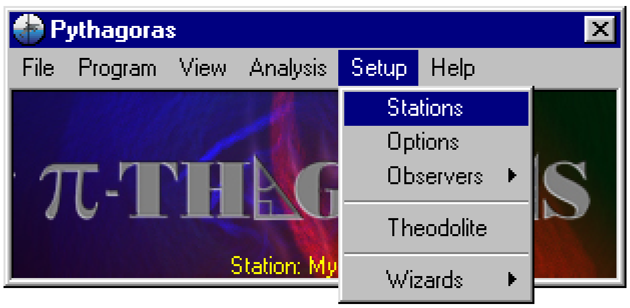


If you do not see your database file, make sure you are looking in the correct directory and the file contains the extension PDB or SDB. Once you select the file, double-click on the file to open the database file as a station settings or database file. *Pythagoras* will then prompt you if you would like the selected file to be your default database or station settings file.

Creating Pythagoras' Database - To create a new Station Settings File or a new Database, select create a database or station settings file from the main menu. Once selected, the program will prompt the user for the location they would like to store the database. The program will then proceed in creating the database and ask the user if they would like the newly created database to be their default database.



Station Setup



The station is the observation site where the researcher sets up the theodolite. For *Pythagoras*, the station is represented by a set of parameters that characterize the observation site and differentiate it from other stations. The parameters of at least one station must be entered for the program to work, but the user can define up to 11 different stations. Once a station has been defined, *Pythagoras* stores all the parameters in the Station Settings Database; therefore, unless you want to define a new fix type or behavior category, only eye height and environmental conditions need to be updated.

The parameters needed to set up a station are:

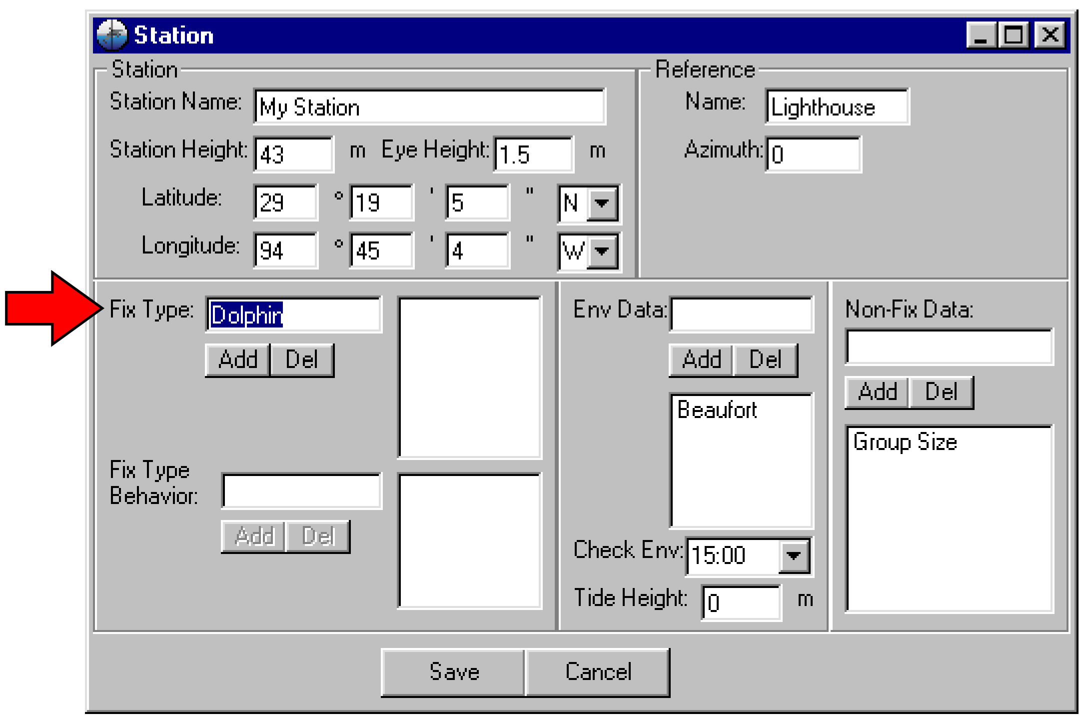
Station Parameter	Description	Example
Station Name	A unique textual and/or numeric identifier to that station.	“My Station”
Station Height	The exact height from the mean sea level to the platform or site where you set up your theodolite.	48.23 m
Eye Height	The height from the theodolite platform to the eyepiece of your theodolite. This distance will most likely change every time you set up your theodolite at the station and must be updated accordingly.	1.23 m
Latitude & Longitude	The geographic position of your theodolite station.	29°45’04.3’’ N
Reference Name	A textual/numerical name of the reference point for your station. This helps the researcher remember the point that was used as a reference.	“Lighthouse”
Reference Azimuth	The angle (degrees) between the geographic north bearing from your station and the line formed by the bearing from your station to the specified reference point. This angle allows reference from bearings taken from the station to geographic north.	79.88
Fix Type	The object(s) you attend on fixing.	“Dolphins”
Fix Type Behaviors	Associated behavior(s) for each fix type.	“Traveling”
Non-Fix Types	Data not associated with the fix itself.	“Group Size”
Environmental Conditions	Environmental variables determined by the user.	“Beaufort”
Environmental Check Interval	Time interval at which the program reminds the user to record environmental conditions.	01:00

Defining Fix Types - *Pythagoras* determines a fix every time the observer electronically or manually records the horizontal and vertical angles from the theodolite. The program then performs calculations to estimate the position for each fix. The angles from the theodolite can be entered manually, by writing theodolite readings into a notebook for their later input into *Pythagoras*; or automatically, by connecting a digital theodolite to a computer and executing the command (clicking the "Fix" button or shortcut key – Chapter 2) to save the data.

Every record of theodolite angles must be assigned to the object being fixed, which is referred in *Pythagoras* as the Fix Type. For this reason, you must assign a name to each type of object being fixed. This can be done by giving a textual description to each fix type, such as "dolphin", "whale", or "boat". The researcher thereby creates a customized list of fix types. This list is uniquely configured for each station.

To create your list of fix types, go to the station setup window. Then, in the Fix Type text box, write the type of objects that you will be tracking and click Add.

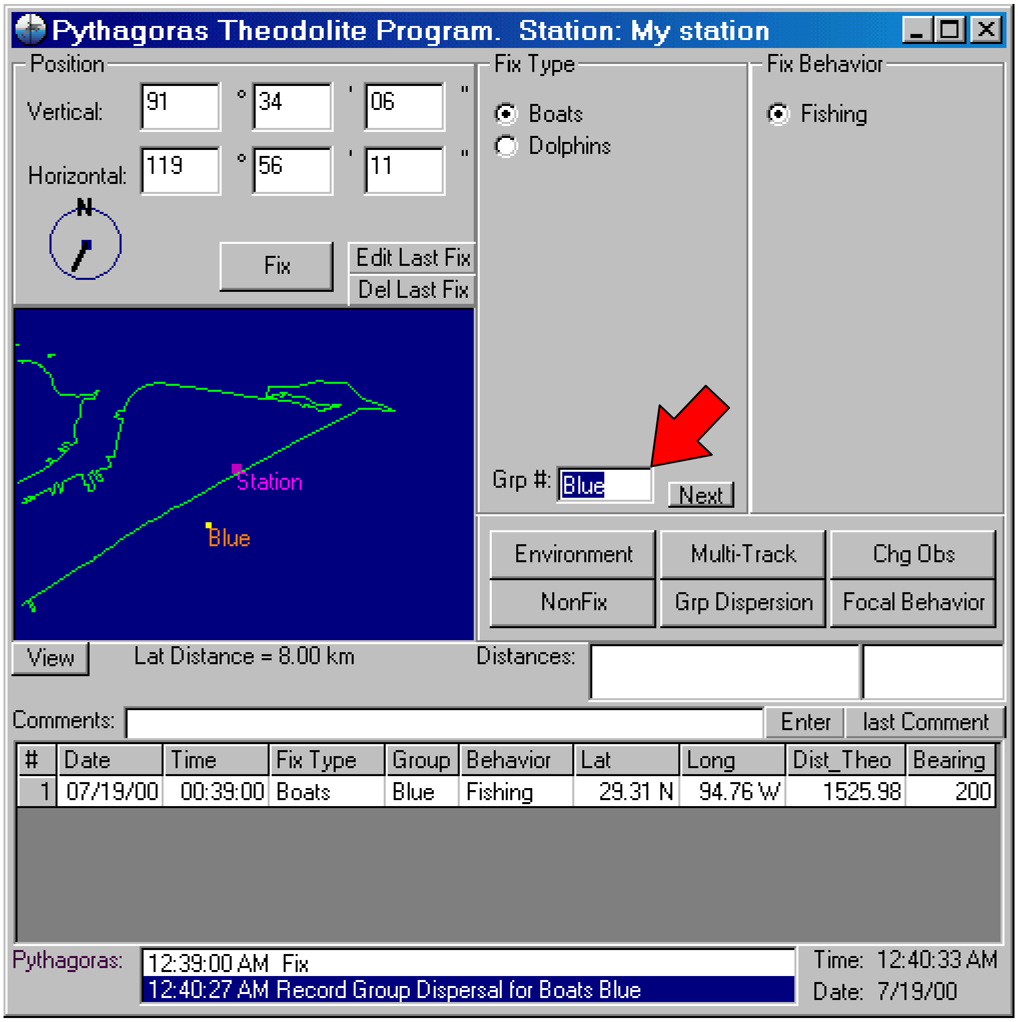
In the following example, the user is adding the "Dolphin" fix type:



A fix type must be selected to start tracking any object. If no fix type is selected before clicking the "Fix" button, an error message will be displayed.

Usually the researcher will track the same fix type multiple times during each session. This makes it necessary to separate the different objects of the same fix type for each session (e.g. the different whales tracked that day). The researcher may want to assign a different number to each object being fixed (e.g. whale1, whale2, etc.). *Pythagoras* offers an option for automatic increase in the numerical value assigned to each consecutive fix type. To activate this option go to the options window and check the "Auto Increment Group Number" option:

Alternatively, the user can assign a particular number, word, or combination of both to each fix type (e.g. “boat blue”, where “boat” is the fix type and “blue” is the identifier). In this case the user must specify the group identifier in the tracking window:

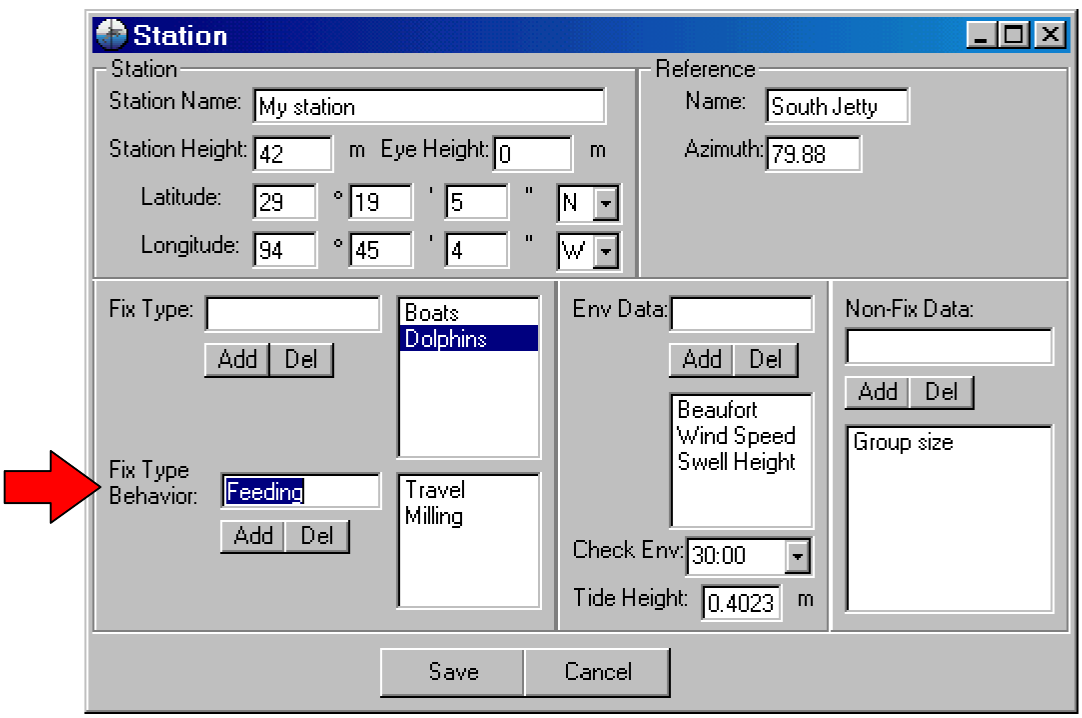


The researcher may also define the associated behaviors for each fix type. The associated behavior, as well as the date, time, theodolite reading, and position are entered together as a row in the database for every fix that the researcher makes. Ancillary non-fix data (i.e. group size, species, etc.) can be defined by the researcher and saved with the corresponding fix.

Defining Behaviors Associated with Fix Types - Many of the studies that use theodolites for tracking cetaceans involve ethological observations. The researcher may want to record the behavior of the animals being tracked and record that information with the position of each fix. *Pythagoras* allows the researcher to include up to eleven different behavioral categories associated with each fix type. The user may create a list of possible behavioral categories for each fix type.

The associated behavioral categories are defined in the station setup, after fix types have been determined. To enter a behavioral category, go to the station setup window and select the fix type for which you want to enter the associated behavior. Then, write the category in the "Fix Type Behavior" text box and click on the "Add" button.

In this example, the "Feeding" behavioral category is being added to the list for the "Dolphin" fix type for "My station":



The list of behavioral categories will be displayed in the tracking window when the user selects the fix type.

A behavioral category does not necessarily have to be selected when tracking cetaceans or ships. If no category is selected in the “Fix Behavior” menu when the fix button is clicked, the “Behavior” field in the database will be empty.

Although the “Fix Behavior” option is available for all the fix types, some objects being fixed, such as boats, will not display behavior. However, this option may be useful to researchers because it allows them to enter information about the fixed object that, although is not precisely behavior, may be of particular interest. For example, the researcher can enter categories such as “fishing”, “trawling”, “stopped”, “swimmers enter water”, etc., and link this information to the spatial and temporal location of the boat or object being fixed.

Defining Non-Fix Type Data - The researcher can define non-fix variables (data not related to the position of the fix type) to be recorded. Some examples of non-fix data are species, group size, number of calves, number of adults, etc.

The data for non-fix variables are usually entered only once for each object being tracked. For this reason, the "Non-fix" window does not need to be on the screen permanently, and it is not automatically displayed when the tracking window is open. The user must click the "Non-fix" button (or press Ctrl + n) in the tracking window to open the non-fixed variables window. After clicking the "Non-fix" button, a window with the list of non-fix variables that were defined by the user are displayed along with text boxes for the user to enter the corresponding text or numerical value.

