17 Application case studies

17.1 REAL WORLD EXERCISES

17.1.1 World fisheries statistics

The Fisheries Department of the Food and Agriculture Organization of the United Nations keeps track of fisheries productions throughout the world. This data is stored in the FISHSTAT program. A copy is available through:

1. The world wide web: http://www.fao.org/fi/statist/FISOFT/FISHPLUS.asp.
2. E-mail: FIDI-Inquiries@fao.org.
3. Normal mail: Senior Fishery Statistician, FIDI, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy.

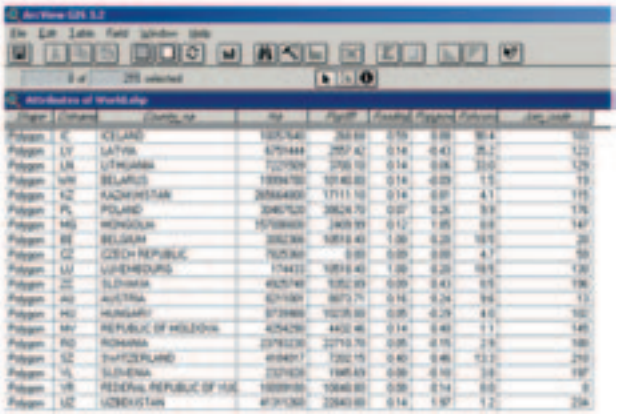
Obviously the preferable way to get the program is to download it from the internet, so that you can work with the data immediately and have the most up to date data. A summary file has been compiled for use with this manual (the file 'world fisheries production.dbf', in the folder: RW_01_World_fisheries). This file contains the following fields:

- Joincode (a number, specific to the country);
- Country (containing the country names);
- Total (containing the total fisheries production of the country [all data in this file concern with the year 1999 and are in metric tonnes]);
- Inland_cap (containing the inland capture fisheries production of the country);
- Marine (containing the marine capture fisheries production); and
- Aquacultur (containing the aquaculture production of the country).

Join this file to the Theme 'World.shp' (in the folder: 'RW_01_World_fisheries'). The 'World.shp' Theme contains the world map that was used during the World Food Summit in 1995. Per country the map contains one polygon. Furthermore the file contains per country the following data (fields), among others:

- Shape (here a polygon);
- Cntname (unique abbreviation of the country name);
- Country_name;
- Ha (the total area of the country, including economical zones, in hectares);
- Pop95 (estimated size of population in 1995);
- Join_code (a unique number specific to the country, equal to the joincode number in World fisheries production.dbf) (Figure 17.1).

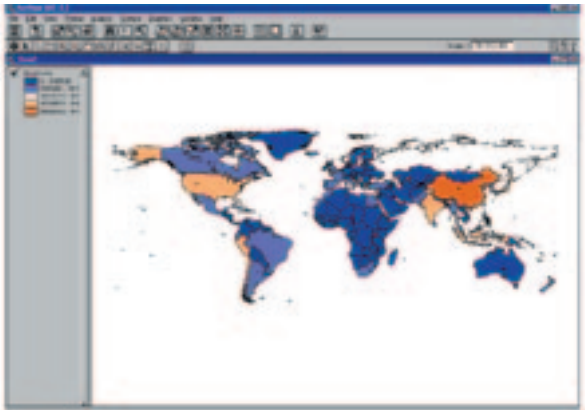
FIGURE 17.1
Attributes of 'World.shp'



Add the Theme 'World.shp', open the attributes table and verify whether or not you see all fields mentioned above. Add the file 'world fisheries production.dbf' to the tables, open it and check whether or not all above mentioned fields are there. Now we are ready to join 'attributes of World.shp' and 'world fisheries production.dbf'. Join both tables with the Joincode and Join_code fields. (remember that the 'world fisheries production.dbf' file is the file that contains the data [the **source table**] you want to join). If you do not remember how to join tables, please review chapter Joining data with location on a map, on page 23.

After joining both tables, go to View and have a look at the map (Figure 17.2). Change with the legend editor the legend type into **Graduated Color**, with as classification field **Total** and **Blues to Oranges dichromatic** in the color ramp. By doing this the result will be a world map with the countries with the lowest fisheries production in Blue and the countries with a high fisheries production in Orange.

