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"Continuing Management and Development of the Southeast Alaska Subsistence Fisheries Geographical Information System (GIS) Database"

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ABSTRACT

As part of this project, subsistence fisheries harvest data are presented in a Geographic Information System (GIS) created using Environmental Systems Research, Inc. (ESRI) ArcView® software. The GIS contains data for communities in Southeast Alaska, from Yakutat south to Ketchikan. Community harvests for the years 1985 to 2001 are organized by harvest location, and the GIS user can display these harvest locations in the map windows built for this project. The GIS also maps the locations in Southeast identified as having Customary and Traditional use of fish stocks. The GIS is modified to allow users with little or no GIS experience to use a graphic, map interface to browse, sort, select, and view salmon harvest data. The user can choose from three pre-defined map legends to depict harvest data. Each community's yearly harvest between 1985 and 2001, as well as the cumulative harvest per location, are available in Microsoft Excel files linked to the map. Users who are familiar with ArcView and GIS can access the source data files and integrate the data into other GIS projects.

Key Words: Salmon, Subsistence Harvest, Southeast Alaska, Geographic Information Systems, GIS

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INTRODUCTION

In the rural communities of Southeast Alaska, fish constitute the largest component of the annual subsistence harvest, and most of that fish is salmon. The average household uses more edible pounds of salmon than other types of fish. Also, in most communities, more households pursue, harvest, and use salmon than any other type of fish (Wolfe 2000, ADF&G 2003).

In addition to its caloric contribution, salmon have traditionally had great social, economic, cultural, and political value to the Tlingit people of Southeast Alaska. Prominent Tlingit clans owned individual salmon streams, negotiated the use of those streams by others, and maintained clan ownership through a system of inheritance (Langdon 1977; Oberg 1973; Olson 1967).

The Alaska Department of Fish and Game (ADF&G), Division of Subsistence, has conducted research on the contemporary use of salmon within the contexts of subsistence traditions, social organization and cultural heritage. The Division approaches the subsistence pattern of a particular community as a complex whole, influenced by history, culture, economy, demography, and geography. Division researchers often employ methods that produce a quantitative assessment of harvests (e.g. estimated number of pounds harvested, percent of households participating, etc.). In addition, researchers develop qualitative, descriptive means of documenting subsistence. Harvest mapping is frequently a component this research; mapping helps to visually describe where members of a community look for and harvest subsistence resources. The Division of Subsistence Technical Paper Series contains much of this research, including work conducted specifically in Southeast Alaska (Firman and Bosworth 1990; George and Bosworth 1988; Mills 1982; Thornton et. al 1990). These studies show that, throughout the state, including Southeast, the salmon harvest traditions and traditional use areas persist in the modern era.

ADF&G has collected extensive quantitative data on subsistence salmon harvests. In Southeast Alaska, the ADF&G Division of Commercial Fisheries collects subsistence salmon permits from fishers and generates estimates of the subsistence salmon harvest annually. The Southeast subsistence fisheries data are kept in a database at the ADF&G office in Juneau. These tables contain salmon harvest estimates, organized by species and by the fisher's community of residence, cross-referenced to location of harvest. A description of these harvest estimates, statewide, is also published by the ADF&G, Division of Subsistence, in its Alaska Subsistence Fisheries Annual Report series (ADF&G 2003), funded by the USF&WS Office of Subsistence Management.

This project, the "Southeast Alaska Subsistence Salmon GIS Database", adds value to the existing harvest database for Southeast Alaska communities by linking the tabular harvest estimates to harvest locations on a map. By showing harvests on a map, this project creates a geographic context in which to consider subsistence salmon harvests. The

spatial relationships apparent in an interactive digital map are useful to natural resource managers whose focus is on ecosystem composition and the interaction of ecosystem components. Resource maps communicate information about proximity, distribution, and position along geographical boundaries or continua, information which affects the user's understanding of the organization and operation of an ecosystem (see below, "Discussion").

An earlier project, funded by the Office of Subsistence management (FIS00-039), incorporated Southeast salmon harvest data into a map-based visual framework. This project, updated the maps, added more data and enhanced the functionality of that earlier project. The interactive, map-based framework used in these projects is called a "Geographic Information System" or GIS, and is a powerful tool for organizing data with a geographic component. GIS technology is used in diverse fields (including science, marketing, surveying, and natural resource management) to collect, organize, and analyze spatial information by connecting tabular data to locations on a map. A GIS is a computer program that organizes information in a way similar to a database. The Southeast Alaska Subsistence Salmon GIS Database is built with ESRI ArcView software, is written onto a CD, and constitutes the final product for this project.