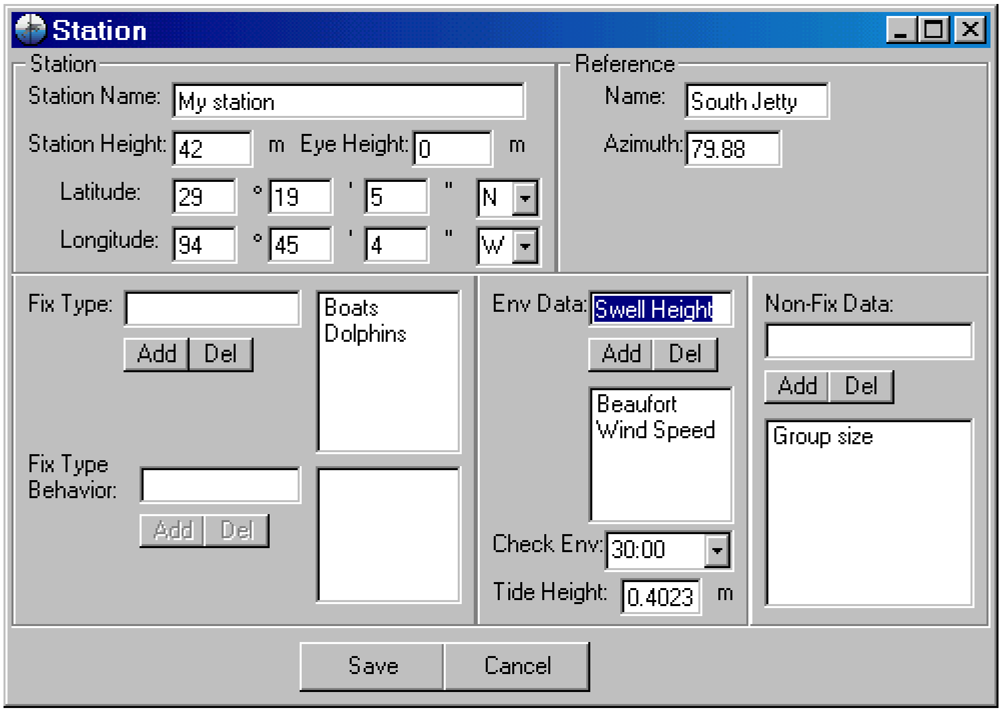
Warning: Non-Fix data are recorded in sequence into *Pythagoras*' database. If you delete one of the non-fix variables, you will restructure the sequence, which can cause subsequent data to be stored in the wrong column. Therefore, once you have defined your non-fix variables, it is recommended that you do not delete any of them.

Defining Environmental Variables - Many theodolite studies may want to include the environmental conditions of their study area (Beaufort, Swell, Wind speed, etc). *Pythagoras* allows you to define up to 10 environmental variables. Tide height is automatically included as an environmental variable and used for distance calculations due to its effect on observation height.

There is a list of environmental variables for each station. You can add a new environmental variable by opening the station setup window and by either adding a new station or editing a current station.

Type in the name of the environmental variable in the text box provided next to "Env Data" and then press "Add" under the text box. After you have added the variable, it will be displayed in the list box below the "Add" button. These data are stored in *Pythagoras*' database to be used later in adding environmental data in the field.

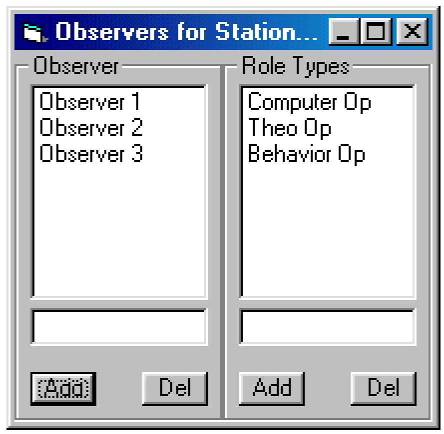
In this example, the "Swell Height" environmental variable is being added to the list for "My station":



Warning: Environmental data are recorded in sequence into *Pythagoras*' database. If you delete one of the environmental variables, you will restructure the sequence, which can cause subsequent data to be stored in the wrong column. Therefore, once you have defined your environmental variables, it is recommended that you do not delete any of them.

Defining Observers and Observer's Role - *Pythagoras* allows you to create a database of observers and their role in your study. This database allows you to register the time and position for each observer participating in data collection. If you want to use this option you must create a database by selecting the option from the setup menu.

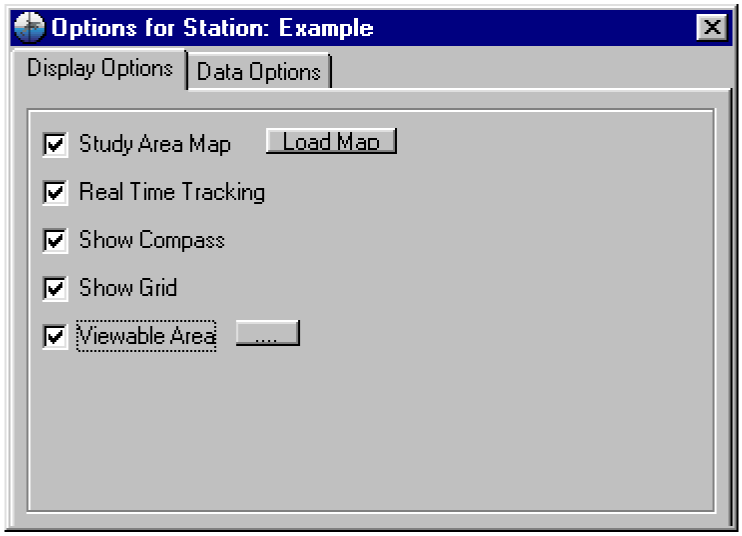
An observer data form will appear for you to enter the names of the observers and the types of roles you would like to define.



You are limited in defining up to seven observers and seven role types. Once defined, you can select the current observers and their role in your study.

Station Options

There are two main types of options you can configure for each station: Display Options and Data Options. To setup the station preferences go to the options window. The first group, Display Options, includes the configuration of the Tracking window that will be displayed when you are collecting data. The options that you can select in this window are:



Study Area Map - Digitized maps can be displayed in the tracking window, allowing you to plot in real time the position of the trackline(s) on the study area map. Once you select this option, you can specify the digitized map data file for your study area by clicking the "Load Map" button. *Pythagoras* can import digitized maps with the following formats: Arc Info (ungenerated), Mat Lab, MapGen, and Surfer. Based on the position of the station and the estimated distance to the horizon, *Pythagoras* will scale the map for your local study area. The study area information is saved into a file for future reference.

Suggested web sites to obtain digitized maps of your study area:

Coastline Extractor http://crusty.er.usgs.gov/coast/getcoast.html
USGS http://edc.usgs.gov/doc/edchome/ndcdb/ndcdb.html

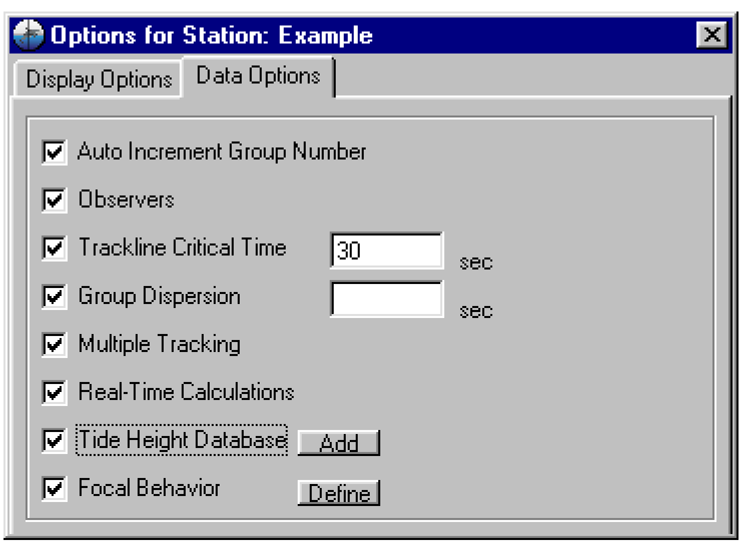
Real Time Tracking - Real time tracking graphically displays the current trackline. The trackline is unique in terms of the fix type and group currently being tracked.

Show Compass - A compass is displayed to indicate the bearing, referred to geographic north (i.e. geographic north on the upper part of the screen), from the station to the last fix registered.

Show Grid - A grid is displayed to indicate each minute in both longitude and latitude of your study area.

Viewable Area - The user can adjust the viewable area of the digitized map displayed in the tracking window. To do this, you must enter the distance in kilometers that you want to display in the tracking window. If this option is not selected, *Pythagoras* will automatically select the displayed area based on the minimal distance between your station and the track line(s) of interest.

The Data Options group specifies the additional data menus that will be used during data collection and real time calculations that will be performed and displayed in the tracking window. The options that you can select in this window are:



Auto Increment Group Number - This function helps the user to start tracking a new subject. Each time the user clicks the button "Next" in the Fix Type section of the tracking window, the program adds a new group and assigns it the number i+1 (i corresponds to the last group number for that fix type).

Observers - The name and role of each observer can be defined and recorded in the field. When observers change role types, the user only needs to push the button or use shortcut keys to change the settings.

Trackline Critical Time - This option allows the user to be warned when the time interval between two fixes is too long. The user defines a "critical time" between two consecutive fixes. If the interval between fixes is above the critical time, a broken line (*Pythagoras* default trackline is solid) will appear between the two fixes.

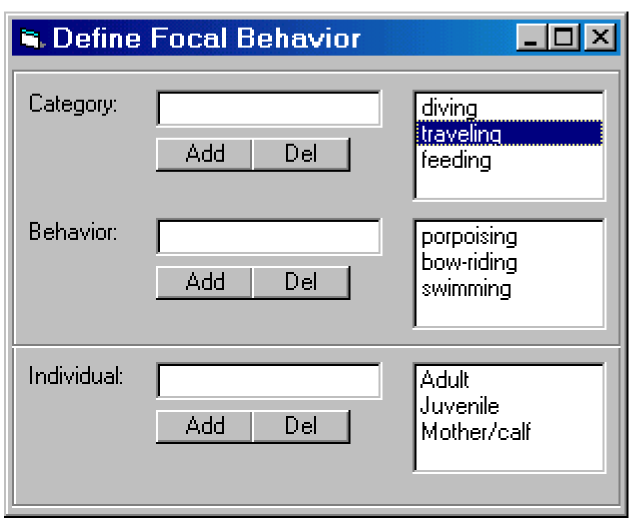
Group Dispersion - This option allow users who are tracking groups/schools of animals to estimate the dispersion of the group. Group dispersion is estimated by calculating the distance along two axes of the area occupied by the group.

Multiple Tracking - This function provides an efficient method to keep track of multiple objects being fixed at the same time. If this option is selected, then the user starts fixing an object, the fix type and fix type identifier (group number) appear as a button. The user can fix this group by just clicking the button.

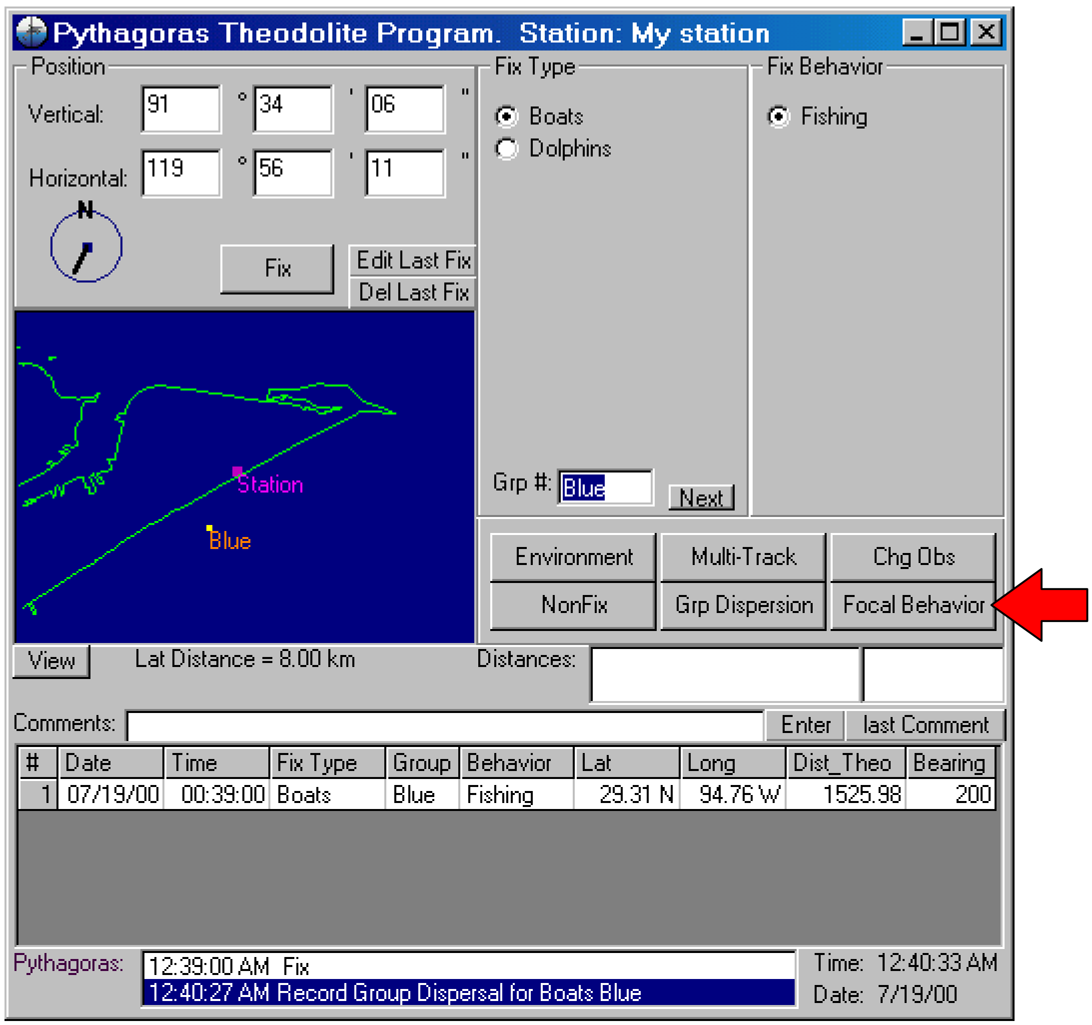
Real-Time Calculations - One of the great advantages of *Pythagoras* is the possibility of real-time calculation and plotting of points and tracklines. However, this function takes some memory and processor time. For this reason, and thinking about the users who may not have a "fast" computer available for field data collection, *Pythagoras* gives the user the choice to perform calculations in real time. If this option is not selected, the program will run faster, but some options of real time tracking will not be available.

Focal Behavior - *Pythagoras* allows the user to specify behavioral events and classify them by category. Up to 28 different behavior types can be included in each category. Additionally, there is an option to specify categories of individuals, like adult, juvenile, mother/calf, male, female, etc., so that this information can be saved in the record of each focal behavior observation.

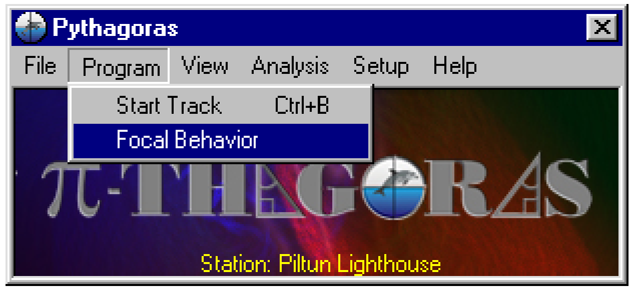
Defining Focal Behavior - In this example, three behavior types have been specified in the category “traveling”:



If this option is selected, and after the list of behavior types has been defined, the user can collect focal behavior data very easily (Chapter 2). The Focal Behavior data collection window can be accessed from the Tracking window, by clicking the 'Focal Behavior' button:



Or from the ‘Program’ menu in the main window:



Once opened, the Focal Behavior data collection window offers an easy and fast way to collect behavioral data. Although this window does not have a fix function to estimate location, the user can record detailed observations with clicking a button. Moreover, it allows the user to define their own categories and lists of behavior types.