FIGURE 17.2
World fisheries production



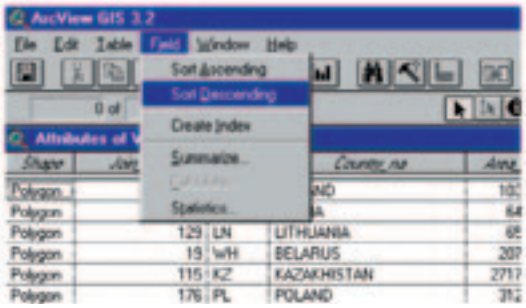
Filtering

The produced map shows clearly that China had the highest fisheries production in the world in 1999. Have a look at the data in more detail. Open the 'Attributes Table of

FIGURE 17.3
Attributes of 'World.shp'

World.shp' (Figure 17.3) (either by pressing the Attributes button in the Tool bar, or by going to the project screen [close the view window], clicking on the tables icon, and then clicking on 'Attributes of World.shp'). After opening the 'Attributes of World.shp' table we'll see:
You need to sort the data according to Total fisheries production. First press the field heading 'Total'. Now sort the data descending, so that China will be on top of the list. Click on **Field/Sort Descending** via the menu bar (Figure 17.4).

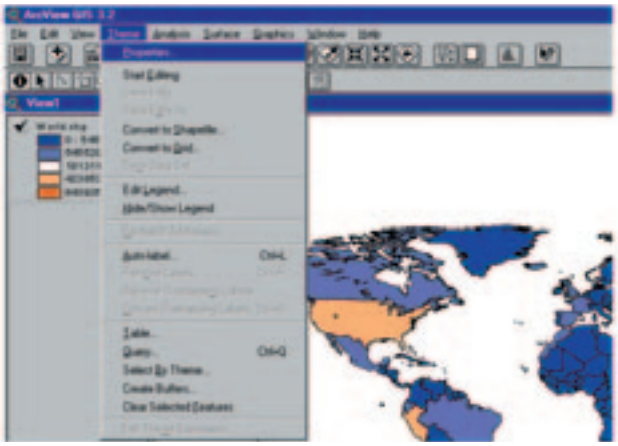
FIGURE 17.4
Sort Descending menu



The window that pops up shows the 'Attributes of the world.shp' table sorted on total fisheries production. The country with the highest production in the world is China, with a production of 47 499 759 metric tons of fish in 1999. Peru follows as second in the list with 8 439 351 metric tons. The production of China is more than 5.5 times higher than second placed Peru. This will have an effect on the way we can see differences between the countries.

What if you want to produce a map without China, so that you will get a clearer picture about the differences between the other countries? Have a try: first close the 'Attributes to world.shp' table, and go to the view of 'World.shp'. Now click on: **Theme/Properties** via the menu bar (Figure 17.5).

FIGURE 17.5
How to get to the Theme Properties window

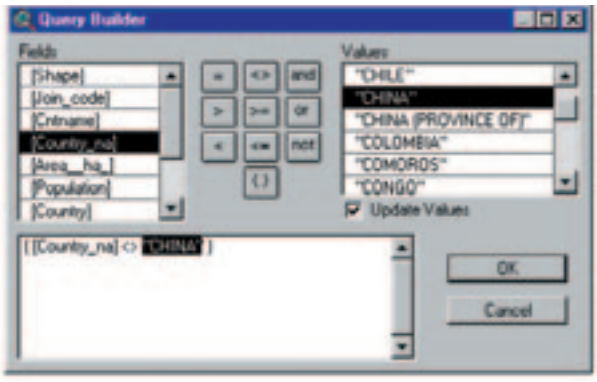


The Theme Properties window pops up. Make sure there's a square around the **Definition** Icon.

Press the **Query Builder** button.

The **Query Builder** window will pop up. Here you will be able to filter which countries are going to be shown (or will not be shown). Filter on the field **[Country_na]**, in other words: double click on **[Country_na** in the Fields select box. You will see that **[Country_na]** will appear in the bottom Query Builder box. Now select (double click) the sign <>, which means 'unequal to'. Also this will appear in the Query Builder box. The last action will be to select (double click) 'China' from the values screen (Figure 17.6).

FIGURE 17.6
A built query



Verify that the Query Builder looks the same as the above example. Now press **OK**. The Query Builder will disappear and you will see the view of 'World.shp' with the **Theme Properties** window on top of that. Press **OK** in the Theme Properties window. A new view appears, a map of the world without China (Figure 17.7).

