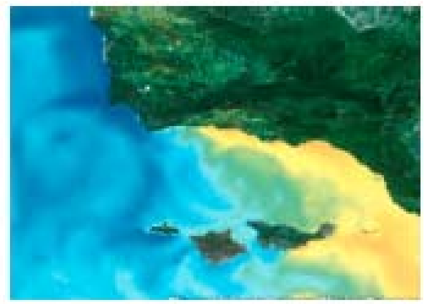
GEO 465/565 Invisible Boundaries

Based on the *Mapping an Ocean Sanctuary* series of the Center for Image Processing in Education



Assessing fish distribution in the Channel Islands Marine Sanctuary

The waters that swirl around the five islands contained within the Channel Islands National Park and Marine Sanctuary in California combine warm and cool currents to create an exceptional breeding ground for many species of algae, plants and animals. Each current has unique physical and chemical characteristics, creating invisible boundaries that divide the sanctuary into separate water masses; each mass has its own characteristic flora and fauna. The diverse bounty found around the northern Channel Islands results from these distinct water masses and their associated organisms.

A. Copy the lab3 folder from the Geo_565/data folder into the lab3 folder in your student directory

B. Start ***ArcMap*** and open the project **InvBound.mxd** from the lab3 folder that you previously copied to your student directory.

C. The view opens showing the southern California coast, bathymetry, topography, sanctuary boundaries, and major islands of the Channel Islands National Marine Sanctuary.

Understanding Currents

Two main currents impact the waters of the sanctuary: the prevailing southbound California current and the north-bound Southern California countercurrent. The California current brings cold, nutrient-rich water from the Gulf of Alaska. It is part of the wind driven, clockwise *gyre* system found in the Northern Hemisphere oceans. The Southern California countercurrent travels northward, along shore, bringing warmer water up along the coast. (A **gyre** is a large, circular wind-driven current found in each of the major ocean basins. Gyres in the Northern hemisphere flow clockwise while those in the Southern Hemisphere flow counter clockwise).

D. Turn on the **California current** and **S. California countercurrent** layers by clicking in the boxes before each of their names. Both of the currents should appear on your map.

E. **Zoom-in** on the Channel Islands National Marine Sanctuary, represented by the black line surrounding the islands. Click on the Zoom-in tool and draw a box around the designated area.

1. Which islands would you expect to have flora and fauna more closely similar to northern California? Southern California? Why?

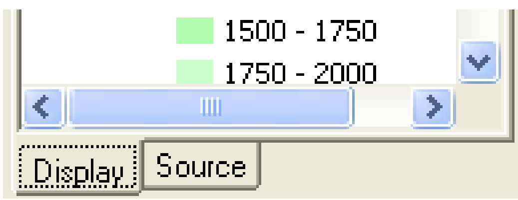
Beginning at Point Conception, the California coastline follows an east-west, rather than a north-south, path. This area is called the southern California Bight. The east-west orientation of the shoreline and the presence of the Channel Islands offshore protect the region from ocean waves and northwesterly winds that cause upwelling. Upwelled water from regions north of Point Conception enters the western end of the Santa Barbara Channel and moves eastward along its southern boundary. (A **bight** is a curve in the coastline. **Upwelling** is a process which carries nutrient rich water upward towards the surface. It increases the productivity of an area, supporting plankton blooms and attracting many fish species.)

F. Turn on the **SST0798** theme by clicking check box 

in front of the **SST0798** theme. It shows the average sea surface temperature in degrees Celsius during July 1998.

Daily sea surface temperature (SST) readings were collected by satellites and averaged together using computers to produce this map. By averaging the SST data over several days scientists minimize cloud interference and obtain better data. Warmer temperatures are shown in shades of yellow, orange and red, cooler temperatures in blues and purples.

G. Move the **SST0798** layer below the **California Current** and **S. California Countercurrent** layers so you can see both. *ArcMap* draws its map from the bottom up; layers appearing at the top of the table of contents window are drawn last, or on top.

- On the bottom of the table of contents window make sure that the **Display** tab is activated.
- 

- **Click and hold** on the layer name. Drag it to its new location, up or down the table of contents window.

H. Change the colors of the **California Current** and **S. California Countercurrent** layers if you have difficulty seeing them on top of the **SST0798** layer.