Subsistence harvest data are well suited to the organizational framework of the GIS. In the Southeast Alaska Subsistence Salmon GIS Database, the subsistence permit data, stored in the database called "Alexander", are linked to a map depicting streams and waterways in Southeast Alaska. The database contains detailed information on the number of salmon reported harvested, referenced by fisher's community of residence and cross-referenced by location of harvest. The data were organized so that the maps illustrate the amount of salmon for any stream, the streams fished by members of a certain community, and streams fished during certain years. The user can query and sort the data along the lines of these variables. In this way, the GIS stores, organizes, and displays fisheries data according to their spatial relationships, and makes it accessible in a visual, searchable format.

The new features of this project (as compared to its previous format) are two additional years of harvest returns (2000 and 2001), and new formats that prepare the database for more complex lines of inquiry. These formats include the geographic locations of federal and state "Customary and Traditional" use findings, harvest estimates for sockeye (broken out of estimates for all salmon), and tables containing community harvest histories and harvest locations graduated by intensity.

Also in this version are new links and display options that make interaction with the GIS more user-friendly. Some of the display options execute certain analytical tasks for the user (such as the menu option to display the harvest locations that contribute 90% of the community harvest, see Figure 5). Despite the new, built-in queries, this version of the GIS preserves the way the earlier version allowed the user to access the basic data tables to create custom queries, the results of which can be depicted on the map interface.

This project includes a map representing the areas in Southeast defined as having fish stocks used customarily and traditionally by members of a certain community or communities. These "C&T" findings were made by either by the Alaska Board of Fisheries, or by the Federal Subsistence Board, or both. The boards are directed by sections of either the Alaska State Subsistence law (AS 16.05.094; AS16.05.258 (a)), or the law that established the Federal Subsistence Program (36CFR 242.24(a)(2); 36CFR 242.16), which require documentation of the location and geography of subsistence activities.

By providing some of the geographical data that helps define C&T use of fish stocks (such as distance between the fisher's home community and harvest location, location of the stocks traditionally used, and patterned use of stocks that occur on the landscape), the Southeast Alaska Subsistence Salmon GIS Database contributes to the documentation of harvest location and geographic relationships for the ongoing task of managing subsistence uses in Alaska.

OBJECTIVES

The objectives of this project as presented in the Investigation Plan included:

1. Identify and map fishing areas as described in the Southeast Alaska fishing regulations for 2000-2001, including bag limit and historical information for each fishery.
2. Adapt and update data tables for 2000, create hotlinks between presentation tables and maps.
3. Create maps showing federal and state customary and traditional use designations.
4. Present the project to selected Southeast Alaska communities. Make the GIS available to federal managers of subsistence fisheries.
5. Adapt and update data tables for 2000, showing sockeye harvests specifically.
6. Create maps showing each community's harvest area, based on 90% of salmon harvest.

The first objective was the only one of the seven that was not completed. This was due mainly to time constraints related to adjustments to the work being done on the other, more technically challenging objectives related to the functionality of the GIS. The history of each Southeast community's fishery was charted (harvest numbers and harvest location names), but information on the regulations, locations, and bag limits for each the individual permitted streams was not included in the GIS. The investigator gave priority to the tasks of linking the maps to tables and charts (see Objective 2), and enhancing the map display options (Objective 6), over the task of mapping a selection of fishing area boundaries because the former created access to new lines of data (quantitative, statistical, by location, by community) that make the GIS more valuable. Updating the basic harvest tables, and creating the programs to run the hotlinks (to harvest tables and

charts, and to change the map legend properties) were the tasks needed to reach Objectives 2 and 6, and performing these tasks took longer than the investigator expected.

The inclusion of 2000 and 2001 harvest data, sockeye harvests, the hotlinks to pre-configured harvest data tables, and the increased flexibility for harvest data map presentation are the main improvements to this project's version of the GIS. The hotlinks were completed as part of Objective 2, and Objective 5 saw the addition of sockeye harvests (broken out from overall salmon harvest). While the Investigation Plan called for adding the 2000 data, the extended schedule of the project allowed the investigator to include the 2001 data as well (with only little extra work). And the goal set out in Objective 6 was elaborated upon so that the map legends show not only the top 90% harvest locations, but also a graduated scale of the productivity of different harvest locations. (See Results section for more discussion of why these features were given priority by the investigator over those defined in Objective 1.)

Objective 3 was met with the inclusion of a map showing the areas where fish stocks are designated as having Customary and Traditional uses by the state and the Federal Subsistence Program. These C&T findings are mapped in the GIS in a separate map view, and contain information on the fish species, water bodies, and communities linked to each federal C&T finding, and the fish species and water bodies for each state C&T finding. Also included are the references in the Alaska Administrative Code where each state C&T use is defined. (See Figures 8 and 9.)

As was true of the earlier version of this project, the Southeast Alaska Subsistence Salmon GIS Database was presented to community representatives from the Southeast region (Objective 4). In 2004, Central Council of Tlingit and Haida Indian Tribes of Alaska ("CCTHITA") presented the data contained in this GIS, plus new data incorporated into it by the Division of Subsistence, during several meetings with corporation representatives and tribal representatives in Juneau. These presentations also included Tlingit placenames, data created by CCTHITA with technical assistance from Ecotrust, Inc. See the final report for CCTHITA FIS project FIS02-038 for details on that conference.