FIGURE 17.7
View of the world without China

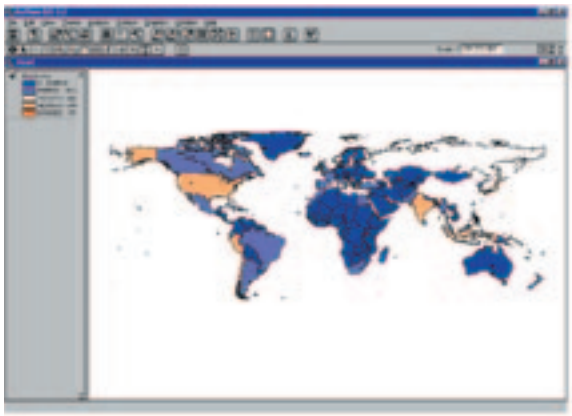
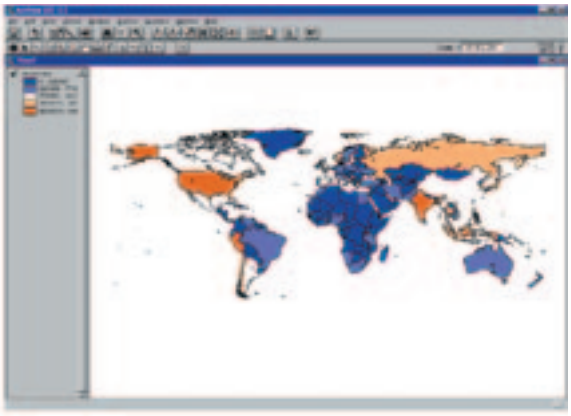


FIGURE 17.8
World fisheries production without China



The map didn't change in its legend, so there's still no clear difference between the different countries in the world. Let's change that. Go to the **Legend Editor**, change the **Classification field** to **None**, and back to **Total**. Make sure the **Color Ramps** are still on **Blues to Oranges dichromatic** and press **Apply**, close the **Legend Editor** and have a look at the result (Figure 17.8).

Now it becomes clear that after the high producer China, the other high producers are to be found in Asia and the Americas. Striking is that the countries in Africa all belong to the low producers.

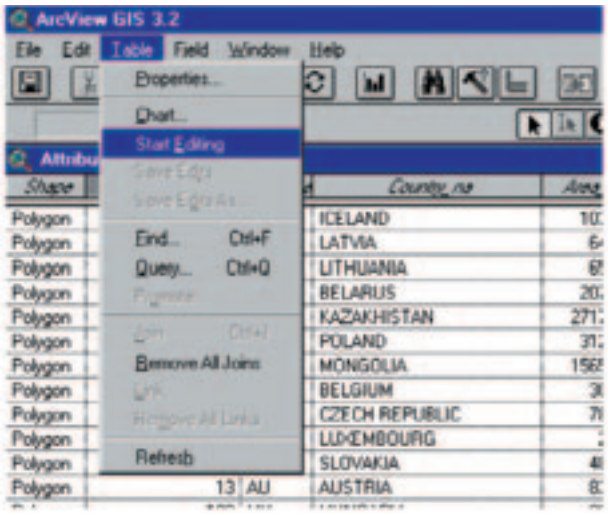
To get the complete worldmap back you simply remove the query in the Theme Properties by pressing the Query Builder button, deleting the Query, Press **OK**, again press **OK** in the Theme Properties screen, re-edit the legend in the legend editor.

Calculate

You have seen how to make a world map with the world fisheries data, clarify this map by removing the country with the highest fisheries production (China), but what about the productions per capita? If we want to see those, we first have to do some calculations which also can be done in ArcView.

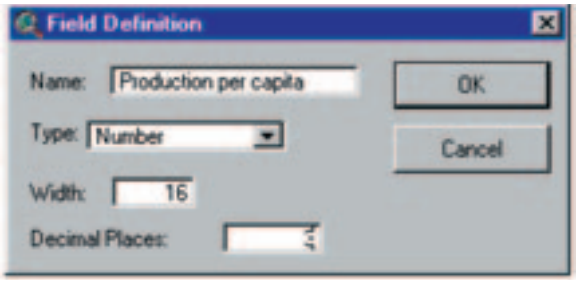
From the view of 'World.shp' go to the (new, joined) attributes of this Theme. First we have to add a field where we can put the results of our calculations. Go to: **Table/Start Editing** via the menu bar (Figure 17.9).

FIGURE 17.9
Start editing attributes table of 'World.shp'



When you do that, you will see the lettertype of the field headers change from *italic* to normal (only the fields that are shown with normal lettertypes can be edited). Now we can edit the table. To add a field we go to **Edit/Add Field**. A **Field Definition** box pops up where we can define the different properties of the new field (Figure 17.10). In the **Name** field we'll put the name: 'Production per capita', **Type** field is 'Number', Width is 16, and for 'Decimal Places' we will put 3.