I. Activate the **SST0798** layer. Use the Info tool to find out the sea surface temperature at different locations around the sanctuary. They were rounded to the nearest degree Celsius.

2. What was the surface water temperature range found around the Channel Islands during July 1998?

3. Prevailing northern winds buffet the Channel Islands. How do they affect the water temperature between the northern and southern sides of the islands?

Winds are named by the direction from which they blow, while currents are describe in terms of where they are flowing to. Northern winds blow from the north to the south.

J. Turn off the **California current**, **S. California countercurrent, Bathymetry, Topography**, and **SST0798** Layers.

Collecting Fish Abundance and Distribution Data

The resources found on land and in the waters surrounding the Channel Islands are managed by several different state and federal agencies. In 1982, resource managers at the Channel Islands National Park, in cooperation with the Channel Islands National Marine Sanctuary and the California Department of Fish and Game began the Kelp Forest Monitoring project as a way to monitor changes and to assess the health of the ecosystem. Scientists use a variety of techniques including quadrat and transect counts, random point contacts, video monitoring, and a "roving diver" fish count to collect population abundance and distribution data for the area's algae, invertebrate, and fish populations. In this activity, we are going to analyze fish data collected using the "roving diver" method. The method was added as a survey technique in 1996.

During a "roving diver" fish count in the Channel Islands National Marine Sanctuary, SCUBA divers record all species they encounter, although they actively search for seventeen key species. Divers begin collecting data as soon as they enter the water. They are encouraged to explore the area within ten meters of an established transect line, looking under ledges, among kelp fronds, along sandy and rocky areas, and at different levels within the water column. The Channel Island National Park created permanent transect lines by drilling eye-bolts into and running a lead line across the sea floor. The permanent transect lines enable the SCUBA divers to monitor the same locations each year. Divers record the species names and abundance on an underwater slate using a pencil. The absence of any of the key species is also noted. Data are compiled by the Channel Islands National Park staff and used to help better manage the area's resources.

K. Turn on the **KeyFish** layer. The locations of the sixteen dive sites will appear.

L. Change the **color** and **symbology** of the **KeyFish** layer to make it more visible.

M. Open the **KeyFish** attribute table.

- **Right-click** on **KeyFish** layer name and select open attribute table from the menu.

N. Use the scroll arrows to explore the table.

4. How many records are there? What information is provided about each fish sighting?

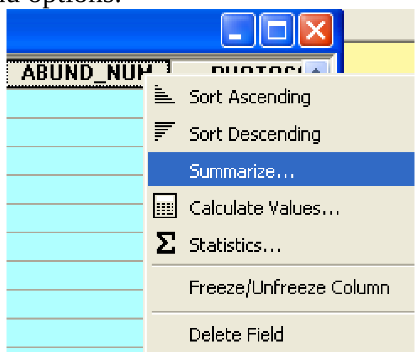
The *Abundance* and *Abund_num* categories both provide a relative estimate for how many fish were spotted. By assigning each abundance code a number, we can determine the average group size seen for each species. Species not observed are assigned an *abundance* code of "-" and an *Abund_num* of "0". To make your analyses easier, only record from actual sightings of the seventeen key species are included in the KeyFish database.

Understanding Abundance Codes:

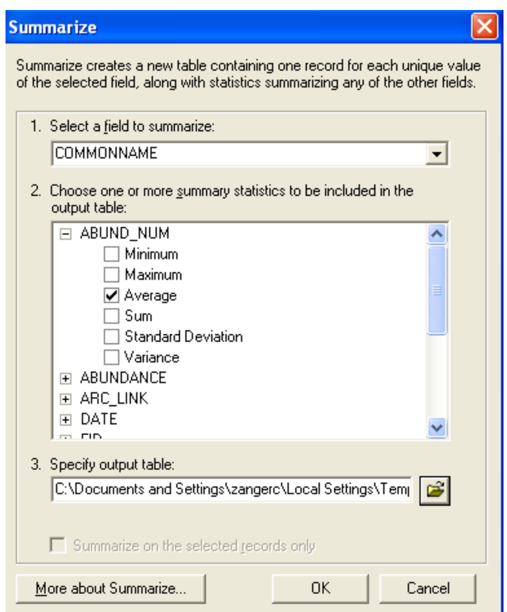
Group Size	*Abundance*	*Abund_num*
Single,1	S	1
Few, 2 - 10	F	2
Many, 11-100	M	3
Abundant, 100 +	A	4

O. Determine the number of times each species was sighted and its average *Abund_num* value.

- Right-click on the **CommonName** category in the data table, then click on Summarize from the menu options.