METHODS

This project was accomplished using existing databases, with subsistence salmon permit data collected and tabulated by the ADF&G, Division of Commercial Fisheries. The data from Southeast Alaska fisheries are stored in the "Alexander" database, a data repository housed in the ADF&G offices in Juneau. The principal investigator first performed queries of the data for Southeast communities for 2000 and 2001, collected a series of tables, then formatted the those tables so the information could be added to the

other years' harvests already in the GIS database. Alexander uses stream identification variables (names and indexed codes from the Anadromous Stream Catalog) in its database structure, and those were converted into a format to allow for linkages with the existing ADF&G map coverages, digital maps showing coastlines, streams, communities, etc.

Making the two data sets (the formatted Alexander tables and the tables associated with the GIS coverages) match took more time than expected (Objective 2). There were many cases in the Alexander database of multiple names for the same fishery, or misspellings of fishery names, and even multiple names for the same community (such as Ward's Cove and Ketchikan, or Douglas and Juneau). Extensive checking and cross-checking of salmon harvest numbers by location, by year, and by the fisher's community of residence all had to be executed by hand by the investigator.

In the earlier version of this GIS, the investigator used a method of formatting the data using the Anadromous Stream Catalog coding system. This method was cumbersome and inefficient, so for this version he attempted a modified method which used the stream name as the primary index for harvest data. The modified method involved as much labor as the previous method, but provided more accurate data for the GIS output. This was done with careful attention to detail so data would not be lost when transferred to the GIS data structure.

Using Arc View 3 software, a set of scalable maps was created using the harvest data, allowing for depictions of each community's harvest by fishing location. Tables and charts depicting the harvest information were linked to the community features on the maps using scripted programs written in ArcView 3.3's programming language, Avenue.

This GIS comprises a database that the user interacts with as a series of "map items." These map items contain harvest information from Southeast Alaska communities representing overall salmon harvests, and the sockeye salmon portions of those harvests specifically. The harvest information depicted in the maps here is a sum total of all the subsistence salmon harvests documented for Southeast Alaska streams, by Southeast Alaska community residents, between 1985 and 2001. (For individual year harvests, see discussion below on Excel charts and tables, and source data tables.)

In addition to map items containing harvest information, the GIS contains a separate section containing map items depicting the areas designated having state or federal C&T uses defined for fish species.

The ArcView GIS uses a "windows" environment, styled after the user interface familiar to users of Microsoft Windows operating systems. Users interact with the GIS windows environment in much the same way they would using Microsoft Word or Excel, using the mouse to move a cursor around the screen, "clicking" on buttons, tools, and menus to perform certain tasks.

Each of the map items is found in the appropriate map window, which the user selects from the Table of Contents window that first opens the project. Figure 1 shows the window that contains different types of maps available for display seen in the vertical Table of Contents menu on the left side of the ArcView window. The user clicks on one of these and the window opens onto a map with the "map items" that make up that particular map.

Figure 2 shows the map window titled "Subsistence Salmon Harvests." The map item "Hoonah Salmon" is selected (shaded box around the title) and activated (a check mark in the box next to the title). The legend for the map item "Hoonah Salmon" is located right below the map item name, showing that Hoonah salmon harvest locations will be represented by a red dot, and while the map item is active, those harvest locations appear as red dots on the map. The user activates and deactivates the map items simply by using the "Select" tool (the small box with the black arrow icon) to click the check mark on and off.

More than one map item in any map view can be displayed at one time (see Figure 5). In the cases where map items overlap on the map view, the map item that is closest to the top the list on the legend will obscure those below it. To remedy this, map items can be repositioned within the legend column by clicking and dragging.

There are several "buttons" on the GIS interface that allow the user to zoom in and out on the map view, open map item data tables, and other tasks that give the user power to select alternative ways of reading and representing the harvest data.

The investigator created a special button that allows the user to change the way the data contained in the selected map item are displayed on the map. This button, the "Legend" button at the top left of the map view window, opens a dialogue box that allows users to select the way they want to display the data for a particular community, either as a uniform set, by graduated points showing increasing harvests (at intervals pre-programmed by the investigator) or by filtering the set of harvest locations to show only those that contribute 90% of the community's harvest. Figure 3 shows the dialogue box, and the options for displaying the selected map items. This feature is available for both the all-salmon maps and the sockeye-only maps. By using the dialogue box to select the way they want the harvest data grouped, users produce thematic maps containing the requested information.

Figure 4 shows the Hoonah Salmon map item with the legend "Graduated Points By Harvest" selected. The legend shows dots in an array from light to dark, representing harvest locations that range from 1-199 salmon (the lightest color), to harvests of 4,000-9,228 salmon (the darkest). Figure 5 shows those harvest locations for Angoon, Craig, and Juneau that constitute 90% of each community's total cumulative harvest. The legend for each map item shows that the "90% Harvest" legend option has been selected using the "Legend" for these communities.