FIGURE 17.10
Field definition pop-up for added field



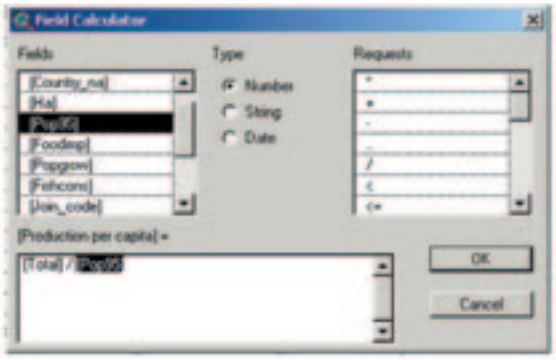
After pressing **OK** you will get a message saying: 'Field name too long. ArcView will truncate field name and use original name as alias. Continue?'. Press **Yes** and see the new field appear at the right end of the table. You can also see that the header is 'pressed' (Figure 17.11).

FIGURE 17.11
Attributes table of World.shp with added Field

Now the calculation can start. Make sure the header of the field **production per capita** is 'pressed'. Press the calculate button. The Field Calculator window pops up.

The field calculator has four parts; 'Fields' where you can choose with which fields you make your calculations, 'Type' which defines the fields with which you do the calculations, 'Requests' where you can define which calculations you want to make, and a field where you see the formula that you make. For the field **production per capita** we want to calculate how much fish is produced per capita in each country in kg/capita. So you have to divide the field **Total** by the field **Pop95**. First double click in the **Fields** part on **[Total]**. You will see **[Total]** appear in the bottom field. After this you go to the **Requests** part and double click a **/**. Also the slash you will see appearing in the fourth part. Now the last field we're going to put in, double click on **[Pop95]** and see it appear in the fourth part (Figure 17.12).

FIGURE 17.12
The Field calculator ready to perform the calculation



Press **OK**.

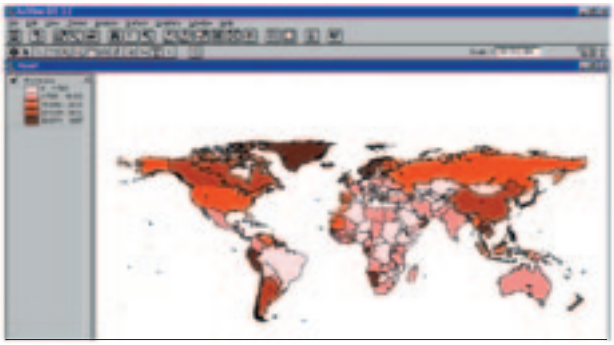
You will notice that the numbers in the **production per capita** field are very low. Why is this?

As you might have guessed we have calculated the production in metric tons per capita, while we want to get kg/capita. So we have to do the exercise again. Follow the above described procedure, after putting the **[Population]** in, also type ***1000**. By doing this you calculate the production per capita in kg/capita. If you now look at the attributes you will see that the figures are changed.

It is now possible to make a map with the production/capita (production per capita) figures. Go to **View** and go to the legend editor (**Theme/Edit Legend**). Change the Legend Type into Graduated color, the Classification Field into 'Production per capita' and press **Apply**.

What strikes is that China isn't among the high producers anymore, but that now Iceland, Greenland and Chile immediately show up on the map as having a high production per capita. If in the legend editor you go to **Classify** and there change the **Type** into **Equal Area**[28], press **OK** and **Apply** you will see the map change into (Figure 17.13).

FIGURE 17.13
World fisheries per capita



Try now to make maps which show Aquaculture production per capita (kg/capita), Inland Water capture fisheries production per hectare (kg/ha), and Marine capture fisheries production per country.

17.1.2 Frame survey Lake Volta, Ghana

This exercise is based on the work of de Graaf and Ofori-Danson (FAO, 1997b) in the FAO project: Integrated development of artisanal fisheries (IDAF). Lake Volta (Figure 16.14) was formed as a result of the damming of the Volta River by the Akosombo dam in 1964. The created lake has a surface area of about 8 400 km^2 or 3.6 percent of the surface area of the country, a shoreline length of 4 800 km, a maximum depth of 70 m and a mean depth of 19 m. Trees were not removed before the creation of the basin and the existing tree stumps have a considerable impact on fisheries and navigation on the lake. It was early realized that the building of the dam would have major effects apart from power production. These effects were primarily the effects on public health, transportation and the development of a new fishery.