- This will pop up a Summarize window. Check the **Average** box for ABUND_NUM. This will include the average in the output table, as well as the number of unique records for each fish's common name. Notice how many other options there are for summarizing data. This helps with large data files. **Read** the next step before you click OK.



- Make sure **1 (Select a field to summarize)** is set to **COMMONNAME**, and that 3 **(Specify output table)** is set to the lab3 folder, in your directory.
- Click **OK.**
- *Be patient, the computer is crunching data!*
- Select **Yes** from the Summarize Complete Window.

- Scroll to the bottom of the Table of Contents (making sure you are in the Source tab).

  If you don't see your table there, click on the Add Data button  and navigate to the folder you saved the summary table to and add it.
- **Right-click** on the table and select **Open** from the menu options.
- **Right-click** on the Count_COMMONNAME column and select **Sort-Descending**.
- This organizes the table with the highest values at the top. Try sorting other columns ascending or descending and see how the data changes.

5. List the 5 most commonly sighted fish species. Give the number of sightings and average abundance number for each.

- There are a number of ways one could calculate the average abundance. Using the tools within ArcMap: perform a **Select by Attributes** selection of the appropriate COMMONNAME then, using the selected records only, view **Statistics** by **Right-clicking → Statistics** in the ABUND_NUM column. Remember to **Clear Selection** after you finishing analyzing each spp.

6. For the following species: blacksmith, treefish (juvenile), and rock wrasse (female), give the average abundance number and explain in words the average group size seen.

Note: Remember that the Abundance and Abund_num codes refer to the total number of individuals seen, not the group size.

The Effects of Water Temperature on Fish Populations

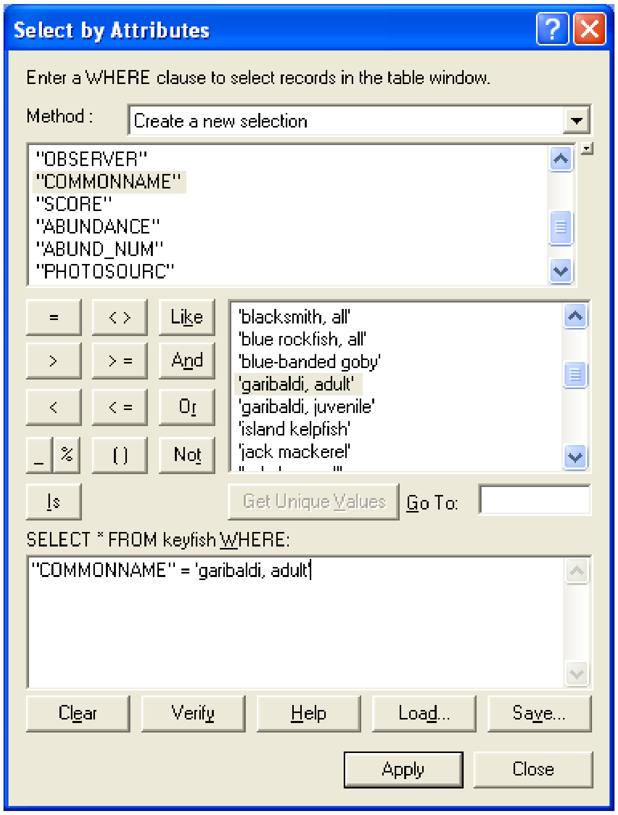
The Channel Islands represents a *transition zone* between the cooler northern waters and the warmer southern waters. Each current brings its own unique organisms, increasing the species diversity of the area. While many species are found throughout the Southern California Bight region, some species have their northern range limit in sanctuary waters, while other have their southern range limit within the sanctuary.

We will begin querying the data base to determine the distribution of individual fish species within the sanctuary. Garibaldi's are one of the best known California marine fishes. Adult Garibaldi's are bright orange, very territorial and feed on attached invertebrates. They are commonly found near rocky reefs or in kelp forests.