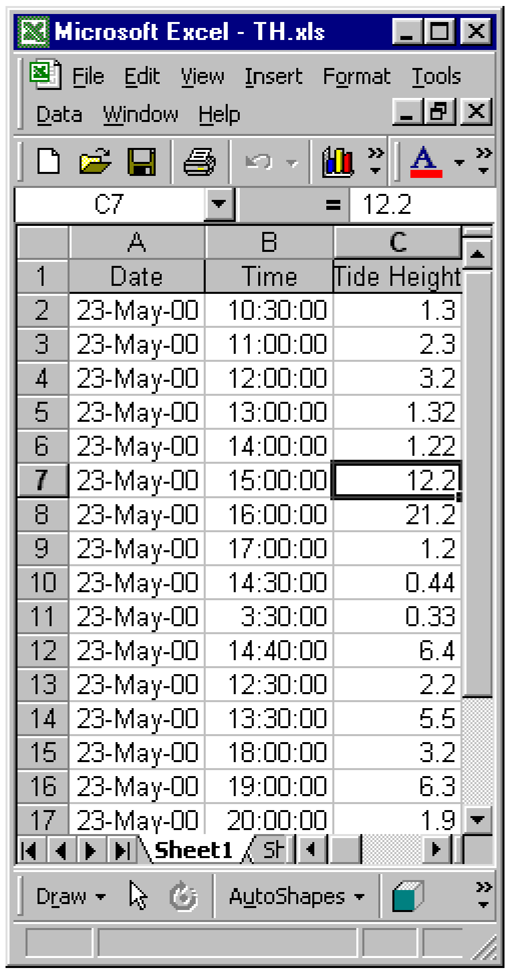
Tide Height Database - Tide height can affect the accuracy of the distance estimations, and therefore is an important environmental variable to be considered. *Pythagoras* gives the user the option to import tide height data stored in Microsoft Excel or Access format and use them in distance calculations.

Once the database has been imported, the program will automatically search the closest tide height value according to the date and time of the observations in the database and the date and time when the fix was made.

In order to be imported into *Pythagoras*, predicted or observed tide height data can be retrieved from tide tables or from the Internet and saved in Excel or Access files. The format should be as follows:

Excel Spreadsheet

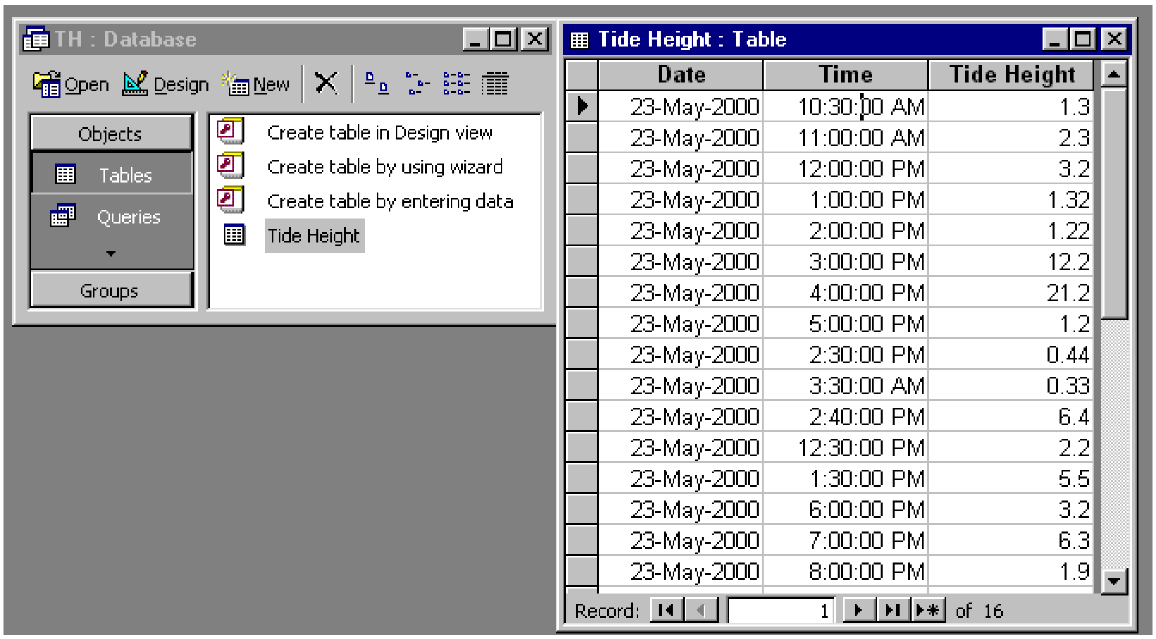
- Program will ask if spreadsheet contains header information, header may consist of only one row.
- Spreadsheet name must be named “Sheet1”
- Column A must contain the Date
- Column B must contain the Time
- Column C must contain the Tide Height Value



	A	B	C
1	Date	Time	Tide Height
2	23-May-00	10:30:00	1.3
3	23-May-00	11:00:00	2.3
4	23-May-00	12:00:00	3.2
5	23-May-00	13:00:00	1.32
6	23-May-00	14:00:00	1.22
7	23-May-00	15:00:00	12.2
8	23-May-00	16:00:00	21.2
9	23-May-00	17:00:00	1.2
10	23-May-00	14:30:00	0.44
11	23-May-00	3:30:00	0.33
12	23-May-00	14:40:00	6.4
13	23-May-00	12:30:00	2.2
14	23-May-00	13:30:00	5.5
15	23-May-00	18:00:00	3.2
16	23-May-00	19:00:00	6.3
17	23-May-00	20:00:00	1.9

Access Table

- Access Table must be named "Tide Height"
- Tide height table must contain the columns named as Date, Time, and Tide Height, with appropriate values filled in for each.



Comma Delimited Text File

- Format: Month, Day, Year, Hours, Minutes, Seconds, Tide Height Value
- Commas must be between variables
- No Header information
- The maximum number of tide height points accepted by *Pythagoras* is 10,000 entries per file.

Wizards

Several wizards were developed to help set up your station and theodolite.

Theodolite Wizard

This wizard will help you set up your theodolite and communication port settings for your theodolite

Station Wizard

This wizard helps you setup information pertaining to your station.

Station Height Wizard

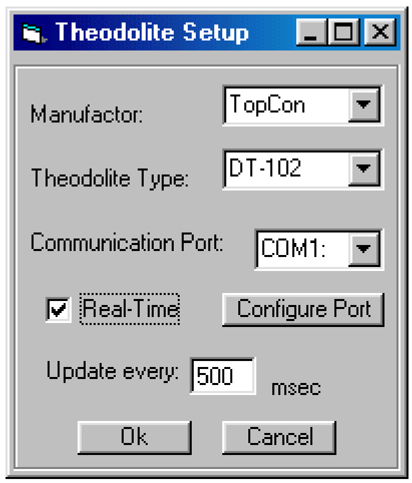
The Station Height wizard provides calculations and visualizations to help you determine the height of your station.

Option Wizard

This wizard will help you select appropriate options for your station.

Theodolite Setup

This setup window enables the user to configure the program to ensure proper data transference between the computer and the theodolite. You must select the appropriate options depending on the theodolite manufacturer and model being used. You must also specify the communication port by which the theodolite cable is connected to the computer, and configure the port (see theodolite user manual for port specifications).



Manufacturer

Currently there are three settings that you can choose for manufacturer: Topcon™, Sokkia™, and None. If the researcher does not have a digital theodolite or cannot successfully connect it to the computer, the data can be manually entered into the computer. In this case, the user must select "None" as the theodolite manufacturer. This option can also be used to analyze previously collected data.

Theodolite Model

Although most models of the same manufacturer have the same communication settings, there can be some difference between models. The following models have been tested or assured by the manufacturer to have the same communication protocol.

Topcon™

Topcon models can be configured for real-time reading. The user may choose to select this option or not. If you do select real-time reading for the theodolite, you may also choose the time interval (in milliseconds) at which the program updates the information. We recommend 500 msec time interval.

Current Models: DT-102

Sokkia™

Sokkia models are point fixes. When the user clicks the 'Fix' button on the data collection form, the computer sends a command to the theodolite and reads the current position.

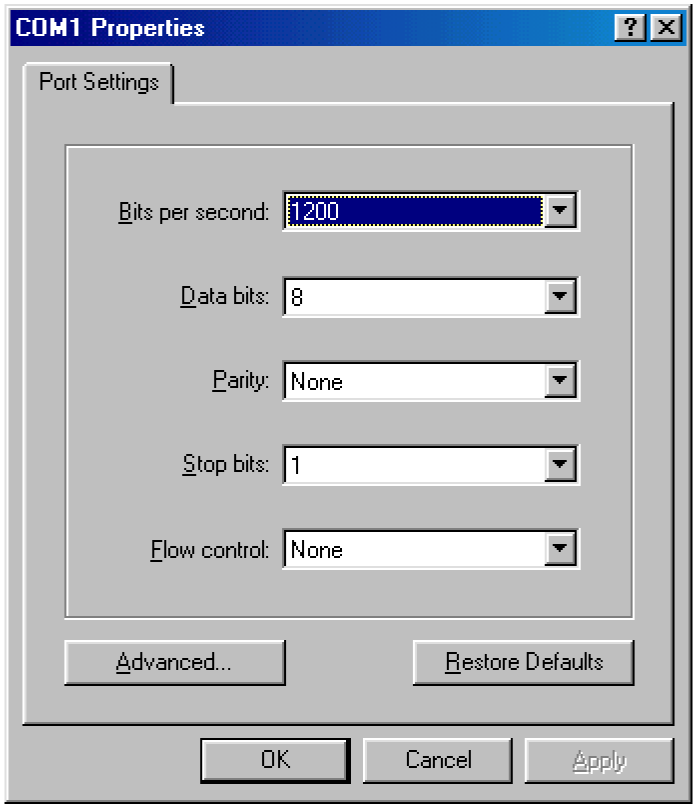
Current Models: DT2, DT4, DT5, DT5A, Set2, Set3, Set4, Set5, and E-Series

None

No settings are necessary (data entered manually).

Communication Port

Most digital theodolites communicate via a RS-232 type cable that is connected to the computer's serial port. The user must define where the theodolite cable is connected to the computer (usually a COM port). The program will display all ports available on your computer.



Communication Port Configuration

Once you have defined the communication port, you must configure the port in order to assure communication between the computer and the theodolite. Most digital theodolites tested for this program have the following settings:

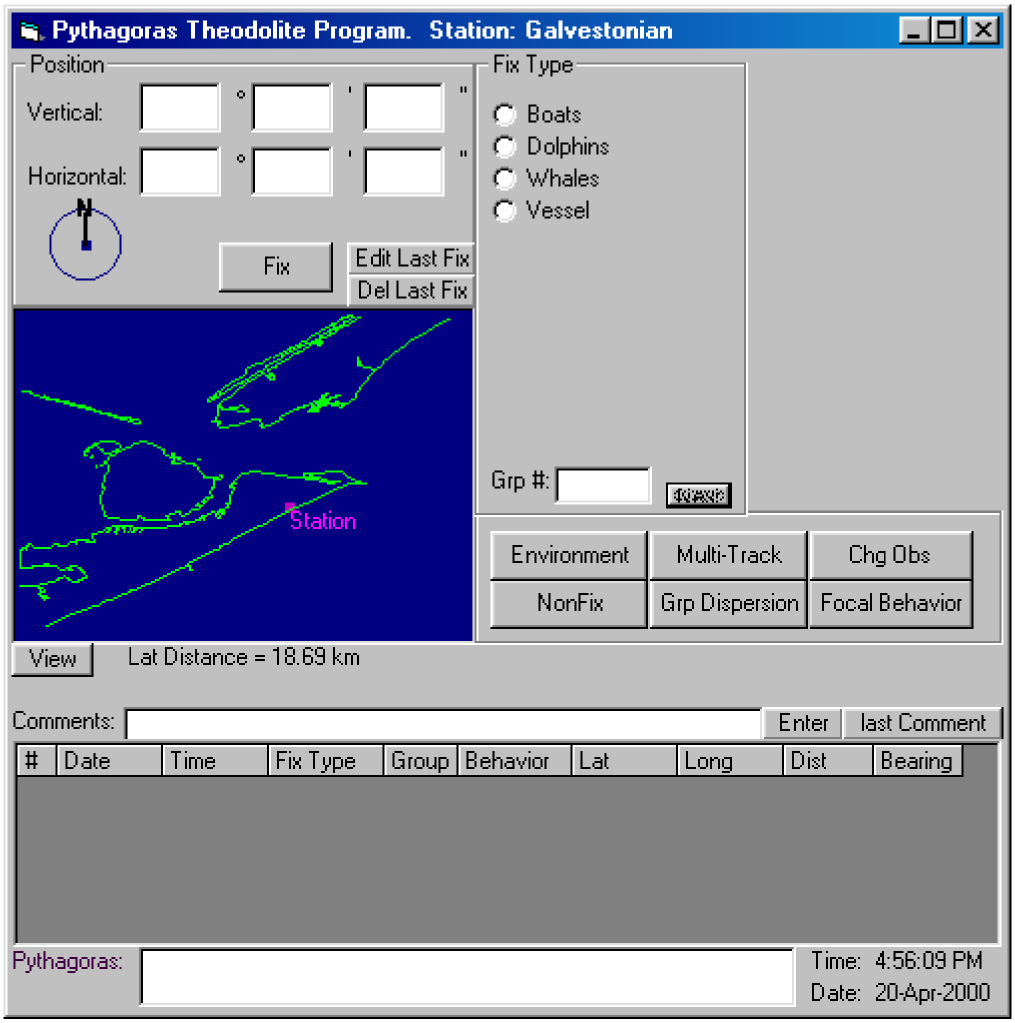
Bits per second:	1200
Data bits:	8
Parity:	None
Stop bits:	1
Flow Control:	None

Please see your theodolite user manual to ensure that you input the proper communication settings for your theodolite.

Chapter

2

Collecting Data



You can control the data collection sheet by either using a mouse or by various shortcut keys. The following provides information to guide you through the main data gathering-tracking window:

Fix Data

Vertical and Horizontal Position - The 'Position' frame, located in the upper left portion of the window, displays the vertical and horizontal bearings to the object being fixed. If a theodolite is connected to your computer and it has been properly configured, the vertical and horizontal angles will be displayed automatically (Topcon™ models can be configured for real time reading, while Sokkia™ models are point fixes - Chapter 1). If you are entering the data manually, click in the appropriate box to start typing the bearing angles.

Horizontal and vertical angles are recorded as degrees, minutes, and seconds. You must select your fix type and group number/name before recording a fix of the group. Behavioral information is optional and can be edited later. Once you fix a group, information pertaining to that fix will be illustrated at the bottom of the data grid.

Selecting Fix Type and Associated Behavior - You can either click on the fix type or use Ctrl + a (plus moving your up/down arrow keys) to select your fix type. Once you select a fix type, the behaviors associated with the fix type will be displayed on the right of the fix type. You can select the behavior with the mouse or by pressing Ctrl + z.