From its creation in 1964 till 1977 fisheries was monitored thoroughly by a number of projects and Institutes. A first full frame survey, carried out in 1970 and repeated in 1975, indicated that 13 800 canoes were operated by 20 600 active fishers. The catch of Lake Volta was monitored since 1969 with a stratified catch and effort monitoring system, whereby the lake was divided in seven strata. Total catch during the period 1969–1977 is presented in Table 17.1.

[28] This method classifies polygon features by finding breakpoints so that the total area of the polygons in each class is approximately the same.

TABLE 17.1
Estimated catch of Lake Volta 1969–1977

Year	Estimated catch *(metric tonnes/year)*
1969	61 700
1970	39 200
1971	39 000
1972	36 000
1973	35 900
1974	37 300
1975	41 900
1976	40 700
1977	38 300

After 1977 the monitoring system on Lake Volta deteriorated and in 1995 major questions were:

- How many fishers are present at Lake Volta?
- What is the fisheries production?

IDAF set up, and carried out a full frame survey in Stratum 7 of Lake Volta, which lies between longitude 0° 10' west to 1° 05' west and latitude 8° 8' north to 8° 20' north and extends for about 60 km south and 50 km north of Yeji (Figure 17.14).

FIGURE 17.14
Lake Volta with stratum 7 (in red)

During the frame survey all villages were visited. In the villages interviews were held with groups of fishers. The following information was collected:

- Name of the village, when it was created and the number of ethnic groups in the village.
- Number of families, number of people per family, number of fishers per family.
- Number of canoes, number of winch boats, number of gill nets per canoe, crew number, major fishing gear, and target species.

- Transport facilities to the main market of Yeji and schooling for children.
- The number of ovens used to smoke the fish and the number of Chokor ovens.

Description of the situation in the stratum 7 of Lake Volta

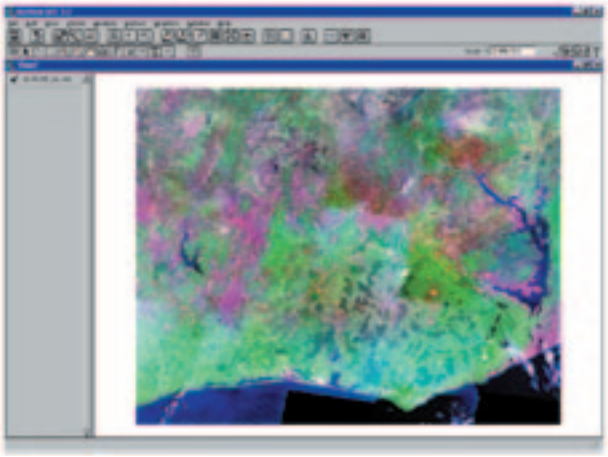
The fisheries can be characterized by the use mainly of two types of boats:

- A canoe, owned and operated by a family using gillnets, hook and line, traps, or similar equipment.
- A Winch-boat, mostly owned by large traders and operating with a hired crew of around 10 people, using a small purse seine in the deeper water.

There are almost no roads in the area and most of the transport of goods and people is done with large transport boats. Almost all fish is smoked or salted and sold once a week to large traders at the fish market of Yeji. Most of the fish is smoked in traditional ovens which use a considerable quantity of wood. Deforestation of the shorelines is a major problem and risk for Lake Volta. Therefore the project introduced the use of the Chokor oven which uses less fuel wood. All data are digitized and can be used to carry out a preliminary analysis in GIS in the following exercise.

1. Open ArcView, Open a New Project, and Open a New View. Set the working directory. Make sure the extension MrSid Image Support is installed (go via the menu bar to: **File/Extensions...**, and check the box of MrSid Image Support). This extension makes it possible to work with satellite images.
2. Add the Theme 'N-30-05_loc.sid' from the 'RW_02_Lake_Volta' folder to the View. Make sure you have 'Image Data Source' in the Data Source Types: selection box. Check the legend checkbox of the Theme, and wait a while, as this is a very big file. After waiting you will see Figure 17.15. This is a picture of west Central Africa, and if you look on the right hand side, you will see Lake Volta. Compare this picture with Figure 17.14.