P. **Right-click** on the Keyfish layer. Select **Open Attribute Tabl**e from the Menu options.

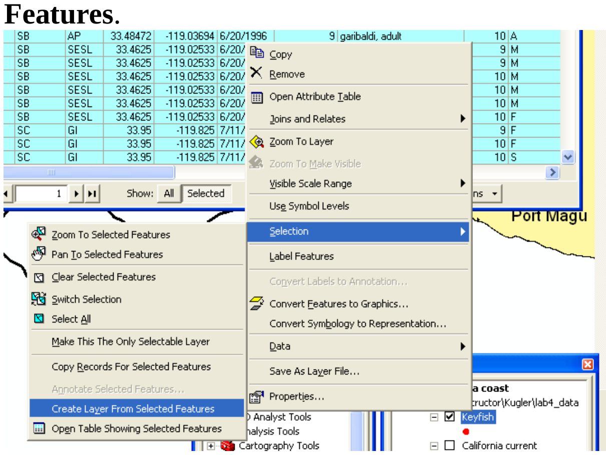
Q. Select the Options button at the bottom of the Attributes Window, and select **Select by Attributes** from the menu. This opens the Select by Attributes window.

R. Double click on **COMMONNAME**, single click on the **"="** sign and then click on the **Get Unique Values** button. Once the whole list of names comes up, scroll down and double-click on **garibaldi, adult.** This window builds the SQL query that will select all Adult Garibaldi all the other fish in the Keyfish attribute table. Click on **Apply**. See image below for an example



- Scroll through the attribute table until you see some of the selections. Then click on **Selected** button at the bottom of the Attribute table. This shows only the selected Adult Garibaldi, rather than the whole attribute table.

S. With the Keyfish attribute table open and the adult garibaldi still selected, Right-click on the Keyfish layer in the Table of Contents.

- Click on **Selection** in the Menu bar, and then **Create Layer From Selected Features**.
- 

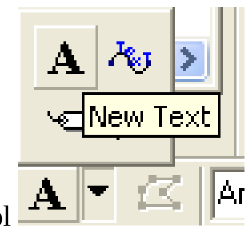
T. The new layer will be at the top of the Table of Contents. **Close** the Attribute Table. **Slowly** double click on the name of the new layer and change the name to **Adult Garibaldi**.

U. **Repeat** the steps outlined above to first query for and then to create layers for each of the following species: **señorita, island kelpfish, striped surfperch, blue rockfish, and California sheephead.** Check to ensure KeyFish Attribute Table is the active theme before each query.

V. Change each layers symbology to a unique symbol and or color.

The Channel Islands represents a transition zone between the colder Oregonian biogeographical province and the warmer California province. While the exact boundaries shift slightly each year, the historical boundaries have been drawn for you.

W. Add the Biogeoprovinces (**biogeopro**) shapefile (from the lab3 data folder). It shows the historical location of the Oregonian Province (colder water), Californian Province (warmer water), and the transition zone. Click OK at the projection warning box

X. Label the biogeoprovinces. Select the New Text tool 

from the Drawing tool bar at the bottom of the ArcMap project window. (Set size in the font size window at the bottom of the screen)

- Click in the channel between Point Conception and San Miguel. Type "**Oregonian Province**." Click in the ocean between Port Magu and Santa Barbara Island. Type "**Californian Province**." You may have to resize the text. To do so, double click the text box, and click on "Change symbol."
- The boxed-in area between the south side of Santa Rosa and Santa Cruz Islands south to Santa Barbara Island is the transition zone between the provinces. Click inside the boxed-in area and type "**Transition Zone**."

7. Study the individual species layers. Complete the chart below. Place an "X" next to each province the fish are found in. Use "XX" if the fish are found at all the sites in the province and "X" if the fish are found only at some of the sites. Copy or create a table like the one below in your Word write up.