Group Information - Each trackline of the same fix type is separated by group number/name. The program keeps track of the last group number/name for a fix type, therefore avoiding retyping the entry when moving between fix types. You can select the option to auto increment the group number/name or simply click on or press Ctrl + I, to increment the group number for that fix type.

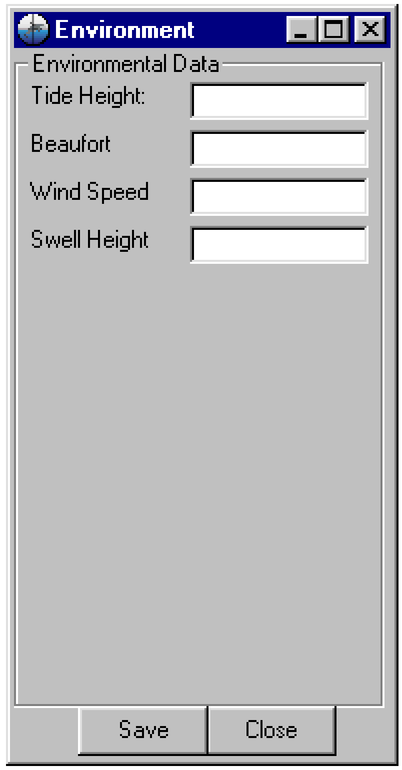
Data for your station are displayed only for that current day. Therefore, each day you go out into the field, you will begin with an empty data sheet. Once you fix a group, the date, time, fix type, group, behavior, latitude, longitude, distance to station, and bearing are displayed in the data grid. The data for the last fix are also displayed above the comment line.

Modifying Data - There are two methods of modifying data after they have been entered into the database. One pertains to the immediate last fix and the other pertains to all fix data for that day. In order to modify the last fix you made, you can either select the 'Edit last fix' or 'Delete last fix' button. To modify any of the other data for that day, simply double click on the fix information in the data grid box.

Environmental Data

You can open your environmental variable(s) data sheet by pressing the 'Environment' button or shortcut key for environmental data.

Adding Environmental Data - Type in the data you want to record and press “Save” to add the information to your database. Once you are finished with the data sheet, press close. Environmental data will be displayed in column format window (up to 10 non-fix variables + tide height).

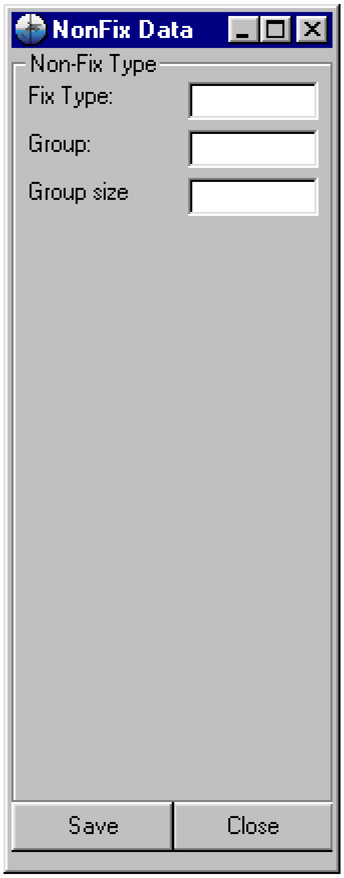


Check Environmental Time Interval - Depending on the time interval you selected in your station setup, the computer will remind you both visually and auditory (if you have sound) to record environmental conditions for that specified time. The visual display will appear at the bottom text box and the auditory signal is given in the form of a "beep".

Non-Fix Data

You can open the non-fix data sheet by pressing the 'NonFix' button or shortcut key.

Adding Non-Fix Data - Enter the type of data you want to record and press “Save” to add it to your database. Once you are finished with the data sheet, press close. Non-fix data will be displayed in column format window (up to 11 non-fix variables).



Comment Data

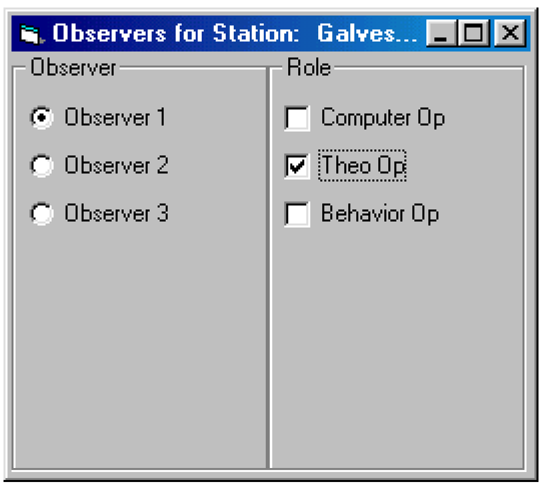
Adding a Comment - You can type a comment into the comment line (above the fix data grid) and add it to the database by pressing the 'Enter' button (or Ctrl + Enter) next to the comment line. If no information is displayed in the comment line when you add it to the database, "Add Comment" will be displayed for that comment line.

Editing a Comment - You can edit the last comment by pressing the 'last comment' button or by using it's shortcut key.

Observer Data

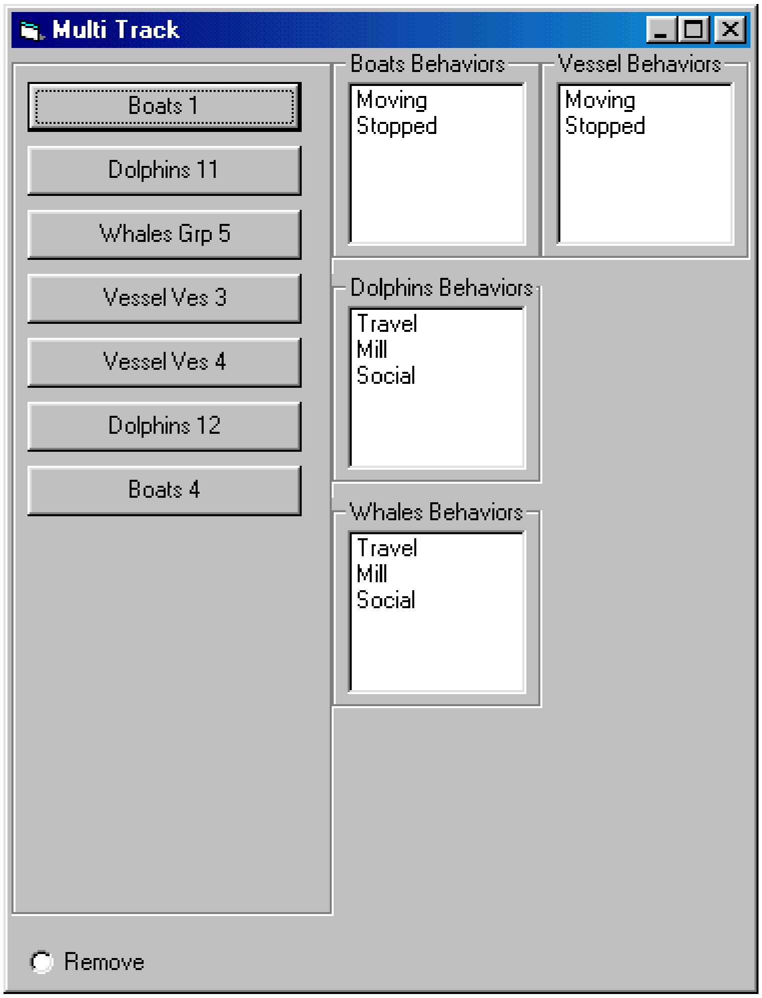
If you checked the option to record observer data, a button will appear for you to select your current observers and the role of each observer.

Adding Observer Data - Once you have created your list of observers and the types of roles that you would like to record, you can select each observer relative to the role that he/she is currently conducting. Check in the appropriate box to define the roles for the observers and then simply close the form page (data will be automatically saved to the database).



Multi-Track

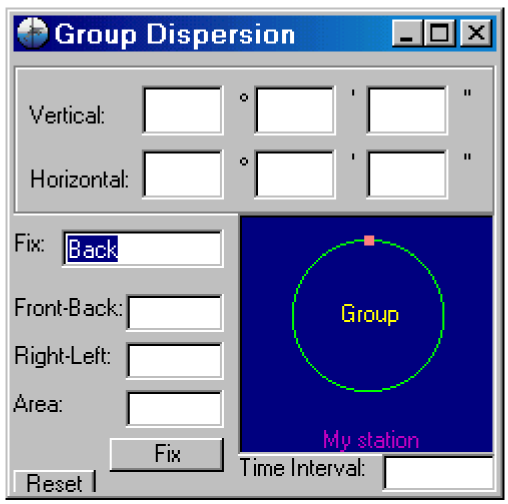
The multi-track option helps you to efficiently fix multiple fix types rather rapidly by providing unique buttons for current fix types and their associated group number.



Once you make an initial fix of the group, a multi-track button will appear with the unique fix type and group number/name. Behaviors associated with the fix type will also appear to the right of the button for ease in selecting the various behaviors you defined. When the object is no longer in sight, simply click on remove and then press the button for the object you want to remove. You can have up to 13 objects in the multi-track window.

Group Dispersion

This option allows the users who are tracking groups/schools of animals to estimate the dispersion of the group. Group dispersion is estimated by calculating the distance along two axes of the area occupied by the group. The fixes are taken by clicking the button "Grp Dispersion", then a window appears indicating, one by one, the four points (back, front, left, and right) on the edge of the group that need to be fixed by the user. For example, in the Group dispersion window below, the Fix field indicates "back".



This means that the user must fix a point in the back edge of the group. After this point is fixed (by finding the point with the theodolite and clicking the button "fix" in this window), the window will ask for the next points: "front", "left", and "right". After the four points have been fixed, the window displays the length of the front-back and left-right axes (m) and the area (m^2) of the group.

The area is estimated in the shape of a quadrilateral. Although the area occupied by cetacean schools is often other than a quadrilateral, estimating it with only four fixes saves the user valuable time in the field. This is an important aspect if we consider that the fixes used to estimate group dispersion should be taken in the shortest possible time, especially for groups that move quickly. Moreover, the user can continue to fix the track and record behavior by spending a short amount of time estimating group dispersion by taking only four fixes. Those users who are interested in obtaining a more accurate estimation can do so by quickly fixing as many points on the edge of the school as possible, and displaying a track of these points.

Bearing Compass

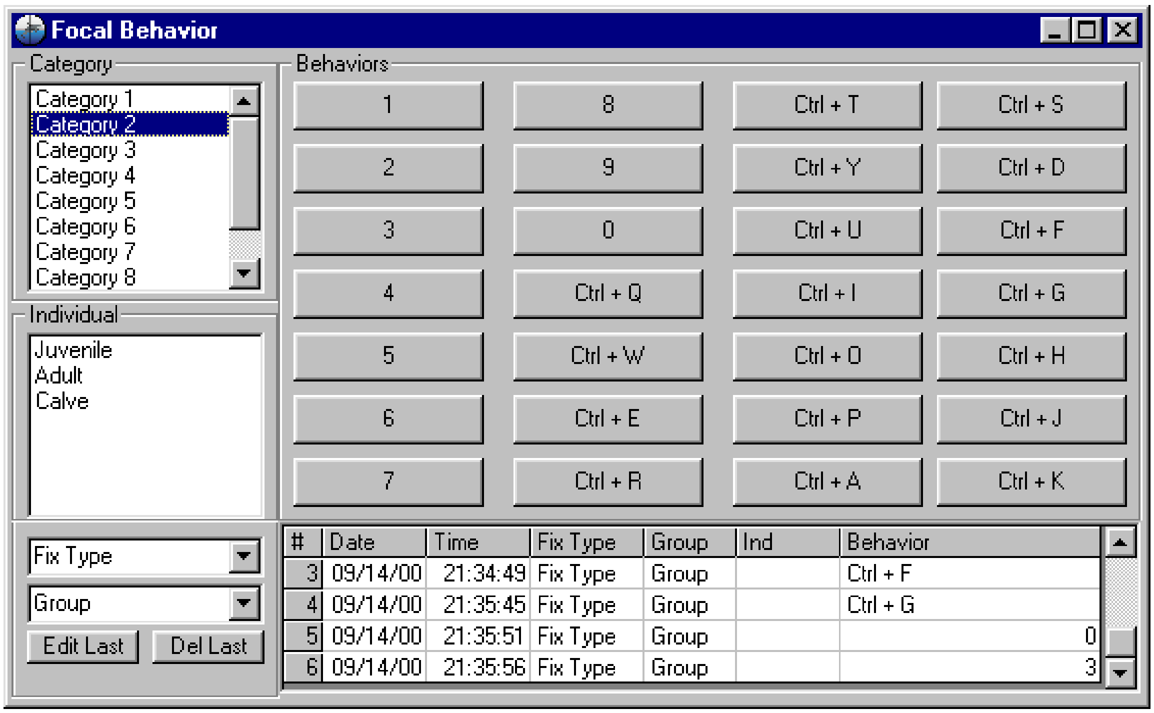
A graphical compass is shown next to the vertical and horizontal information in the upper left of the form page. This display graphically illustrates the current bearing of your last fix.

Focal Behavior

If you selected the focal behavior option, a button will be displayed for collecting focal behavior data. Once selected, the focal data window will be displayed for user to collect focal behavior data.

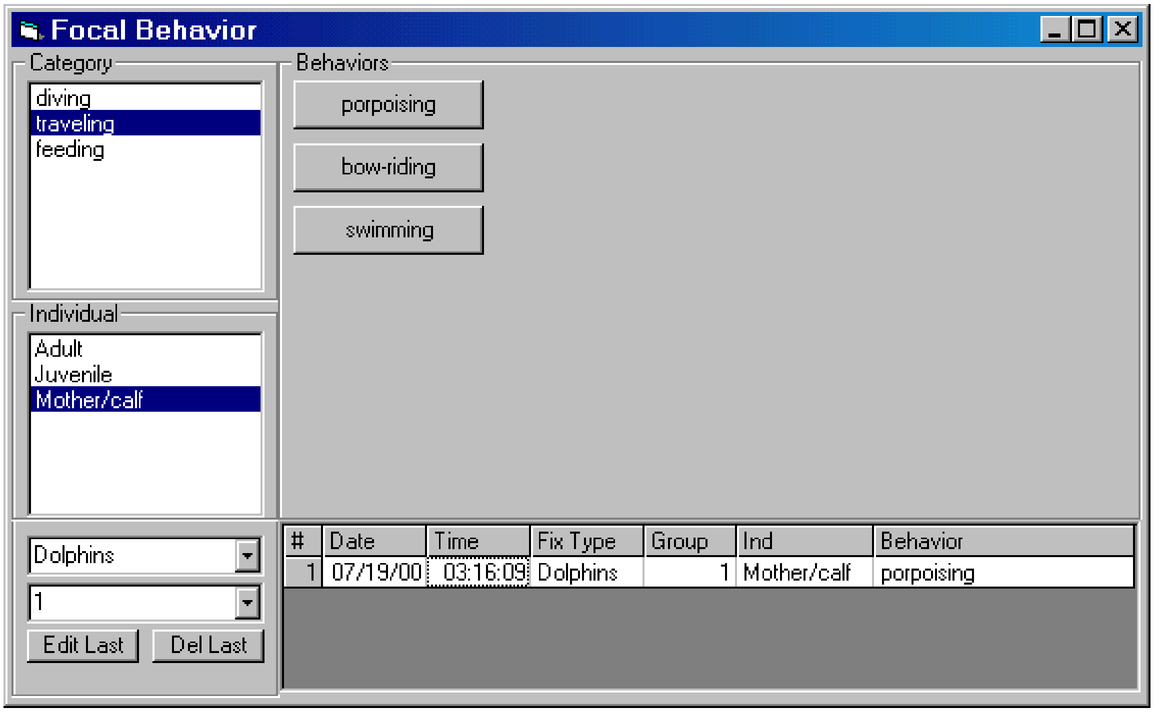
The Focal Behavior data collection window offers an efficient way to collect behavioral data. Although this window does not have a fix function to estimate location, the user can record detailed observations with clicking a button. Moreover, it allows users to define their own categories and lists of behavior types.