FIGURE 17.15
After loading the 'N-30-05_loc.sid' Theme



You are now requested to make an analysis of the situation in Stratum 7 of Lake Volta, the part where the IDAF project was situated. This analysis should include:

- An ArcView-project with which people can get an impression with photographs of the fisheries in Lake Volta.
- A Theme indicating the canoe, winch boat distribution over the villages, where also the number of fishers per village is indicated.
- A Theme (or several maps) showing socio-economic data (like average family size per village, the number of fishers per family per village, villages with chokor ovens).
- A Theme (or several maps) showing fisheries data (like distribution of gillnets and beach seines over the villages, indicating which villages target Tilapia, or

Chriysichtys, average number of crew per canoe over the villages, the number of gillnets per canoe over the villages).

- A Theme which shows the position of the Akosombo dam downstream of Lake Volta.

For this you have the following data available in the 'RW_02_Lake Volta' folder:

N-30-05_loc.sid: The satellite image you have opened before of Central west Africa, with Lake Volta on the right-hand side.

DATA_FRAME_SURVEY.xls[29]: The file containing the data of the frame survey done by the IDAF project. For a description of the data, see the description of the frame survey on the previous page.

Stratum 7.shp: The Stratum 7, The area of the IDAF project.

Chokor.bmp: A photograph showing the Chokor oven, a fuelefficient oven to smoke fish.

Shoreline.bmp: A photograph showing the shoreline of Lake Volta. Pay special attention to the bare trees on the wateredge.

Brush park.bmp: A photograph showing the nifa nifa system. This system is specific for Lake Volta to catch Tilapia. At night the nets are lowered, after which the Tilapia gets stuck in the net, and can get harvested.

Yeji Market.bmp: The place where fish is being sold.

Landing catch.bmp: Close to Yeji market the fish is being landed, do you see the fisheries officer of IDAF collecting the data?

Photo location.shp: A point Theme showing the locations where the above three pictures were taken.

Roads.shp: The roads close to the Stratum 7 area.

[29] The following abbreviations are used as field names in the different Themes:

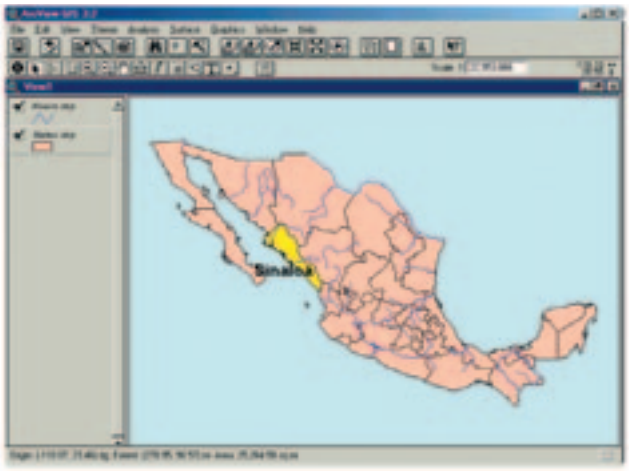
Ethnic	Number of ethnic groups in the village
Population	Total population in the village
Year	Year of construction of the village (0 = unknown)
Nhh	Number of households
Avppphh	Average number of persons per household
Avgfphh	Average number of fishers per household
Fishers	Total number of fishers in the village
School	Presence of school
Canoes	Number of canoes
Bundles	Average number of gillnets used per fishers
Crew	Number of crew per canoe
Winch	Number of winch boats operating from the village
Species	Major species in the catch (TI=Tilapia, HS=Hemisynodontis/Synodontis, CH=Chrysichthys)
Gear	Major gear used (GN=gill net, TR=traps, W=winch, BS=Beach seine)
Avgoven	Average number of fish smoking ovens
Totoven	Total number of ovens
Chokor	Number of Chokor ovens, ovens which use less fuel wood and which were promoted by the project
Transpboat	Transport boats available in the village

17.1.3 GIS analysis of catch data of artisanal fisheries in Sinaloa, Mexico

Sinaloa (Figure 17.16) is one of Mexico's major fishing states. It ranks first in terms of commercial value of output and fourth place in terms of volume of the catch. The shrimp catch, which accounted for more than one third the national total in the past five years, is of prime importance.

The state's fishing industry is primarily a supplier of fresh products. Approximately 95 percent of output is for direct human consumption, and the remaining 5 percent is processed in 119 plants. Spectacular growth has been seen in Sinaloa's aquaculture in recent years. In 1987 there were only 27 fish or shirmp farms, in 1995, that number had climbed to 138. In the same period output of shrimp farms rose from 585 metric tons to 8 725 metric tons.

FIGURE 17.16
Sinaloa state



The artisanal marine catch of Sinaloa is recorded by 10 fisheries offices and data recorded over the period 1990–1999 can be analysed with GIS[30]. The major objective of this exercise is to show linking of data which is not covered in the first part of the manual.