Species	*Oregonian Province*	*Transition Zone*	*Californian Province*
A garibaldi			
B senorita			
C island kelpfish			

D striped surfperch			
E blue rockfish			
F CA sheephead			

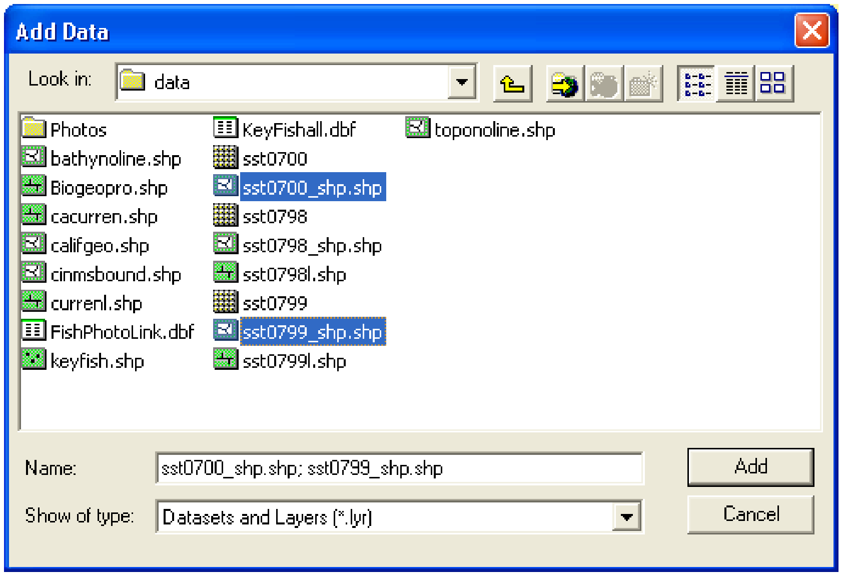
8. Suggest abiotic factors (other than temperature) that may limit the distribution of some species.

Y. Turn off all of the fishes layers.

Impacts of El Niño

The water temperature in the Channel Islands National Marine Sanctuary changes both seasonally (February through May are the coldest periods, while August and September are the warmest) and annually. Major climatic events such as an El Niño or a La Niña period can cause sea surface temperatures to be a couple degrees above or below normal. El Niño events are caused by the weakening of the trade winds which results in a large-scale warming of surface ocean waters in the central and eastern tropical Pacific. They last between 12 - 18 months. During El Niño years, upwelling off the coasts of Ecuador and northern Peru is suppressed (resulting in a tremendous loss of bioproductivity) and warm surface waters spread westward across the Pacific Ocean. During La Niña periods, trade winds strengthen, sea surface temperatures are lower than normal in the eastern tropical Pacific, and opposite weather anomalies occur.

A. **Add** the sea surface temperature shapefiles from **1999** (sst0799_shp.shp) and **2000** (sst0700_shp.shp) to the project. See full names highlighted below in blue.



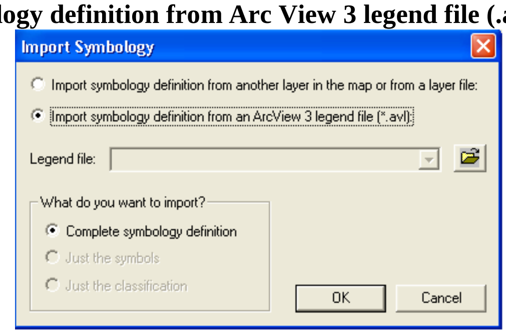
B. Activate the **SST0799** layer and open its Symbology window.

- Right-click on a layer then select **Properties** from the pop up menu. Activate the **Symbology** tab in the Properties Window

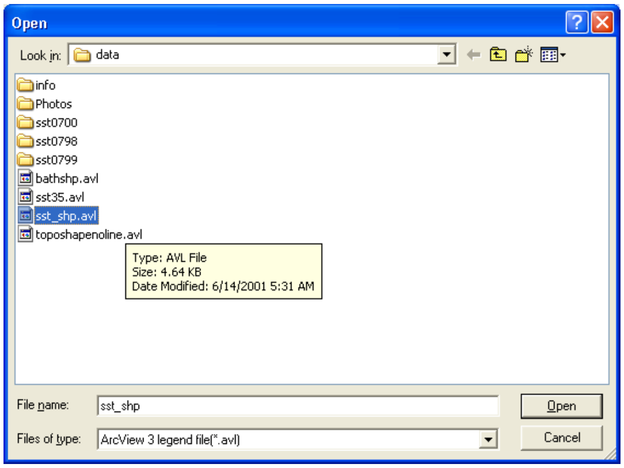
C. Import a previously defined legend file.

- Click on the **Import** button at the top of the Symbology window.

- From the Import Symbology window, make sure the radio button next to the second choice, **Import Symbology definition from Arc View 3 legend file (.avl)**.