Next to the Legend button is a button that opens the Harvest Tables upon which the map items are built. This button has an icon which looks like a bar chart, and when the user moves the cursor over it, the name "Chart" appears. The tables and charts connected to the map items contain community harvest estimates broken down specifically by year and by location. These tables contain data from the Alexander Database, consolidated to show a community's harvest over time, as well as the contribution of each particular harvest location to that community's harvest. The hotlink button "Chart" starts the user's Microsoft Excel program and opens the tables (with corresponding graphic charts) in a new window on their PC (see Figures 6 and 7). From there, users can copy the data to their PC and manipulate it on their own. If the user does not have Microsoft Excel then the hotlink does not work and these particular tables are not available.

These pre-configured displays of harvest data are made easy to use for individuals with little or no GIS experience. However, users with more knowledge of GIS can access the source data directly and make their own queries, sorts, and even update the legends according to their needs. The "Open Data Table" button (see Figures 8 and 9) opens onto the source data tables that the experienced user may want to manipulate for specific purposes (see discussion below). Other buttons and tools, such as "Zoom", "Select" and "Clear Selection", and the "Information" tool, are explained in the Help menu options of the GIS itself.

Figure 8 shows a zoomed-in view of the window "Customary and Traditional Findings Areas" with several of the map items displayed. The black check mark next to the map item name (in this case, the state areas with Customary and Traditional use findings for sockeye salmon) tells the user which map items are currently displayed on the map.

When the "State: Sockeye Salmon" map item is selected, the "Select" tool (with an arrow for an icon) can be used to click on any of the features composing that map item. Figure 9 shows that the map has an illuminated area on Peril Strait (District 13-C) north of Baranof Island. When the "Open Data Table" button is pressed, the source data table for the "State: Sockeye Salmon" map item is opened, and in this case, the selected feature, District 13-C, is illuminated in the table. Figure 9 shows the way that, in any part of the GIS, any map item's features can be selected, and then referenced by opening the data table with the "Open Data Table" button.

RESULTS

This project produced no new knowledge through observation or discussion, but rather developed a new level of organization and access to existing harvest data. With the tabular data available from the Division of Commercial Fisheries' Alexander Database, harvest trends can be assessed and observed using numerical data, but the spatial relationships between waterways, communities, landforms, and harvests remain unknown. The Southeast Alaska Subsistence Salmon GIS Database makes geographical association (e.g. harvests located on a particular bay, proximity of harvest locations, distribution of a community's harvest across several locations, etc.) explicit and easily understood via the visual nature of the data.

The GIS can stand alone as a research and reference tool, or the data files contained within it can be copied and used in other GIS environments. Individuals who work in other fields (fisheries, forestry, environmental studies, permitting, etc.) and are familiar with GIS can access and use these subsistence harvest data in their own projects. The standardized nature of the data files makes it easy to add the harvest map layers to any other set of maps using GIS software, contributing to a continuing integration of spatial data around the state. Either as a stand alone reference tool, or as a source for raw data, the results of this project are useful to anyone developing research, conservation, emergency preparedness, or management plans for the Southeast region. Compared to existing subsistence harvest databases, the Southeast Alaska Subsistence Salmon GIS Database creates a more comprehensive, intuitive structure with which to view subsistence harvest estimates across both time and space.

DISCUSSION

Subsistence harvests throughout the state have been documented using quantitative, qualitative, and geographic variables. Harvest quantification has reflected single year's harvest, multiple years', or historic trend analysis across years. Other measures by which to understand a community's subsistence activity include an estimated per capita harvest, average household harvest, and percentage of households harvesting, using, and sharing resources. All of these perspectives contribute to the understanding of subsistence as a multi-faceted, complex system involving culture, ecology and economy in rural Alaska, and broadens the general understanding of subsistence beyond the quantification of animals harvested (Scott et. al 2001; Wolfe and Utermohle 2000).

Yet another dimension is added to this understanding by mapping the locations of subsistence harvests (Ellanna et. al 1986). Research by the Division of Subsistence has demonstrated the usefulness of this method. Harvest mapping has been an important part of much of the Division's work (e.g. Davis et. al 2003; Fall et. al 1984; Marcotte 1988).

Detailed documentation of harvest locations is useful for a comprehensive, synthetic approach to subsistence resource management. This information has been used by the Alaska Board of Fisheries and the Federal Subsistence Board to provide for subsistence uses as they are practiced on the Alaska landscape. For state designations, the Board is directed to consider "the geographic locations where those domiciled in the area or community hunt and fish" (AS16.05.258(c)(11)). These geographic relationships are reflected in many aspects of the subsistence fishery, from economics (e.g. gas prices for outboard motors), to social connections (e.g. organizing a work party to travel to the fishing grounds), to culture (e.g. fishing spots used by particular families, or as part of a traditional, seasonal round). Well-documented subsistence harvest location data is essential to the task of understanding the Customary and Traditional use of salmon, or any resource, and is also essential to the ability of state management to provide users with a "reasonable expectation of success" (AS 16.05.258 (f)), and for the Federal program to provide for a "continuation of the opportunity for subsistence uses of resources" (ANILCA Section 801(3)) in those locations.