To complete the exercise you will have to perform the following tasks:

- Map the office locations onto a base map of Sinaloa State.
- Link a data table of catch statistics to the map of office locations.
- Create a map showing the average catch of selected species per office.

To complete the task, you will need to use the following ArcView Themes and data tables:

- 'Sinaloa.shp' (map of Sinaloa).
- 'Water.shp' (map of all water features (lakes, rivers etc.) in Sinaloa).
- 'Fisheries Offices.shp' (map of fisheries offices and their location).
- 'Catches.dbf' (data table of catch statistics).

1. Open ArcView, New project, new View.
2. Add the Themes 'Sinaloa.shp', 'water.shp' and 'fisheries offices.shp' from the 'RW_Mexico' folder.
3. Close the new View and Add the table 'Catches.dbf' from the 'RW_Mexico' folder.
4. Open the 'catches.dbf' table and you will see that it contains 23 fields:

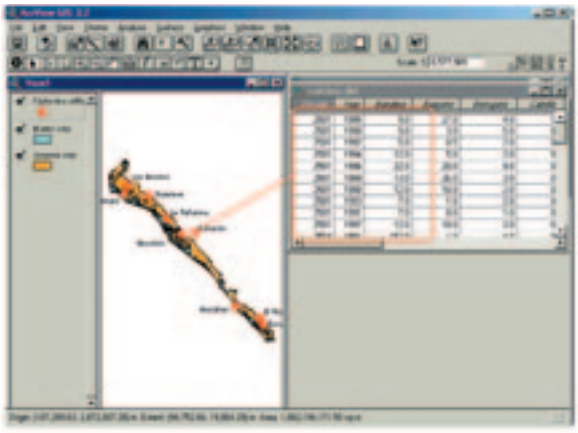
- **Ofcode** – a code assigned to each office;
- **Year** – year when catch data was recorded;

[30] The original exercise was made by Paul Eastwood, Fisheries GIS Unit, Department of Geography, Canterbury Christ Church University College, UK, with data provided by Arturo Ruiz, but is slightly adapted for this manual.

- **Bandera, Banqueta…Tiburon** – catches (in tonnes) of fish per species, the Scientific and English common names are provided in Table 17.2;
- **Total** – total catch (in tonnes) of all species.

The first step would be to join the fisheries data in the table with the location of the fisheries offices and this can be done by using the 'Ofcode' in both themes. However, if you do this the way explained in the chapter: Joining data with location on a map on page 22, you will see that not all data of the catch table will be joined with the attribute table of the fisheries offices. The problem is that the Catch data table contains more then one row (= a record) of data, one row for each year, for each office location (Figure 17.17).

FIGURE 17.17
Multiple data per fisheries office



This is what in GIS is called a 'One-to-Many' relationship. If you join the 'catches.dbf' table with the 'fisheries offices.shp' Theme, ArcView will take the first related record from the table, and ignore the additional records for each office. In these cases, you should **link** the tables instead.

5. Open the 'catches.dbf' table, tile the window, open the 'attribute of fisheries offices.shp' table, tile the window. Activate in both tables the field name 'ofcode'. To link the two tables, from the Table menu choose **Link** (Figure 17.18).

FIGURE 17.18
Linking two tables

If you look at the 'Attribute of Fisheries offices.shp' table you will see that nothing has changed after this action. But the two tables are linked which you can see with the select feature tool:

6. Make the View window active and use the select feature tool  to select any of the offices, i.e. by clicking on the office locations in the view window. All

linked records in the catches.dbf table will be selected (selected records are highlighted in yellow). Once an office and its associated records in the 'catches.dbf' table have been selected, they can be grouped together into a single block.

To do this, first make the 'catches.dbf' table active, and then click the promote records button  . This moves all highlighted records to the top of the data table.

Statistics for the selected records are obtained by first clicking on a column header in the 'catches.dbf' table, then from the Field menu choose Statistics (**Field/Statistics...**) (Figure 17.19 and Figure 17.20). If no records are selected then statistics will be given for all records in the chosen column.