The user can also use short-cut keys to record up to 28 different behaviors for each category:



Each value on the above buttons pertain to the short-cut key used to record that button. Notice that, in order to make it practical and easy to memorize, they have been assigned according to the position of the standard U.S. keyboard (the first ten shortcuts correspond to the row of keys for numbers 1 to 0, the next ten correspond to the row of keys Q to P, and the last eight correspond to the row of keys A to K).

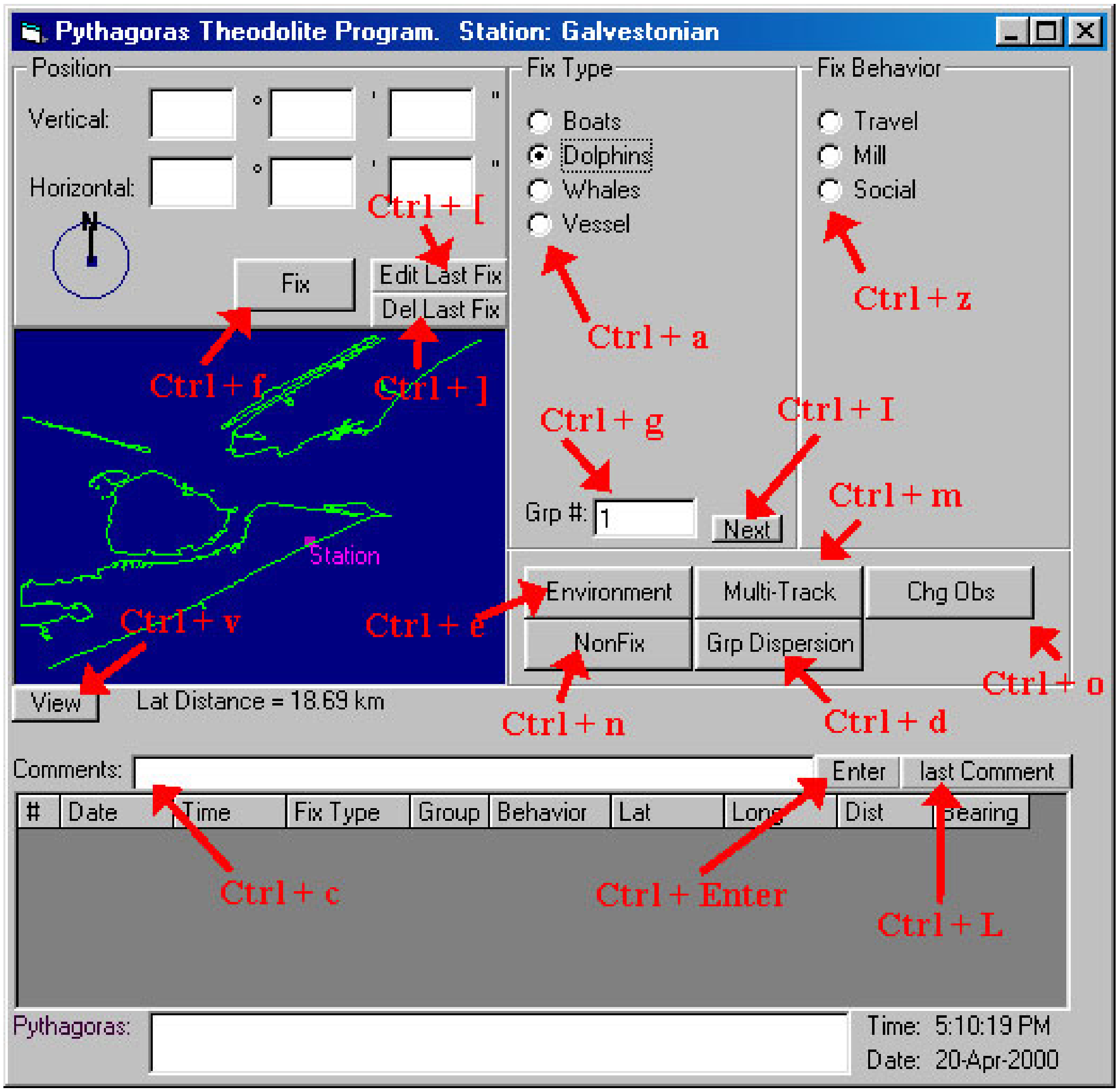
In the example below, the user defined three categories: “diving”, “traveling”, and “feeding”. To record an observation of a mother/calf group porpoising, the user just needs to select the category “traveling”, the “Mother/calf” individual class, and click the button porpoising.



Visual Display

A window is displayed to visually indicate your current trackline. If you have GIS data for you study area, you can import the information to display along with your current trackline. You can either view the track at a specified distance by selecting the view option or you can have the program automatically minimally scale the area to fit the current trackline and your station.

Shortcut Keys

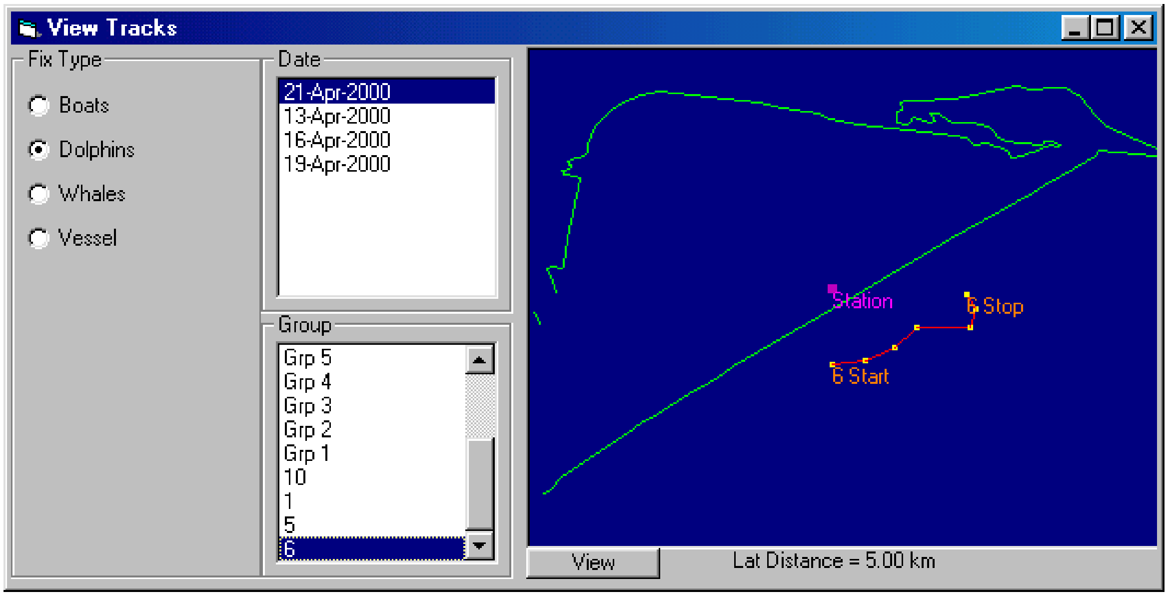


Since a mouse might become obstructive and inefficient for collecting data, *Pythagoras* has many shortcut keys to help you efficiently collect data. The shortcut keys consist of a Ctrl key on your keyboard plus an additional operation key. The additional operation key is case insensitive.

Operation	ShortCut Key
Fix Location	Ctrl + f
Delete Last Fix	Ctrl +]
Edit Last Fix	Ctrl + [
Open or Set Focus on Environment Sheet	Ctrl + e
Open or Set Focus on NonFix Data Sheet	Ctrl + n
Set focus on Fix Type	Ctrl + a
Set focus on Fix Behavior	Ctrl + z
Move to Comment line	Ctrl + c
Add Comment	Ctrl + Enter
Edit Last Comment	Ctrl + L
Move to Group Number/Name	Ctrl + g
Manual Increment Group Number/Name	Ctrl + I
Change View Area	Ctrl + v
Open or Set Focus on Group Dispersion	Ctrl + d
Open or Set Focus on Multi-Track	Ctrl + m
Open or Set Focus on Observer Data Sheet	Ctrl + o

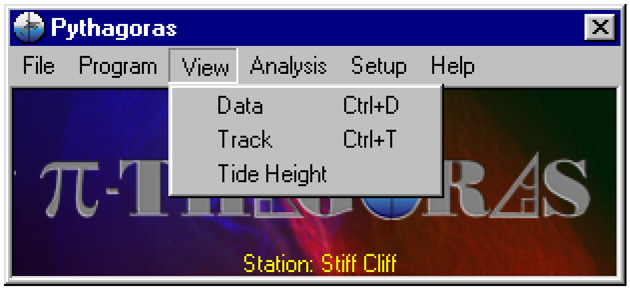
Chapter 3

Viewing Tracks



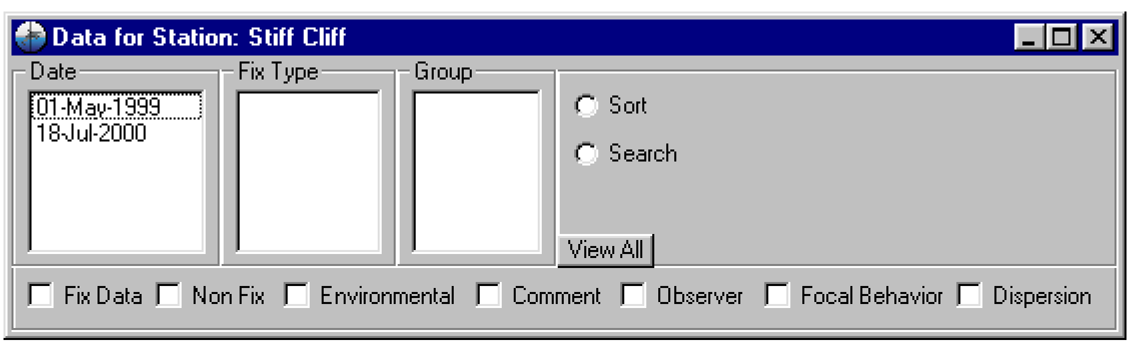
You can visually display your trackline(s) by selecting 'View track' in the main menu. By selecting the fix type, all tracklines for that fix type will be displayed. You can narrow down the number of trackline(s) displayed by selecting a date that you are interested in viewing. Once you selected a specified date, all trackline(s) for that day will be displayed and all groups will be displayed for that day. You can concentrate on a certain group by selecting the group number/name from the list. Once the group is selected, the graphical display will show the trackline for that group and indicate where your initial fix ("Start") occurred for that group and the last fix point ("Stop") for that group.

Viewing Data

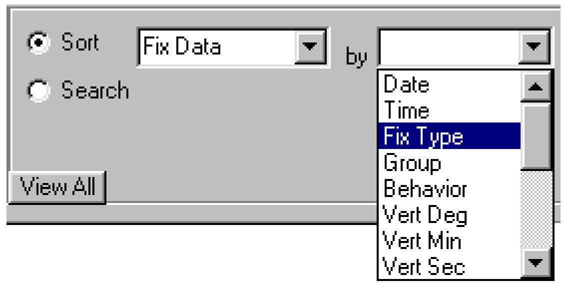


Database

Pythagoras offers an easy way to display and manage your data. You can view your data by selecting 'view data' in the main menu. When you initially open the data sheet, all your data will be presented for that station. You may narrow down your data search by selecting the date, fix type, and group identifier. The data management program provides sort functions that allow you to structure similar data together and a search option to find a specified text or numeric value in a specified column. Distance and course calculations can also be recalculated with updated values (i.e. station height, eyepiece height, reference azimuth value, etc.).

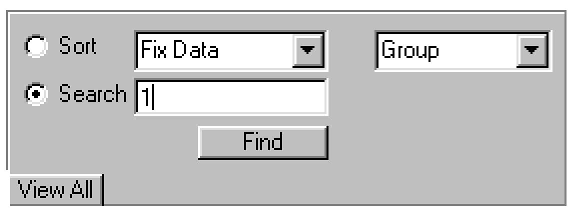


Sorting



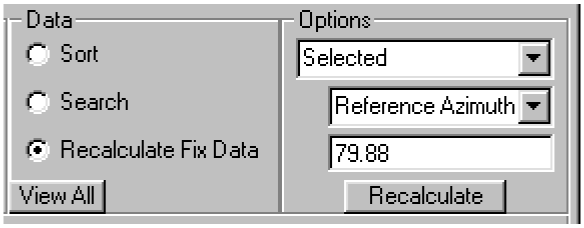
In order to sort your data, you must first choose the dataset you want to sort (i.e. fix, environmental, non-fix, comments). After selecting your dataset, you may select the variable by which you would like to sort. All sorts are ascending.

Searching



You can find a certain value or text in a data set by selecting the data set's name, the variable, and value/text you want to find. Once you have the above information, press find to search for the value/text. The search engine will proceed down the variable and stop once it finds the specified value/text. You may continue by pushing the find next button. The program will notify you when it reached the end of the database.

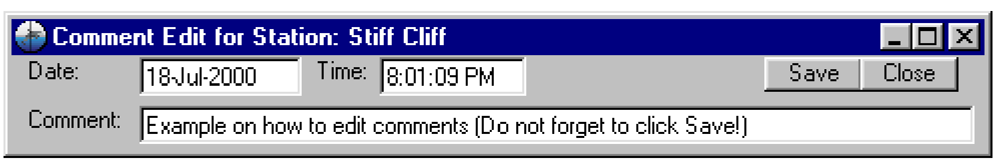
Recalculating Fix Data



The recalculation option will only appear when fix data option is selected. You can recalculate all fix data or a specified portion of the fix data. Single fix recalculation can be performed by simply double clicking on that fix. Once you have chosen all or selected portion of your fix data, then specify which parameters you would like to change for recalculations (i.e. station height, eyepiece height, reference azimuth value, etc.) and place the value you would like to change in the text box provided and press the 'Recalculate' button.

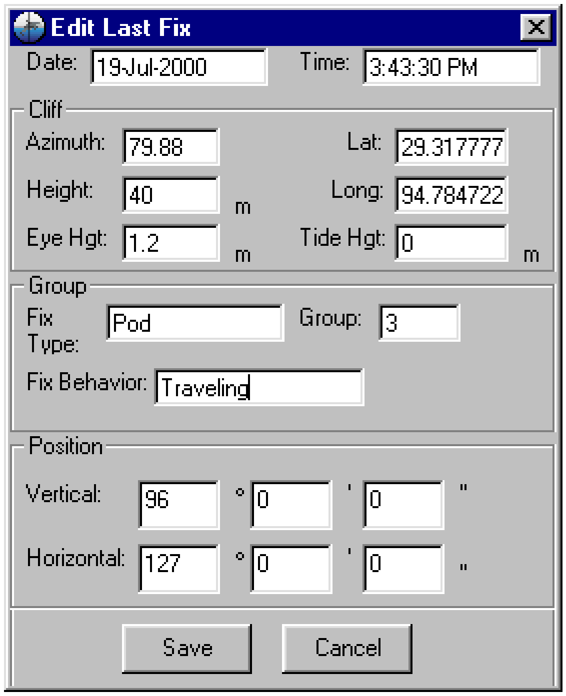
Modifying Data

Editing Comments



Your comment information may be modified by changing the date, time, and/or comment line information. Click on the save button to record changes.