- Use the Open Folder Button  to navigate to the lab3 data folder and select file named **sst_shp.avl**, then **Open.**



- Click **OK** in the Import Symbology window. From the Import Symbology Matching Dialog Window, select **TEMPERATUR** as the Value Field, then **OK.**

D. Repeat the above steps to change the legend for the SST0700 Layer.

You can now easily compare the SST composites from each of the years. The SST themes are opaque. To compare the maps, alternately turn each layer on and off. Make sure that the SST 0798 layer that was already in your Table of Contents is turned off.

We can show the shift in water temperature between years by tracing a single temperature line and creating a layer. Many temperature lines, or *isotherms*, can be displayed simultaneously. An isotherm line has been created for you for the July 1998 and 1999 SST maps.

E. Add the **SST0798l.shp** layer and turn it on. NOTE the **L** in the name!! If necessary, adjust the color and width of the line. The line follows a single temperature shift, connecting the points with the same temperature.

F. Turn off all of the SST themes except **SST0798**.

G. When you turn on the **SST0798l.shp** and **SST0798.shp** (again, note the L in the name) together you will see the temperature that the line follows. Make sure the line layer is displayed on top of the polygon layer.

9. What temperature shift does the line follow?

H. Turn off the SST0798l and SST0798 themes.

I. Add the **SST0799l** layer and turn it on.

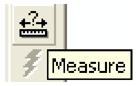
J. Move the **SST0798l** and **SST0799l** isotherm layers so that they are displayed on top of the **SST0700** layer. Turn on all three layers. You may need to change the symbology of the line layers to distinguish between them.

10. Describe the changes in SST that you see during the following years: 1998 (end of an El Niño), 1999 (La Niña year) and 2000 (normal).

You can measure how far the isotherm shifted due to the weather conditions.

K. Turn off the **SST0700** layer.

L. Measure the isotherm shift at the **widest point** on the north side of the islands.

- Select the 

measuring tool.
- Click once on the **1998** isotherm and draw a line to the **1999** isotherm line. Double click to end the line. The distance will appear in the **Measure** window.

11. Measuring from the mainland side of Santa Rosa Island at the widest point, how far (in miles) east did the 16°C isotherm line shift between 1998 and 1999?

12. The 1997-1998 El Niño event was particularly strong. How might the 1998 SST image compare to another the SST image from a different El Niño year?

Temperature fluctuations as small as 1-2 degrees can have dramatic effects on local fish populations. During warmer periods, colder species may swim offshore or to deeper water while warmer species are recruited to the area. During colder periods, the reverse occurs. Other species will stay, but will have a lower reproductive success. First, we will investigate the effects of SST on adult blue rockfish populations. If you have time you can investigate changes in the annual distribution of other species, such as garibaldi.

M. **Search** the **blue rockfish** records (from the blue rockfish layer you created earlier) to determine where the fish were seen each year, beginning with 1996.

- **Open** the **blue rockfish** Attribute Table to search records.

N. Select the blue rockfish records from all the 1996 surveys by changing your query to have all the records meet two criteria. They will occur on or after the first 1996 research date but on or before the last 1996 date. Use the >= and <= functions to build your query.

O.

- Click on the **Options** button at the bottom of the **blue rockfish** Attribute Table, select **Select by Attributes** from the menu..
- Double-click **DATE** from the fields box, and single click the **greater-than-or- equal to** button 

.
- Click **Get Unique Values**
- double-click on the **earliest** 1996 date.
- Single click on the **And** button, and then double click on **DATE** in the field box again. Click on the less-than-or-equal to button 

.