From a basic documentation of harvest locations, managers can begin to understand how a well-constructed subsistence map communicates the inter-relationships between subsistence harvests. Another important observation is the way subsistence harvests are related geographically to other parts of the environment, including other types of harvest (commercial, guided sport), contamination, fires or flooding, or plans for the development of minerals, timber, or tourism. For all of these, location directly affects how subsistence resources will be impacted. For this reason, subsistence map information must be part of the federal government's evaluation of any proposal to use federal lands (ANILCA Section 810(a)). Subsistence salmon harvest maps are useful to management plans that understand how components of an ecosystem inter-relate according to their geography.

The geographic representation of subsistence activities in Southeast Alaska can generate questions that lead to the creation of new knowledge about the way subsistence is traditionally carried out on the landscape. An example is the comparison of the size or geographic extent of different communities' harvest areas; some communities use a constricted, well-defined area while others are more spread out (Thornton et. al 1990, Davis 1999). In 1999, Davis used a GIS to analyze the geographic patterns observed in seal hunting by Alaska Native hunters from Southeast Alaska communities. The analysis showed and described not only the extent of harvest areas, but also distinct boundaries that have been culturally established and maintained between different communities. The GIS was especially useful in making this observation.

GIS allows the user to analyze geographic information and to make observations like those described above. Aspects of proximity can be determined (e.g. distance of harvest

locations from the fisher's community of residence, from other communities, or from land forms, etc.) and distribution (e.g. harvest locations in a particular bay, along a traditional boundary, across the map in isolation or in groups, etc.). These may in turn be co-related to cultural, social, historical, and ecological elements of the subsistence patterns in the area. Using GIS, relationships such as proximity and distribution are discovered more easily than if data were only available in tables or in text.

CONCLUSIONS

The Southeast Alaska Subsistence Salmon GIS Database organizes existing subsistence harvest data into an interactive, visual format. With the subsistence harvest data previously available in tables, the geographic context and relationships of those data would be known to only those people with a comprehensive knowledge of the Southeast harvest locations named in the tables. The Southeast Alaska Subsistence Salmon GIS Database makes that context, and those relationships, apparent to the average user simply by showing salmon harvest locations on a map. In doing this, the project provides a valuable dimension to anyone attempting to understand the complexities of subsistence salmon fishing in Southeast Alaska.

RECOMMENDATIONS

The software used to create this project, ESRI's ArcView, has such a depth of functionality that many users and project developers, including the project investigator, continue to skim only the surface of what can be accomplished using the sophisticated technology ESRI delivers. For any amount of work done using these tools, the user learns more about ArcView and realizes new directions for the work in progress. In addition, the versions of ArcView are continually evolving, increasing in complexity. Each new project stretches the limits of what one can accomplish when working with spatial data.

Because of these situations, it is a challenge to know how best to use the tools at the beginning of a project, when defining objectives and goals in a project proposal. The expanding of Objectives 2 and 6 occurred because the investigator discovered ways to elaborate and make the product more useful, and this happened at the expense of Objective 1, which called for several small-scale maps items depicting the boundaries of a number of subsistence fishing locations.

If in the future the investigator is responsible for GIS projects like this one, he will make extra effort to understand the functionality of the whatever version of ArcView is current, to plan for better use of his time, and to balance the work needed for each stated objective. The experience gained in this project will help tremendously in the planning and early proposal-writing phases of future projects.

Although the Division of Subsistence has no plans to update this GIS with additional years' harvest data, this would be fairly easy to accomplish by accessing the data through the Division of Commercial Fisheries Alexander Database and re-formatting the data tables in this GIS. Some of the functionality of this GIS (the Graduated Points by Harvest, and the 90% Harvest legends, and the Excel tables and charts) would have to re-programmed around the new data, but for the most part, the GIS would accommodate such modifications fairly easily.