Editing Fix Data

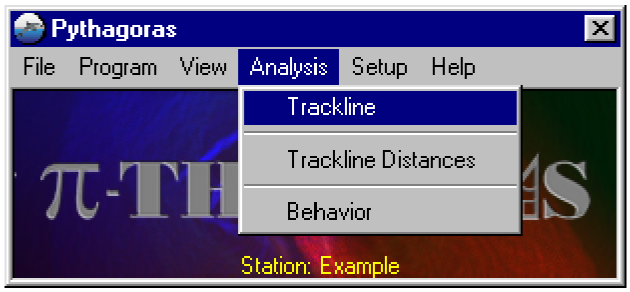


You may modify your fix data by changing any of the parameters indicated above except for the station name. If you change your vertical and/or horizontal position, all calculations are performed again* with the new edited data. After editing, press 'Save' to store the new information into the program's database.

* Recalculating the distance will be based on station information recorded when the object was fixed (i.e. station's geographic position, station height, eye height, and reference azimuth).

Chapter 4

Data Analysis

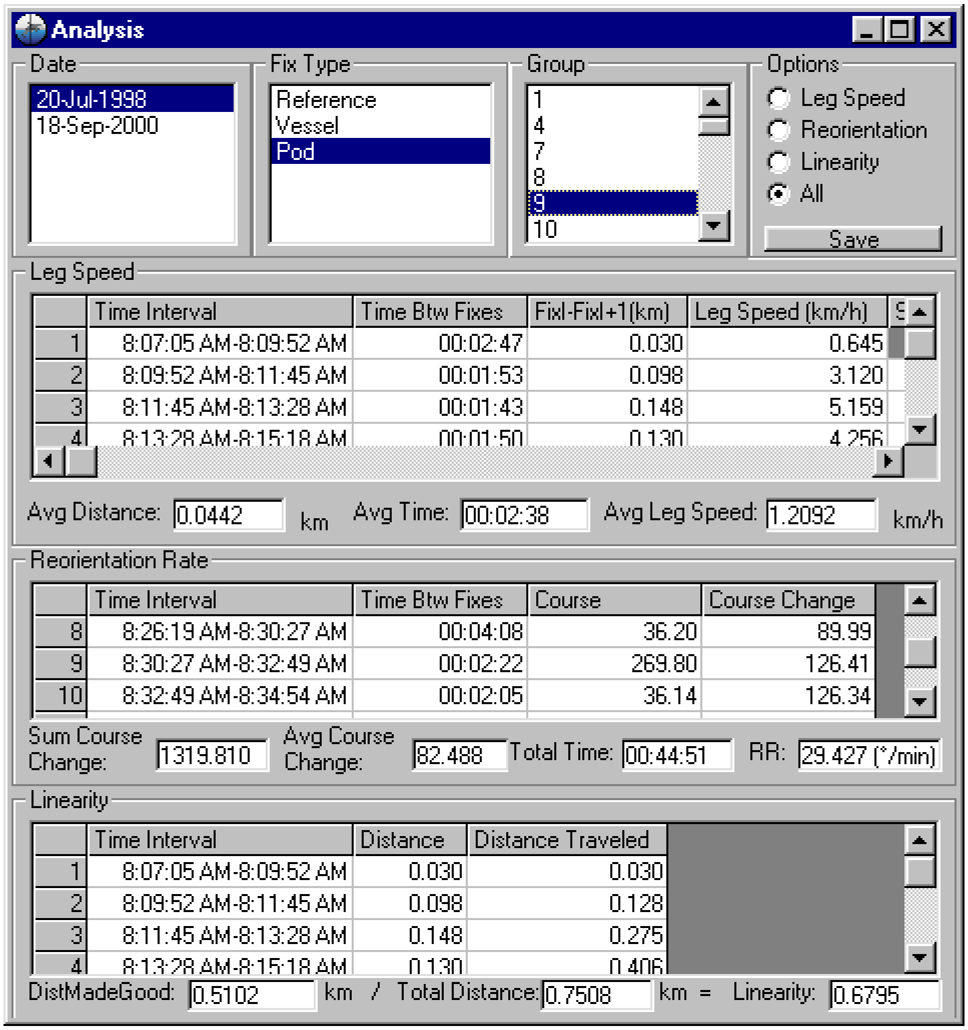


Pythagoras provides three modules for analyzing data:

- *Trackline Analysis* - Estimates Leg Speed, Linearity, and Reorientation rate of a trackline.
- *Trackline Distances* - Calculates the Distance & Course of a trackline. It can also interpolate positions within a trackline based on time and estimate distance and bearing between points of two different tracklines.
- *Behavior Analysis* - Estimates occurrence, behavior interval, interval between two behaviors, and frequency of behavioral data.

Trackline Analysis

Pythagoras offers a simple analysis module to sort, summarize and manage the data you collected for each trackline(s). To start the analysis you must first select the date, fix type, and group number for the particular trackline you want to analyze. Then you must specify, in the "Options" frame, the variables you want to estimate for that trackline: Leg Speed, Reorientation Rate, Linearity or all the previous.



Leg Speed

Leg speed is calculated by dividing the distance traveled between two consecutive fixes by the difference in time between them. The record for each leg displays the distance between the two fixes (Fix_i – Fix_{i+1}) in kilometers, the time between the two fixes (hh:mm:ss), and the leg speed (kilometers per hour).

Linearity

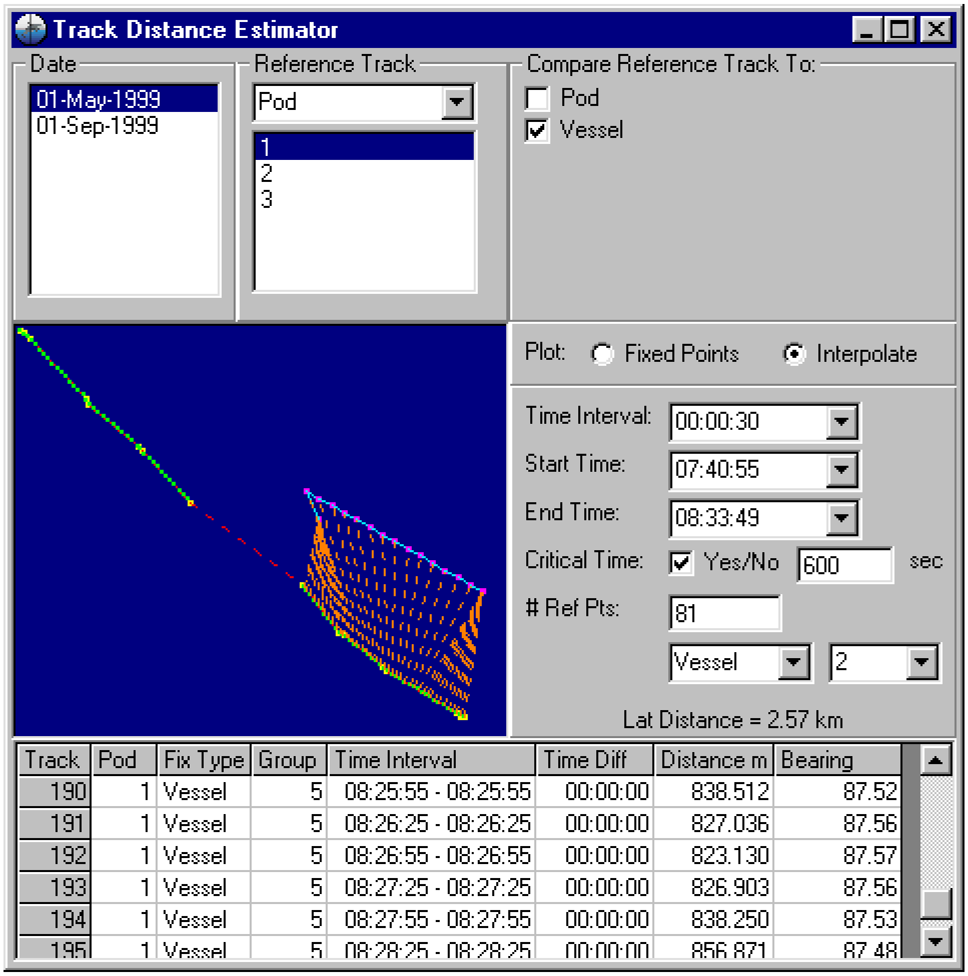
Linearity is calculated by dividing the distance between the initial and end points (net distance) of a trackline by the total sum of the distances (cumulative distances) along the track. Linearity values range between 0 and 1. Linearity values close to one represent a straight trackline, while values close to zero represent a track with no constant direction (Batschellet, 1980).

Reorientation Rate

Reorientation rate is a magnitude of course changes along a trackline. Reorientation rate is calculated by summing all course changes (degrees) along the trackline divided by duration (minutes) of the trackline (Smultea and Würsig, 1995).

Trackline Distances

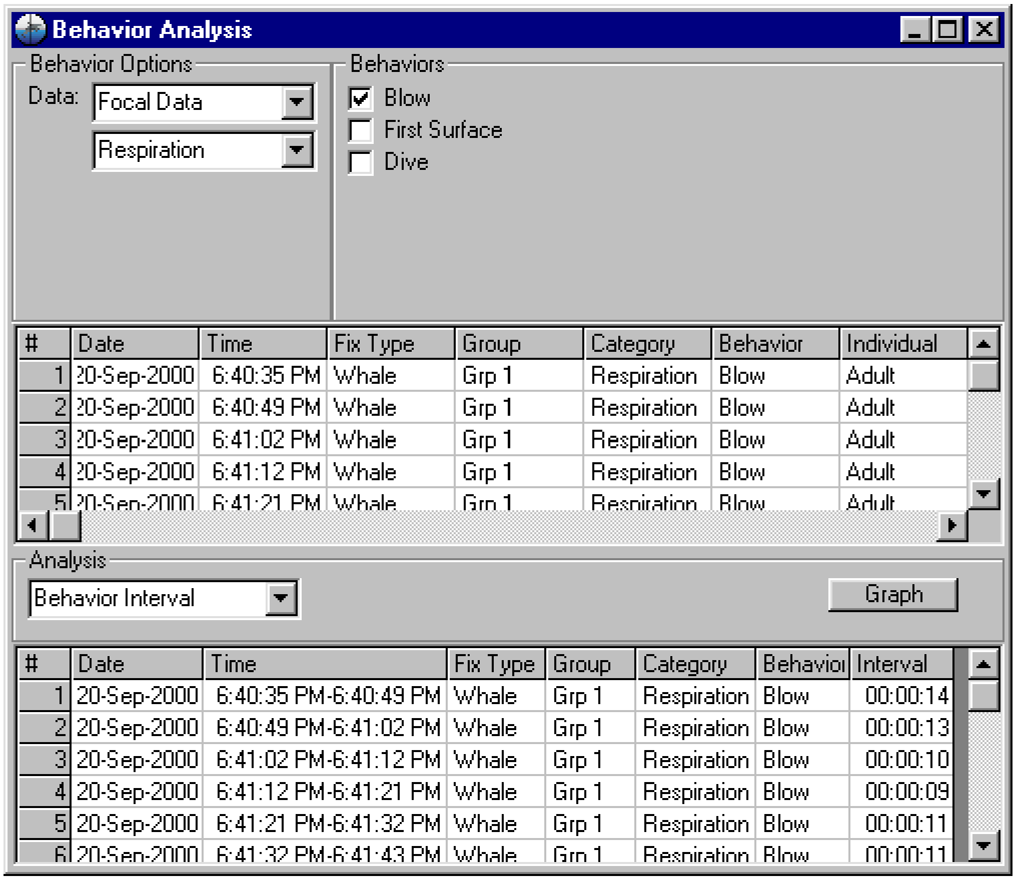
This analysis module can be used to estimate the distance and course within and between trackline(s). Tracklines can be analyzed by selecting the "Reference track combo box", the date, fix type and group number. Once a "reference track" has been selected, you can compare it to other tracklines of the same or different fix type(s) by checking the appropriate box in the "Compare Reference Track To:" frame. For example, in the "Track Distance Estimator" window displayed below, the track for Pod 1 recorded on 01 May 1999, has been selected as the reference track. Vessel 2 has been selected as the track for comparison from 7:40:55 to 8:33:49 at 30 seconds intervals. *Pythagoras* will calculate the distance between Pod 1 and Vessel 2 every 30 seconds starting at 7:40:55 until 8:33:49.



Distance and bearing information can be calculated for fixed points or interpolated trackline points. “Fixed points” option uses only those positions obtained from the actual theodolite fixes. The “Interpolation” option will calculate positions along the trackline based on the specified time interval (e.g. one position every 30 seconds). *Interpolation assumes that the object being fixed travels in a straight line, at constant speed between two consecutive theodolite fixes*. This assumption is hardly observed by swimming animals, especially over long periods of time. For this reason, it is recommended that the user define a critical time between fixed points before interpolating. When the critical time option has been selected, *Pythagoras* will exclude those fixes collected with a difference of time greater than the critical interval (the greater the time difference between fixes, the more probability of violating the “constant speed - straight line” assumption). You can also narrow the time interval for the program to calculate the interpolated points only for those periods when you recorded a good number of fixes with short time difference between them. Interpolation calculations are also computationally intensive, therefore a relatively “fast” computer is recommended.

Behavioral Data Analysis

This module of *Pythagoras* allows researchers to analyze collected behavioral data for occurrence, behavioral interval, interval between two behaviors, and frequency of a particular behavior within a trackline. Both, focal and fixed related behavioral data can be analyzed in this module. To start the Behavioral Data Analysis, first select the data type you would like to analyze (i.e. focal or fix related data) and the fix type or category of behavioral data. Once these two parameters have been defined, the program will display the associated behaviors with check boxes. You can then select the behaviors of interest by checking the box next to the behavior type.



Analysis

Once selected data are defined and appear in the first grid, you can perform analysis on these data by selecting an option under the drop down menu. You can perform four types of behavioral analysis:

1. <u>Occurrence</u> - number of times the selected behavior type was registered within a trackline.

2. <u>Behavioral interval</u> - time interval between two consecutive occurrences of the specified behavior (i.e. blow interval).

3. Interval between two behaviors – duration of a behavior measured as the time interval between consecutive occurrences of two specified behaviors (i.e. first surface - dive = surface time).