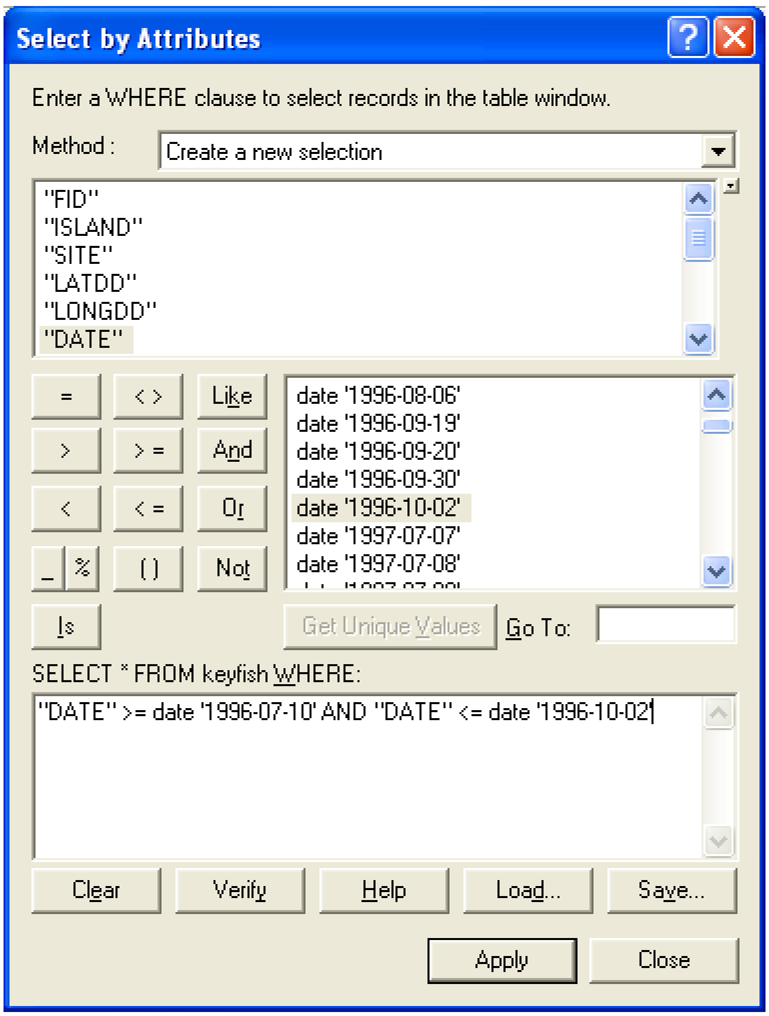
- double-click on the **latest** 1996 date. *You will have to scroll through the list!*

- Click **Apply**, if you get an error message double check your syntax. *See the image below if you need help.*

P. Create a layer from the selected records. See step **T** above if you don't remember. **Name** the record something appropriate for what it is.

Q. **Repeat** the above steps, creating shapefiles for the blue rockfish populations for **1997, 1998, 1999, and 2000.**

R. Congratulations! You've just completed multivariate SQL queries. If you want to experiment just make sure you click the **And** button between each qualifying statement. Date is the only one that needs the word date and single quotes on it. That is because of the unique structure of dates with the slashes in them.



13. What effect does water temperature have on distribution of blue rockfish? How is it affected by El Niño events?

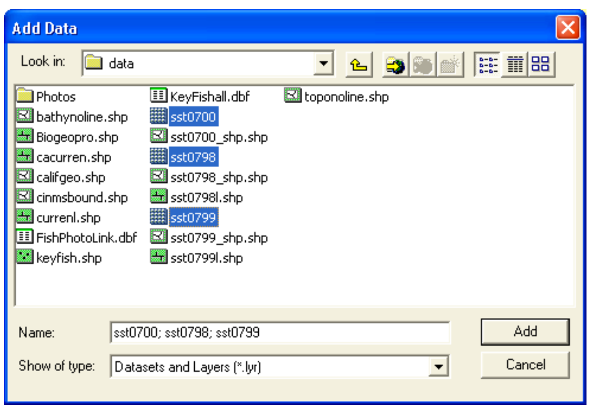
14. What happens to fish as the water temperature changes? How is this different from benthic invertebrates?

15. What effect does spatial temperature variation have on the species diversity of the Channel Islands Marine Sanctuary?