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Figure 1. Project Window, Showing Map Window Names

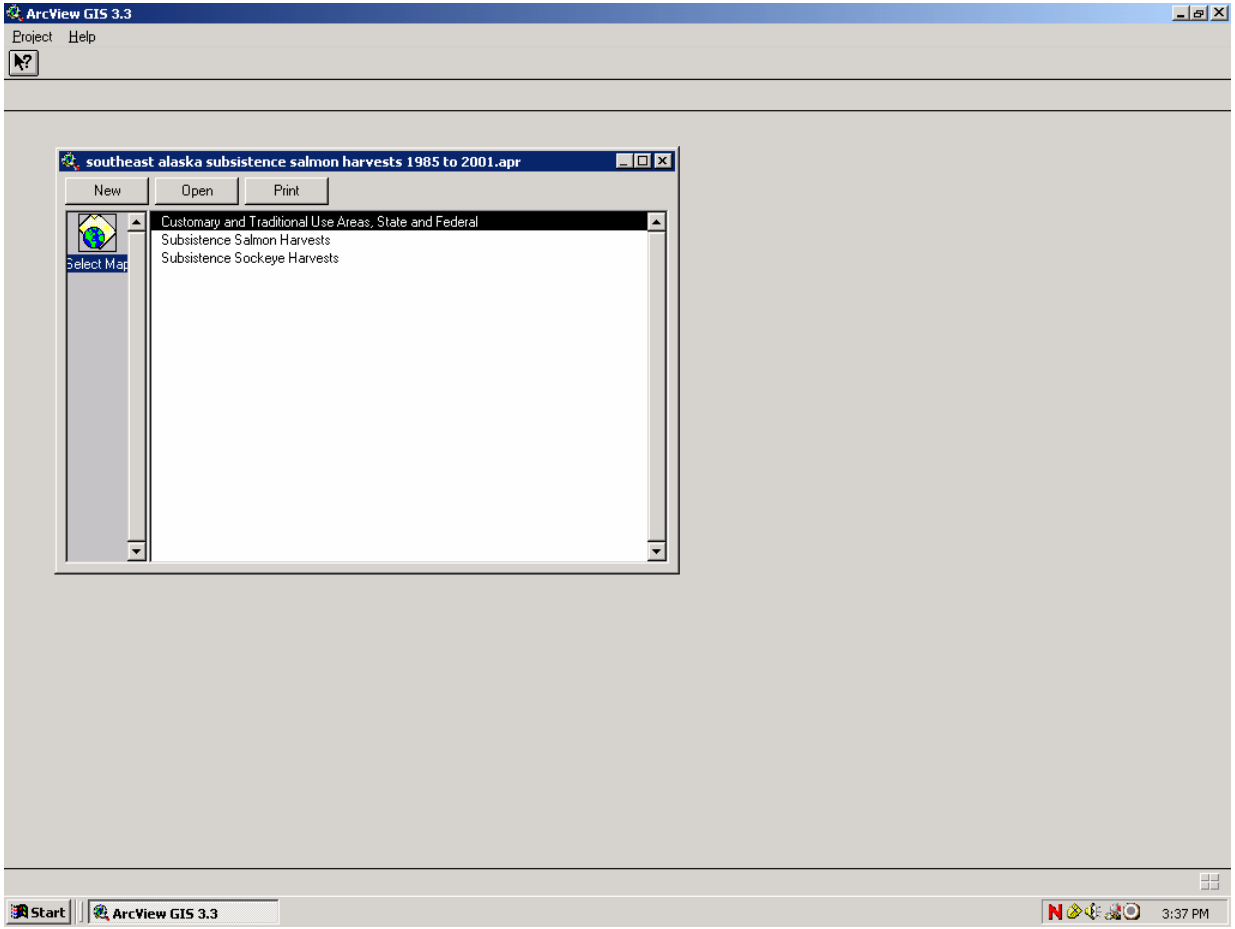


Figure 2. The Subsistence Salmon Harvests Map Window, "Hoonah Salmon" Selected and Active