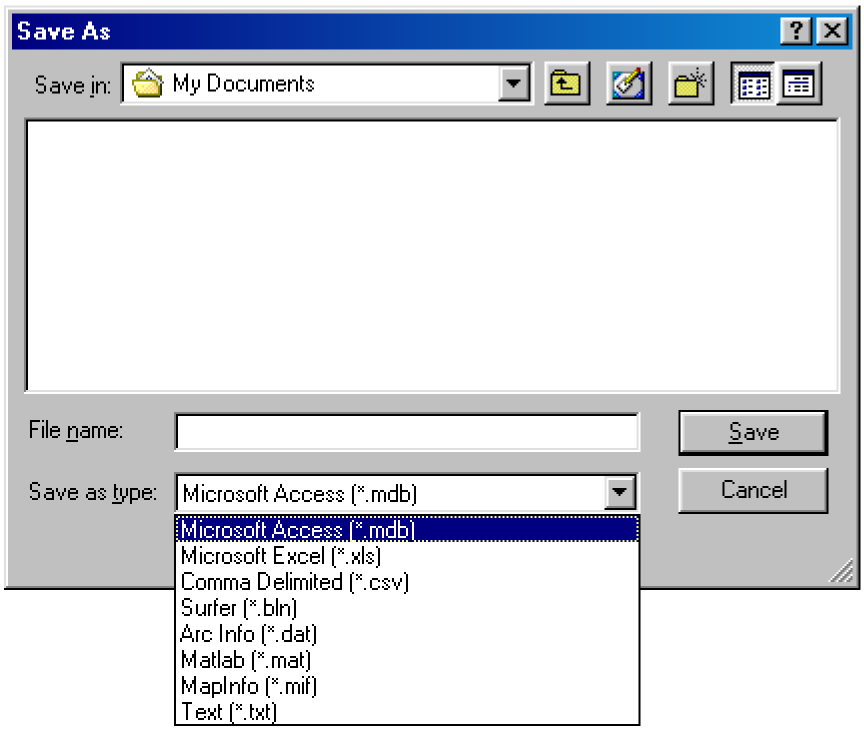
4. Frequency - number of times a behavior type occurred divided by the entire time of the trackline.

Graphs

Analyzed data can be visually displayed by selecting the graph button on this window. Unique columns contain a fix type, group, and date.

Chapter 5

Saving Data



You can export data collected by *Pythagoras* into various formats. Two main types of output are created depending on your selection: 1) Fix, Environment, Non-fix and option related data, and 2) GIS Sighting Data. A description of each type is given below.

Fix, Environment, Non-fix and option related data:

Microsoft Access

- Several Access tables are created to save Fix data, Environmental Data, Non-Fix Data, and various other optional data.

Microsoft Excel

- An Excel Workbook is created with various worksheets pertaining to the Fix Data, Environmental Data, Non-Fix Data, and the various options you selected for your station.

Comma Delimited

- A text formatted data file that separates each variable with a comma. Fix Data, Environmental Data, Non-Fix Data, and your various option data are saved in this format.

Text File

- A space delimited text-formatted file with all relevant data saved.

GIS Sighting Data:

Arc Info

- An ungenerated Arc Info data file with a series of longitude and latitude points of selected trackline(s).

Mat Lab

- A Mat Lab data format with selected trackline(s) points saved.

Surfer

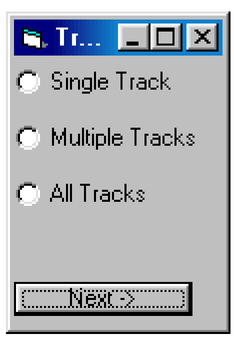
- Surfer importable BLN file with selected trackline(s) points saved.

MapInfo

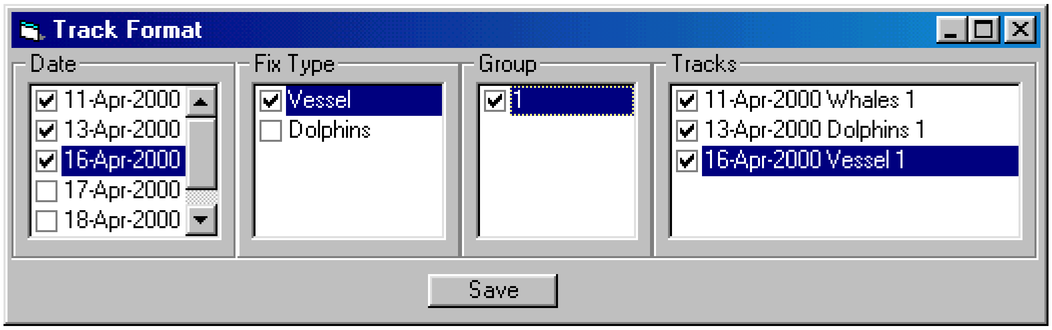
- MapInfo Intermediate File (mif) is stored with selected trackline(s) points saved.

Saving GIS Trackline(s)

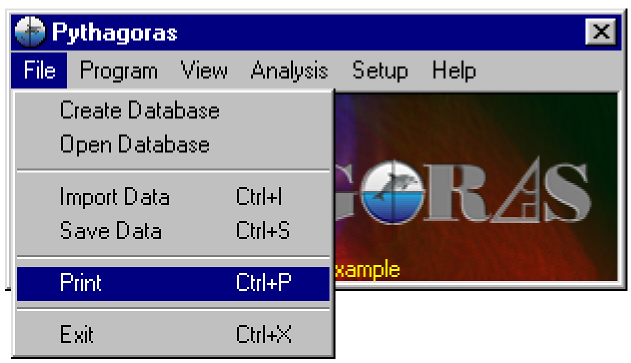
You can save trackline information into various GIS data file formats for your station. The GIS data file can contain single, multiple, or all trackline(s) for your station.



If you decide to select all tracks, no further information is needed and the program will produce your GIS data file in the specified format and location you provided. If you decide to save only one trackline or multiple tracklines, then the program will prompt you to select the trackline(s). Once you decide on the trackline(s) to save, then simply press save and your information will be saved to the file you specified.



Printing Data



You may printout your data for the currently selected station. The data are formatted as an Excel spreadsheet and printed to the computer system's default printer.

Importing Data

Pythagoras' MetaFile

Data can be imported into an existing *Pythagoras* database by means of a comma-delimited metafile. The file contains a command (telling *Pythagoras* what to add), the station name, relevant variables and an End command. Below is a list of commands to add data to *Pythagoras*. All Commands are case sensitive.

Add Station Command (Command = AddStation)

(AddStation, Name of Station, Eye Height, Reference Name, Reference Azimuth, Station Height, Environmental Check interval (as Integer), Station Latitude Hemisphere, Latitude Degrees, Latitude Minutes, Latitude Seconds, Longitude Hemisphere, Longitude Degrees, Longitude Minutes, Longitude Seconds, Tide Height, END)

Add Observer Name (Command = AddObsName)

(AddObsName, Name of Station, Observer Name, END)

Add Observer Data (Command = AddObsData)

(AddObsData, Name of Station, Date, Time, Observer Name, Observer Role, END)

Add Non-Fix Related Data (Command = AddNonFix)

(AddNonFix, Name of Station, Date, Time, Fix Type, Group, NonFix Type, Value, NonFix Type, Value, ….., …., END)

Add Environmental Data (Command = AddEnv)

(AddEnv, Name of Station, Date, Time, Tide Height, Environmental Type, Value, Environmental Type, Value,…,…,END)

Add Fix Data (Command = AddFixData)

(AddFixData, Name of Station, Date, Time, Group, Fix Type, Fix Type Behavior, Vertical Degrees, Vertical Minutes, Vertical Seconds, Horizontal Degrees, Horizontal Minutes, Horizontal Seconds, Reference Azimuth, Station Height, Eye Height, Station Latitude Hemisphere, Station Latitude (decimal degrees), Station Longitude Hemisphere, Station Longitude (Decimal Degrees), Tide Height, END)

Add Comment (Command = AddComment)

(AddComment, Name of Station, Date, Time, Comment, END)

Add Tide Height Value (Command = AddTideHeight)

(AddTideHeight, Name of Station, Date, Time, Tide Height Value, END)

Add Focal Behavior Data (Command = "AddBehavior")

(AddBehavior, Name of Station, Date, Time, Fix Type, Group, Behavior Category, Behavior, Individual, END)

Data can also be edited as a process from the beginning to end of file. Editing Data commands are:

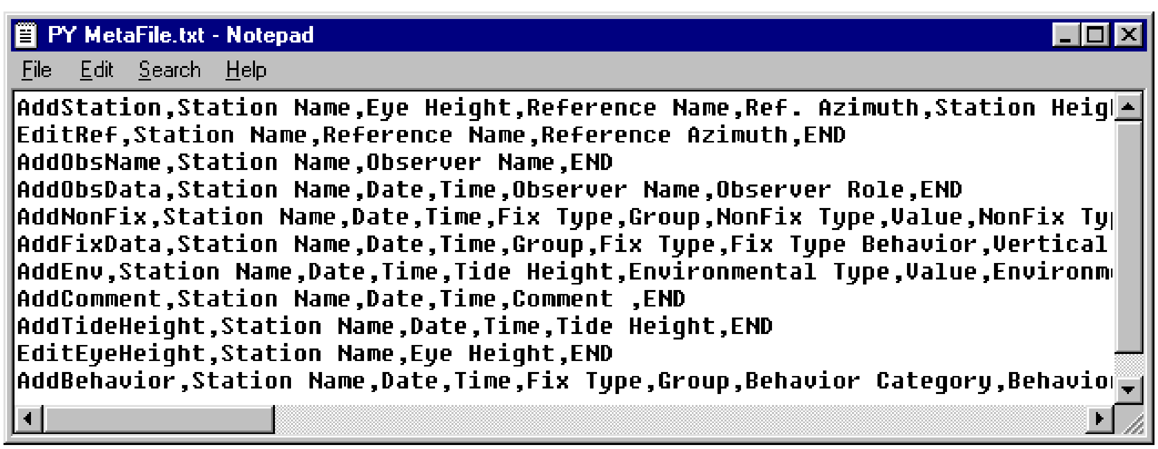
Edit Reference Azimuth (Command = "EditRef")

(EditRef, Name of Station, Reference Name, Reference Azimuth, END)

Edit Station Eye Height Value (Command = "EditEyeHeight")

(EditEyeHeight, Name of Station, Eye Height value, END)

Below is an example of a *Pythagoras*' Metafile:


PY MetaFile.txt - Notepad

File Edit Search Help

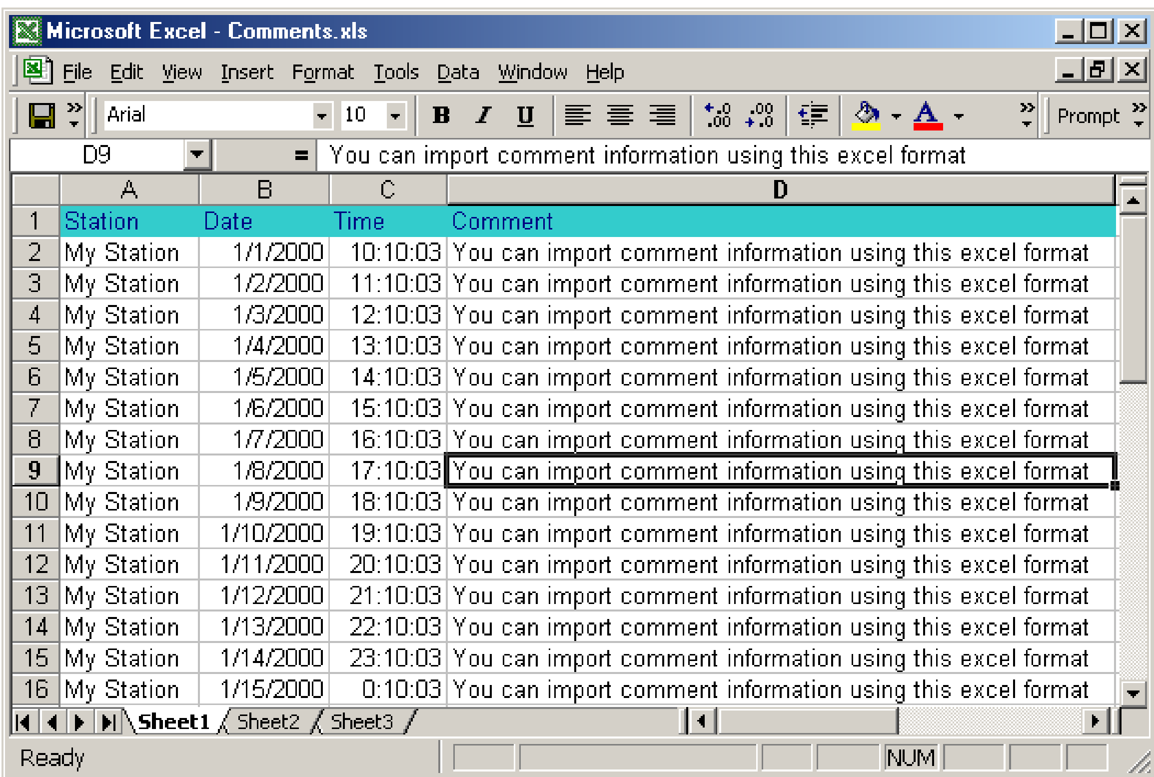
```
AddStation,Station Name,Eye Height,Reference Name,Ref. Azimuth,Station Heig
EditRef,Station Name,Reference Name,Reference Azimuth,END
AddObsName,Station Name,Observer Name,END
AddObsData,Station Name,Date,Time,Observer Name,Observer Role,END
AddNonFix,Station Name,Date,Time,Fix Type,Group,NonFix Type,Value,NonFix Ty
AddFixData,Station Name,Date,Time,Group,Fix Type,Fix Type Behavior,Vertical
AddEnv,Station Name,Date,Time,Tide Height,Environmental Type,Value,Environm
AddComment,Station Name,Date,Time,Comment ,END
AddTideHeight,Station Name,Date,Time,Tide Height,END
EditEyeHeight,Station Name,Eye Height,END
AddBehavior,Station Name,Date,Time,Fix Type,Group,Behavior Category,Behavio
```

Importing Excel Data Files

Excel files can be used to import comment, fix data, and focal behavior data into *Pythagoras*' database. Each Excel worksheet must have Excel's default worksheet title "Sheet1". Header information in the first row is optional and *Pythagoras* will prompt the user if the file they are importing contains such information. Each column within the Excel worksheet must be in the same order to properly import your data.

Excel Comment Data File

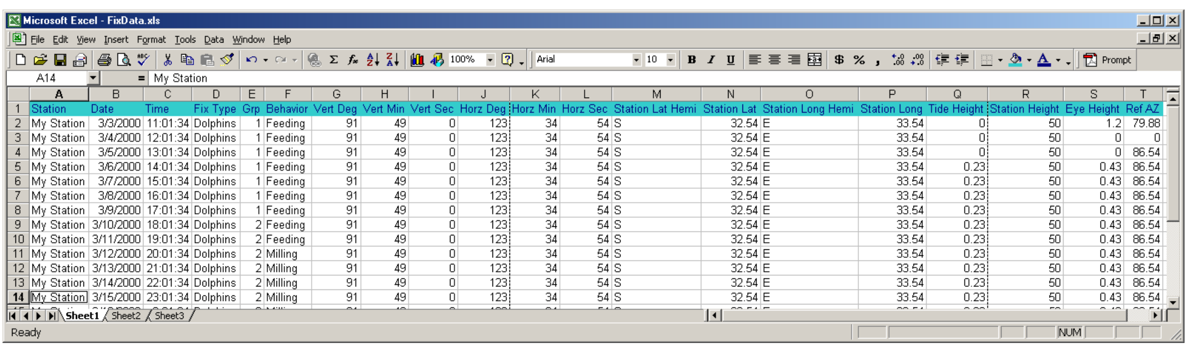
The comment Excel file contains four columns: A) Station Name, B) Date, C) Time, and D) Comment line.