FIGURE 17.19
How to get statistics on selected records

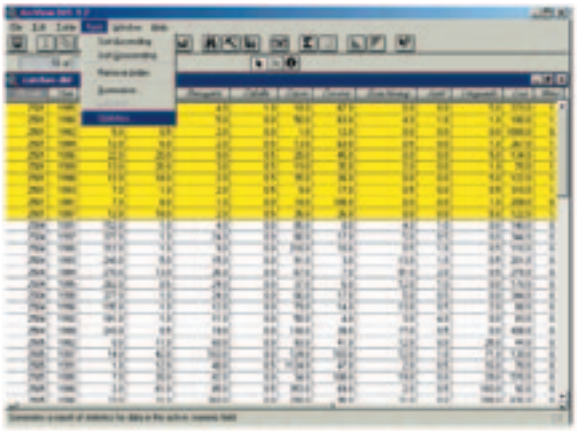
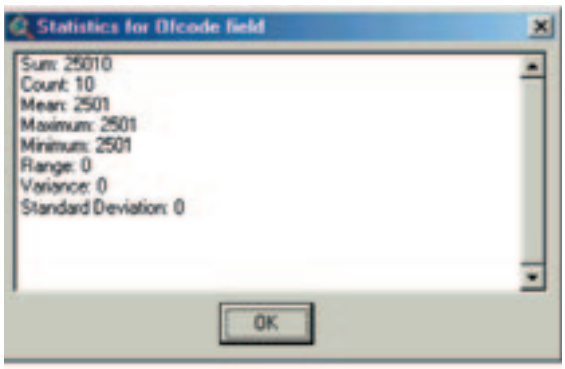


FIGURE 17.20
The statistics window



Please answer the following questions by selecting offices from either the table or the map and examining the associated catch data:

7. Find the mean catch of Berrugata recorded at the Los Mochis office for the years 1990 to 1999.
8. For the Mazatlan office, find the maximum recorded catch of Tiburon and the year when it was recorded.
9. Find the total recorded catch of all species at the Topolobampo office for the entire ten year period.
10. Which office recorded the highest catch of Lenguado in 1995, La Reforma or Guasave?
11. Lisa (*Mugil cephalus*) is the most common species caught by artisanal fishers in the coastal waters of Sinaloa. (You will need to examine the statistics of each office in turn to answer some of these questions).
12. Which office recorded the highest mean catch of Lisa over the entire ten year period?
13. How many offices recorded a mean catch of over 100 tonnes?
14. Is there a spatial pattern in the distribution of catches, e.g. high catches in the north, low catches in the south?

You may have noticed that some species are caught in greater abundance than others. The top three species or species groupings in terms of mean catches over the ten year period are:

- Lisa, *Mugil cephalus.*
- Cazon, juveniles of several shark species.
- Tiburon, *Carcharhinus* spp.

The data for Lisa, Cazon and Tiburon will now be extracted from the catches data table and examined in more detail.

15. Make the 'catches.dbf' data table active and click on the column header labelled 'Ofcode'. From the **Field** menu choose **Summarise...**. In the Summary Table

Definition dialogue box that appears, select 'Cazon' from the Field: pull-down menu and 'Average' from the Summarize by: pull-down menu. Click **Add**. Repeat the procedure for Lisa and Tiburon. Click **Save As**, navigate to a folder where you can save the file and enter an appropriate file name. The Summary Table Definition dialogue box should something like this:

FIGURE 17.21
Summary Table Definition

16. Click **OK** to create the summary table file.

The summary table can now be joined to the 'Fisheries offices.shp' Theme. Click on the 'Ofcode' column header in the summary table and then the 'Ofcode' column header in the 'Attributes of Fisheries offices.shp' table. From the **Table** menu choose **Join**. The summary table should now be joined to the 'Attributes of Fisheries offices.shp' table.

The table contains unnecessary data and can be tidied up. Make the 'Attributes of Fisheries offices.shp' table active. From the **Table** menu choose **Properties…**. In the Table Properties dialogue box make sure that a tick only appears alongside the 'Office', 'Ave_Cazon', 'Ave_Lisa', and 'Ave_Tiburon' fields by clicking in the 'Visible' column to remove ticks from unwanted fields. In the 'Alias' column, type 'Cazon' alongside the 'Ave_Cazon' field, 'Lisa' alongside the 'Ave_Lisa' field and 'Tiburon' alongside the 'Ave_Tiburon' field (Figure 17.22).

FIGURE 17.22
Cleaning up a table

Visible	Field	Alias
	Shape	
✓	Office	
	Ofcode	
	Latd	
	Lond	
	Ofcode	
	Count	
✓	Ave_Cazon	Cazon
✓	Ave_Lisa	Lisa
✓	Ave_Tiburon	Tiburon

17. Click **OK** to save the changes to the table properties.

In the 'Attributes of Fisheries offices.shp' table increase the width of the columns so that all of the data and column headers are clearly visible. The table should now look like Figure 17.23.