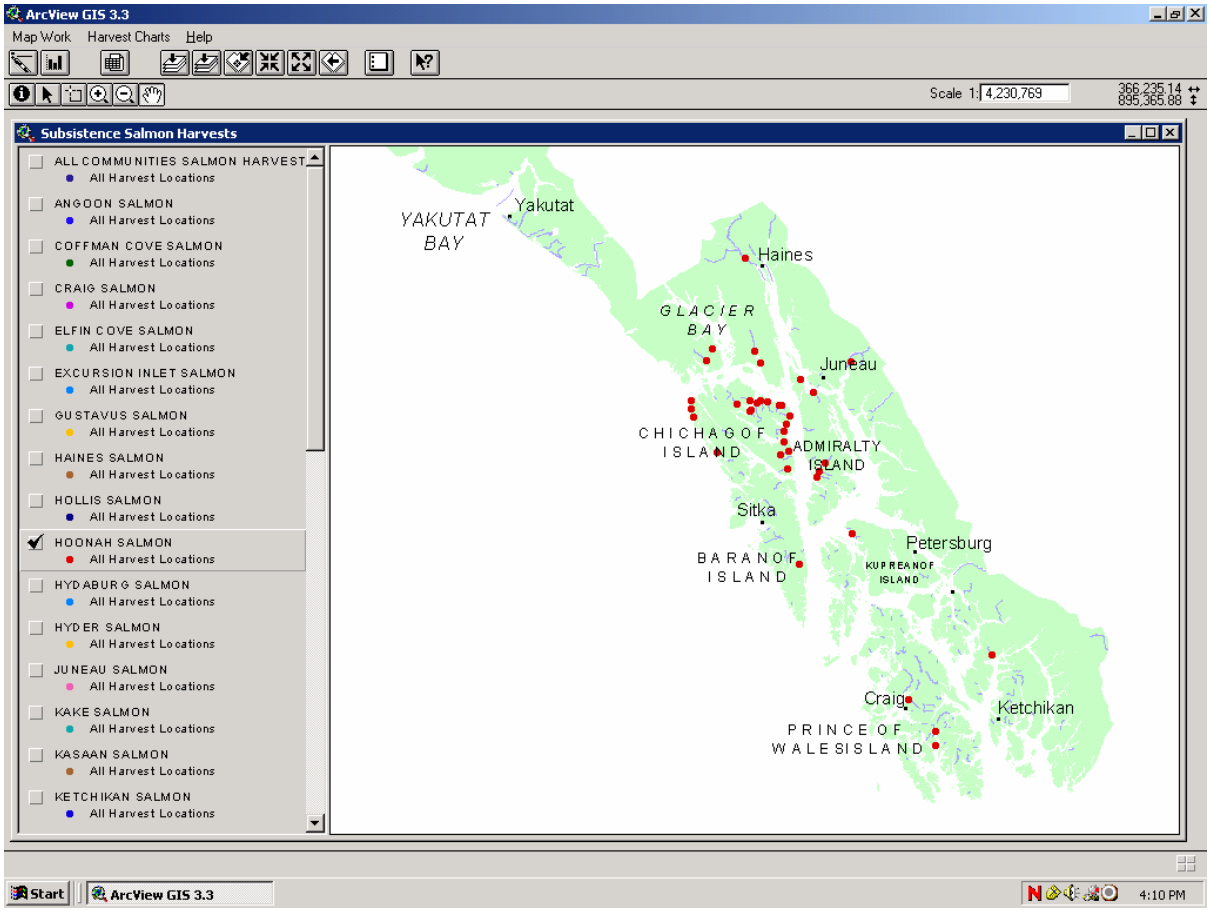


Figure 3. Choosing the Legend for "Hoonah Salmon"