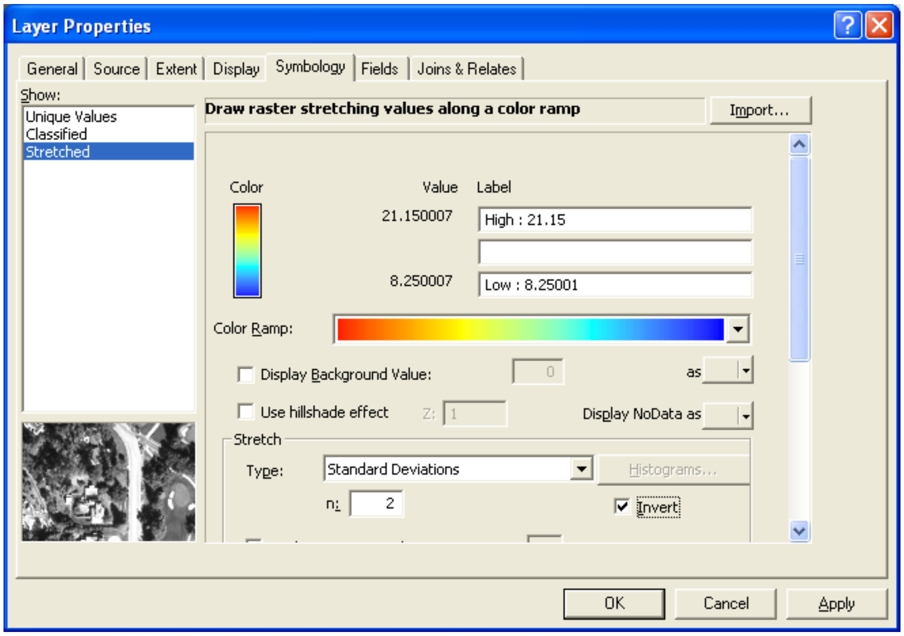
Extension Activities:

A. From the main ArcMap tool bar click on Tools, then Extensions. Make sure Spatial Analyst has a check next to it and close the Window. Right click on the main ArcMap tool bar to show the list of Toolbars. Make sure the Spatial Analyst tool bar has a check next to it. You'll see the Spatial Analyst tool bar in your main Project Window. You can dock it wherever you like.

B. Add the Sea Surface Temp data (SST). From the data folder in your lab3 folder add the **SST0798, SST0799**, and **SST0700** grid files. Use the Ctrl button on the keyboard to select multiple files. Click **OK**.



C. Turn on the SST layers and edit the legends. Open the **Symbology** for each and select the **Red to Blue** color pallet, check the invert check-box and click **OK**. **Repeat** for each of the SST layers.



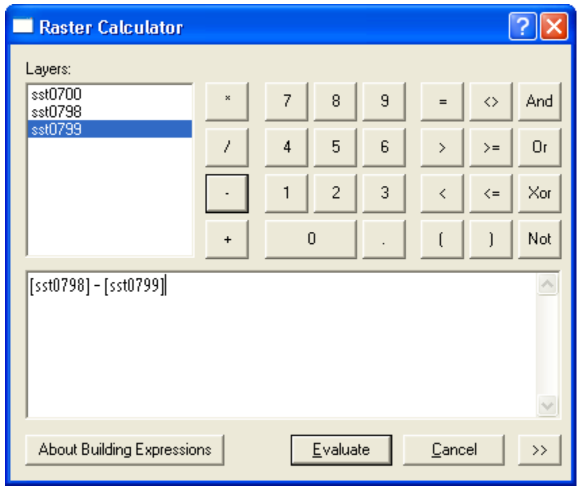
D. Turn off all layers **except** the **SST** grids, **California, Topography**, and **CINMS boundary**.

E. Each of the SST layers is opaque so you'll have to turn off the top layer to see each underlying layer.

16. Which layer is generally the warmest overall? Which is the coolest? How could you find out exactly? *Remember the summary table from earlier.*

F. Let's quantify the difference in sea surface temperature between an El Niño (1998) and La Niña (1999) event. To do this we will subtract one layer from each layer.

- Turn **off** all the SST grid layers.
- Click on **Spatial Analyst** and then **Raster Calculator** from the spatial analyst menu.
- This will open the Raster Calculator window. It is similar to the select by attribute window. Double-click on **SST0798** to add it to the expression, then single click on the **"-"** sign, lastly double-click on the **SST0799**. Then click **Evaluate**.



G. When the computer is finished calculating it will add the calculation to the table of contents. This is a new layer created by subtracting each cells value at each location, a couple of hundred thousand subtractions.

H. Change the symbology to be something that fades from one color to another.

I. Notice the legend values they start at a negative number and go to a positive.

17. What causes this negative to positive result?

18. What part of our study area showed a decrease in temperature from 1998 to 1999? What parts showed an increase?

J. Create a simple map layout with your calculation displayed, export it and attached it to your Word write up. **Drop** your write up in the drop folder and make sure you've put **your name** on it.