	A	B	C	D
1	Station	Date	Time	Comment
2	My Station	1/1/2000	10:10:03	You can import comment information using this excel format
3	My Station	1/2/2000	11:10:03	You can import comment information using this excel format
4	My Station	1/3/2000	12:10:03	You can import comment information using this excel format
5	My Station	1/4/2000	13:10:03	You can import comment information using this excel format
6	My Station	1/5/2000	14:10:03	You can import comment information using this excel format
7	My Station	1/6/2000	15:10:03	You can import comment information using this excel format
8	My Station	1/7/2000	16:10:03	You can import comment information using this excel format
9	My Station	1/8/2000	17:10:03	You can import comment information using this excel format
10	My Station	1/9/2000	18:10:03	You can import comment information using this excel format
11	My Station	1/10/2000	19:10:03	You can import comment information using this excel format
12	My Station	1/11/2000	20:10:03	You can import comment information using this excel format
13	My Station	1/12/2000	21:10:03	You can import comment information using this excel format
14	My Station	1/13/2000	22:10:03	You can import comment information using this excel format
15	My Station	1/14/2000	23:10:03	You can import comment information using this excel format
16	My Station	1/15/2000	0:10:03	You can import comment information using this excel format

Excel Fix Data File

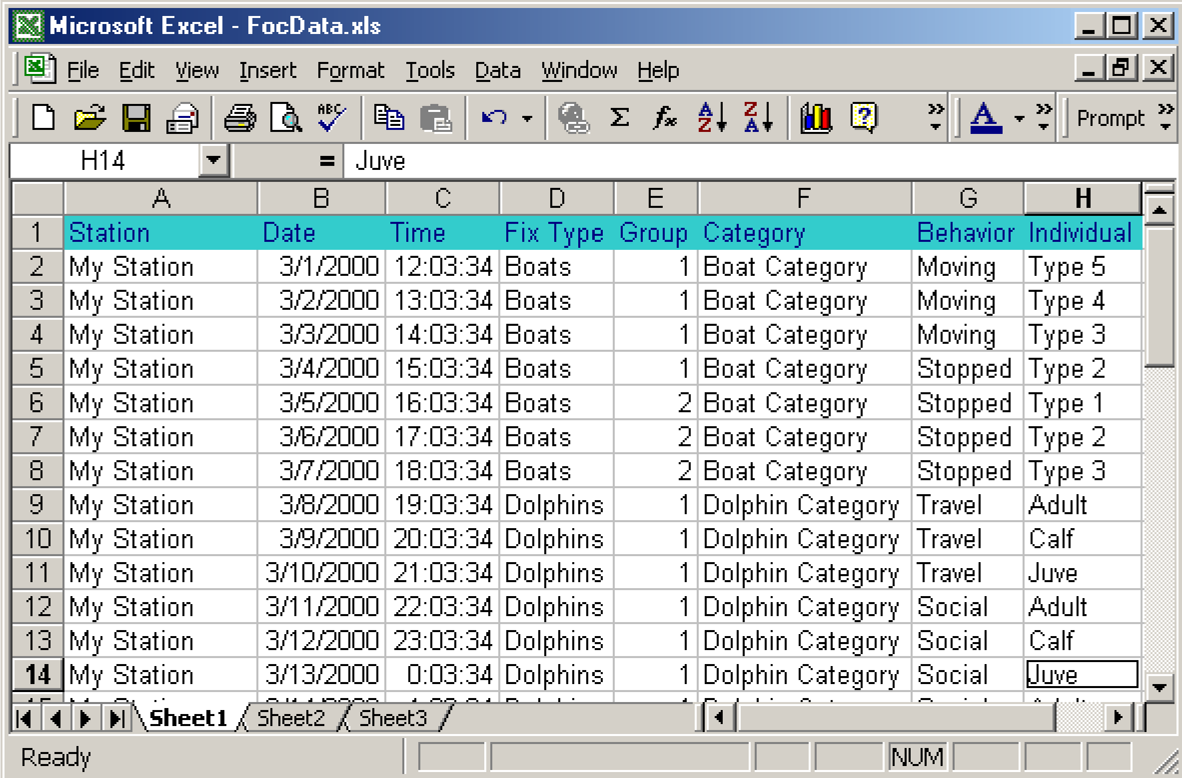
The fix data Excel file contains 20 columns: A) Station Name, B) Date, C) Time, D) Fix Type, E) Group, F) Behavior, G) Vertical degrees, H) Vertical minutes, I) Vertical seconds, J) Horizontal degrees, K) Horizontal minutes, L) Horizontal seconds, M) Station's Latitude Hemisphere, N) Station's Latitude location (decimal degrees), O) Station's Longitude Hemisphere, P) Station's Longitude location (decimal degrees), Q) Tide height value, R) Station's height, S) Eyepiece height, and T) Reference Azimuth.



Station	Date	Time	Fix Type	Grp	Behavior	Vert Deg	Vert Min	Vert Sec	Horz Deg	Horz Min	Horz Sec	Station Lat Hemi	Station Lat	Station Long Hemi	Station Long	Tide Height	Station Height	Eye Height	Ref AZ
My Station	3/3/2000	11:01:34	Dolphins	1	Feeding	91	49	0	123	34	54	S	32.54	E	33.54	0	50	1.2	79.88
My Station	3/4/2000	12:01:34	Dolphins	1	Feeding	91	49	0	123	34	54	S	32.54	E	33.54	0	50	0	0
My Station	3/5/2000	13:01:34	Dolphins	1	Feeding	91	49	0	123	34	54	S	32.54	E	33.54	0	50	0	86.54
My Station	3/6/2000	14:01:34	Dolphins	1	Feeding	91	49	0	123	34	54	S	32.54	E	33.54	0.23	50	0.43	86.54
My Station	3/7/2000	15:01:34	Dolphins	1	Feeding	91	49	0	123	34	54	S	32.54	E	33.54	0.23	50	0.43	86.54
My Station	3/8/2000	16:01:34	Dolphins	1	Feeding	91	49	0	123	34	54	S	32.54	E	33.54	0.23	50	0.43	86.54
My Station	3/9/2000	17:01:34	Dolphins	1	Feeding	91	49	0	123	34	54	S	32.54	E	33.54	0.23	50	0.43	86.54
My Station	3/10/2000	18:01:34	Dolphins	2	Feeding	91	49	0	123	34	54	S	32.54	E	33.54	0.23	50	0.43	86.54
My Station	3/11/2000	19:01:34	Dolphins	2	Feeding	91	49	0	123	34	54	S	32.54	E	33.54	0.23	50	0.43	86.54
My Station	3/12/2000	20:01:34	Dolphins	2	Milling	91	49	0	123	34	54	S	32.54	E	33.54	0.23	50	0.43	86.54
My Station	3/13/2000	21:01:34	Dolphins	2	Milling	91	49	0	123	34	54	S	32.54	E	33.54	0.23	50	0.43	86.54
My Station	3/14/2000	22:01:34	Dolphins	2	Milling	91	49	0	123	34	54	S	32.54	E	33.54	0.23	50	0.43	86.54
My Station	3/15/2000	23:01:34	Dolphins	2	Milling	91	49	0	123	34	54	S	32.54	E	33.54	0.23	50	0.43	86.54

Excel Focal Behavior Data File

The focal behavior data Excel file contains eight columns: A) Station Name, B) Date, C) Time, D) Fix Type, E) Group, F) Behavioral Category, G) Behavior, and H) Individual.



	A	B	C	D	E	F	G	H
1	Station	Date	Time	Fix Type	Group	Category	Behavior	Individual
2	My Station	3/1/2000	12:03:34	Boats	1	Boat Category	Moving	Type 5
3	My Station	3/2/2000	13:03:34	Boats	1	Boat Category	Moving	Type 4
4	My Station	3/3/2000	14:03:34	Boats	1	Boat Category	Moving	Type 3
5	My Station	3/4/2000	15:03:34	Boats	1	Boat Category	Stopped	Type 2
6	My Station	3/5/2000	16:03:34	Boats	2	Boat Category	Stopped	Type 1
7	My Station	3/6/2000	17:03:34	Boats	2	Boat Category	Stopped	Type 2
8	My Station	3/7/2000	18:03:34	Boats	2	Boat Category	Stopped	Type 3
9	My Station	3/8/2000	19:03:34	Dolphins	1	Dolphin Category	Travel	Adult
10	My Station	3/9/2000	20:03:34	Dolphins	1	Dolphin Category	Travel	Calf
11	My Station	3/10/2000	21:03:34	Dolphins	1	Dolphin Category	Travel	Juve
12	My Station	3/11/2000	22:03:34	Dolphins	1	Dolphin Category	Social	Adult
13	My Station	3/12/2000	23:03:34	Dolphins	1	Dolphin Category	Social	Calf
14	My Station	3/13/2000	0:03:34	Dolphins	1	Dolphin Category	Social	Juve

Chapter 6

Calculations

Pythagoras uses a modification of the approximation proposed by Lerczak and Hobbs (1998) to determine the distance along the surface of the ocean from the station to the object being fixed:

$$\beta = \frac{\pi}{2} - \alpha - \theta = 180 - \varpi$$

$$D_0 = (R_E + h) \cdot \cos(\beta) - \sqrt{(R_E + h)^2 \cdot \cos(\beta)^2 - (2hR_E + h^2)}$$

$$\delta = \arcsin\left(\sin(\beta)\frac{D_0}{R_E}\right)$$

$$D = \delta \cdot R_E$$

and the distance from the station to the horizon:

$$\alpha = \arctan\left(\frac{\sqrt{2hR_E + h^2}}{R_E}\right)$$

$$H = \alpha \cdot R_E$$

where

α = angle from horizontal (90°) to horizon and central arc angle from horizon to station.

β = angle from object being fixed to station

δ = central arc from object being fixed to station

θ = angular drop from horizon to object being fixed

h = station height or altitude

R_E = radius of the Earth $(6.371\times10^6\ \text{m})$

H = distance along the Earth's surface to horizon

D_0 = line-of-sight distance to object being fixed

D = distance to object being fixed along the surface of the earth/ocean

ϖ = vertical angle estimated with the theodolite

Once the distance to an object along the surface of the ocean (*D*) is known, the great circumference equation is used to determine geographic position of the fixed object given the location of the station and the azimuth and distance to the subject:

$$\tau = \eta - \rho$$

$$Lat_F = \sin^{-1}\left(\cos(\tau)\cdot\sin(D/60/1852)\cdot\cos(Lat_S) + [\sin(Lat_S)\cdot\cos(D/60/1852)]\right)$$

$$Lon_F = \cos^{-1}\left(\frac{\cos(D/60/1852) - [\sin(Lat_S)\cdot\sin(Lat_F)]}{\cos(Lat_S)\cdot\cos(Lat_F)}\right) + Lon_S$$

where

D = distance (m) between the two points along the surface of the Earth.

τ = bearing from station to subject.

η = azimuth or horizontal angle estimated with the theodolite

ρ = reference azimuth (bearing from station to reference point)

Lat_S = Latitude of the station

Lon_S = Longitude of the station

Lat_F = Latitude of the fixed object

Lon_F = Longitude of the fixed object

The great circumference equation is also used by *Pythagoras* to determine the distance of two points along the surface of the Earth when the geographic coordinates (latitude and longitude) of both points are known:

$$D = \left(60 \cdot \cos^{-1}\left[\left(\sin(Lat_1)\cdot\sin(Lat_2)\right) + \left(\cos(Lat_1)\cdot\cos(Lat_2)\right)\cdot\cos(Lon_2 - Lon_1)\right]\right)\cdot 1852$$

$$\zeta = \cos^{-1}\left[\frac{\sin(Lat_2) - \left[\sin(Lat_1)\cdot\cos(D/60)\right]}{\sin(D/60)\cdot\cos(Lat_1)}\right]$$

where

D = distance (m) between the two points along the surface of the Earth.

ζ = bearing from point 1 to point 2

Lat_1 = Latitude of point 1

Lon_1 = Longitude of point 1

Lat_2 = Latitude of point 2

Lon_2 = Longitude of point 2

Limitations of *Pythagoras*

Pythagoras offers a variety of functions, but some of the resources had to be limited in order for the program to be efficient and user friendly. Below is a list of known limitations of *Pythagoras*.

Limitation
Only 11 Stations possible
Only 11 Definable Fix Types
Only 11 Definable Behaviors for each Fix Type
Only 11 Definable Non-Fix Variables
Only 10 Definable Environmental Variables (not including Tide Height)
Only 28 Definable Focal Behavior Variables per Category
Only 7 Definable Observers
Only 7 Definable Observer roles
Only 13 Objects allowed for the Multiple tracking option
View Trackline for fix type limited to 20,000 fix points
View Trackline for entire day limited to 10,000 fix points
GIS Data import is limited to 500,000 points
Real-Time tracking limited to 1,000 fixes per group

Recommended System Requirements

Pythagoras offers a variety of functions that are dynamic to the researcher's study. If you experience difficulty with processing information, we recommend trying to limit the number of options you choose. For example, one of the most memory consumptive functions is the addition and display of GIS maps for your study area or the graphical display of trackline(s). You can limit resource consumption by not selecting the load study map or auto tracking options.

Pythagoras' setup files = 15.4 MB

Initially, *Pythagoras* needs a large amount (90 MB) of hard drive space to install data access components that may or may not be on your system. Once installed, *Pythagoras* should take up less then 10 MB.

Minimum Requirements

Processor	75 MHz
Operating System	Windows 95/98/ME/2000
Memory (RAM)	32 MB
Hard Drive Space	20 MB

Recommended Requirements

Processor	266 MHz
Memory (RAM)	64 MB
Hard Drive Space	50 MB

Additional Software Recommendation

GIS Software (Arc Info, Surfer, MapInfo) to plot out sighting data

Microsoft Office 2000

Troubleshooting

Pythagoras

Display

If you experience problems with the display of the main menu it could be due to the font size of your operating system. Try changing the font size in Windows (see Windows help menu).

Database

If the program cannot find it's database, you may select the database for it to read. If the problems persist, try reinstalling the application.

Theodolite Communication

1) Ensure you have the proper manufacturer, model, and communication port for your theodolite.
2) Ensure that the RS-232 cable is properly connected to the computer and the theodolite.
3) Observe if the theodolite is properly balanced and displaying both horizontal and vertical readings.
4) Check if your theodolite port is open to send data (See theodolite manual).
5) Evaluate the communication port settings for your theodolite (See your theodolite manual).
6) Check if another device, such as a mouse, is using the communication port (some computers have two ports for one serial port setting).

GIS Data

If you experience difficulty opening GIS data files, ensure that the files are in text format. One solution is to open the file in Windows Notepad or another text program and save the file as a text document.

Acknowledgements

This program would have not been possible without the generous support and advise from many individuals. We thank Bernd Würsig, Leszek Karczmarski, and Dave Weller for their support towards the development of this program and for editing this manual. We appreciate Adam Frankel's help by providing previous source codes of theodolite programs. We also thank Lars Bejder, Lisa Schwarz, and Suzanne Yin for their helpful suggestions. Thanks to Alice Mackay for providing endless hours trying to find potential bugs in the program. We are also very appreciative of the support and camaraderie from the graduate students and interns at the Marine Mammal Research Program at Texas A&M University at Galveston.

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