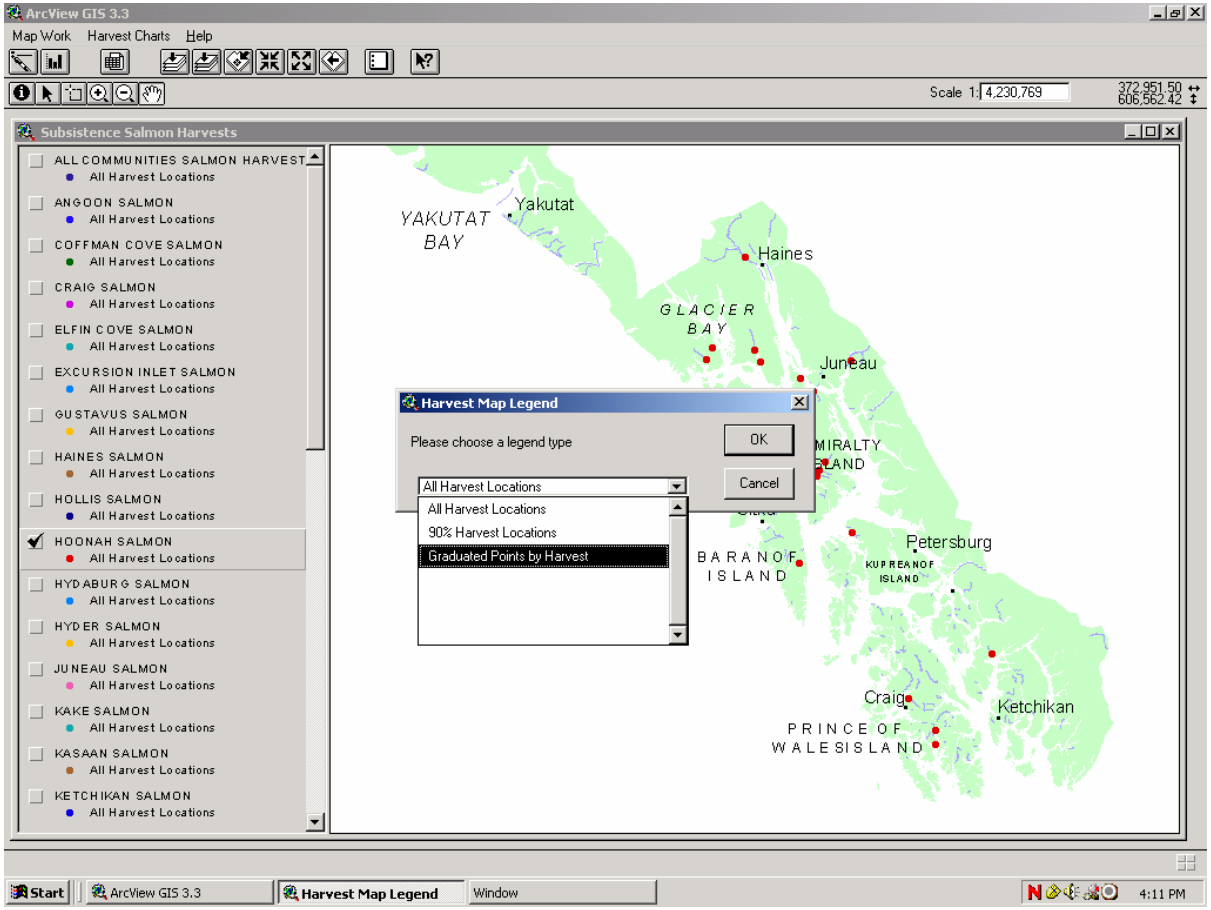


Figure 4. The "Graduated Points by Harvest" Legend for Hoonah Salmon

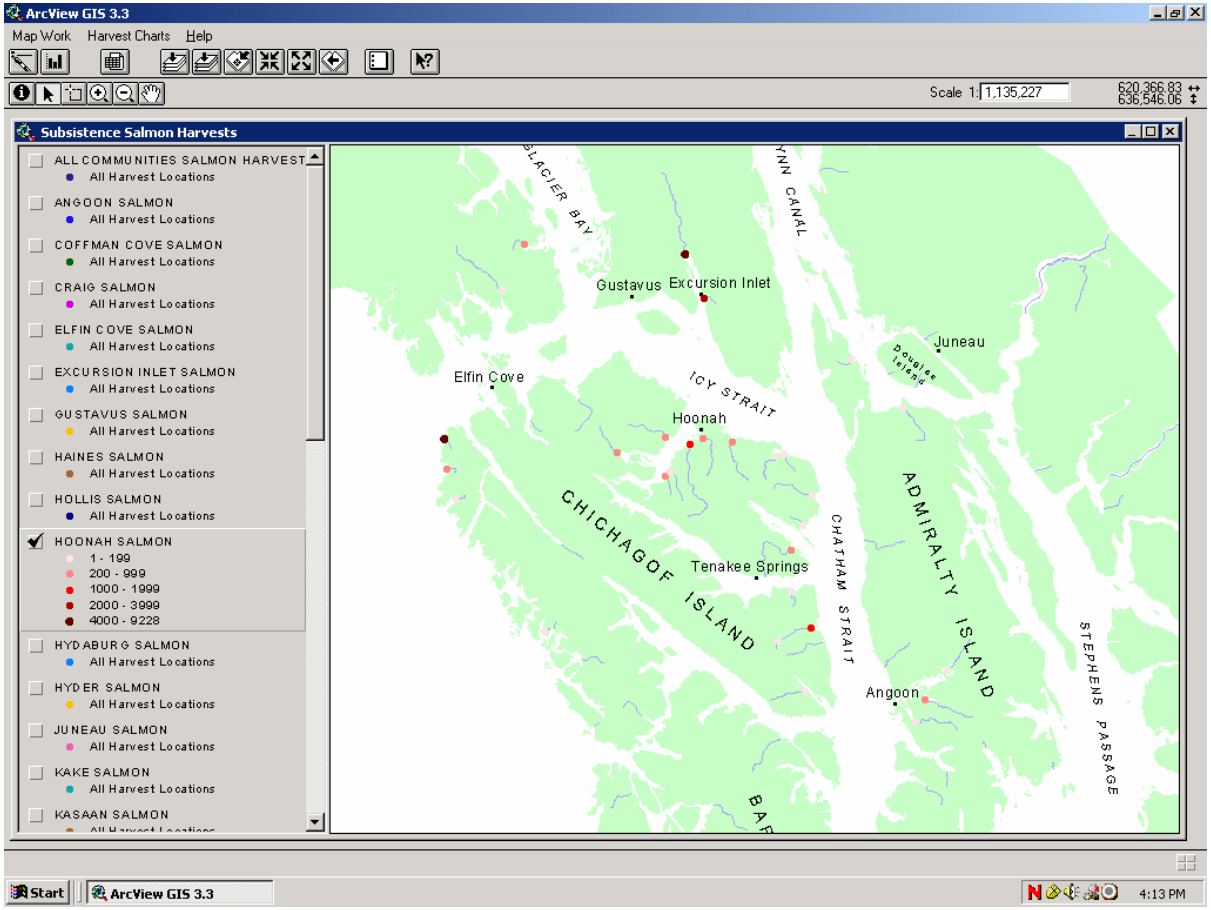


Figure 5. Angoon, Craig, and Juneau Map Items, Shown Using "90% of Harvest" Legend

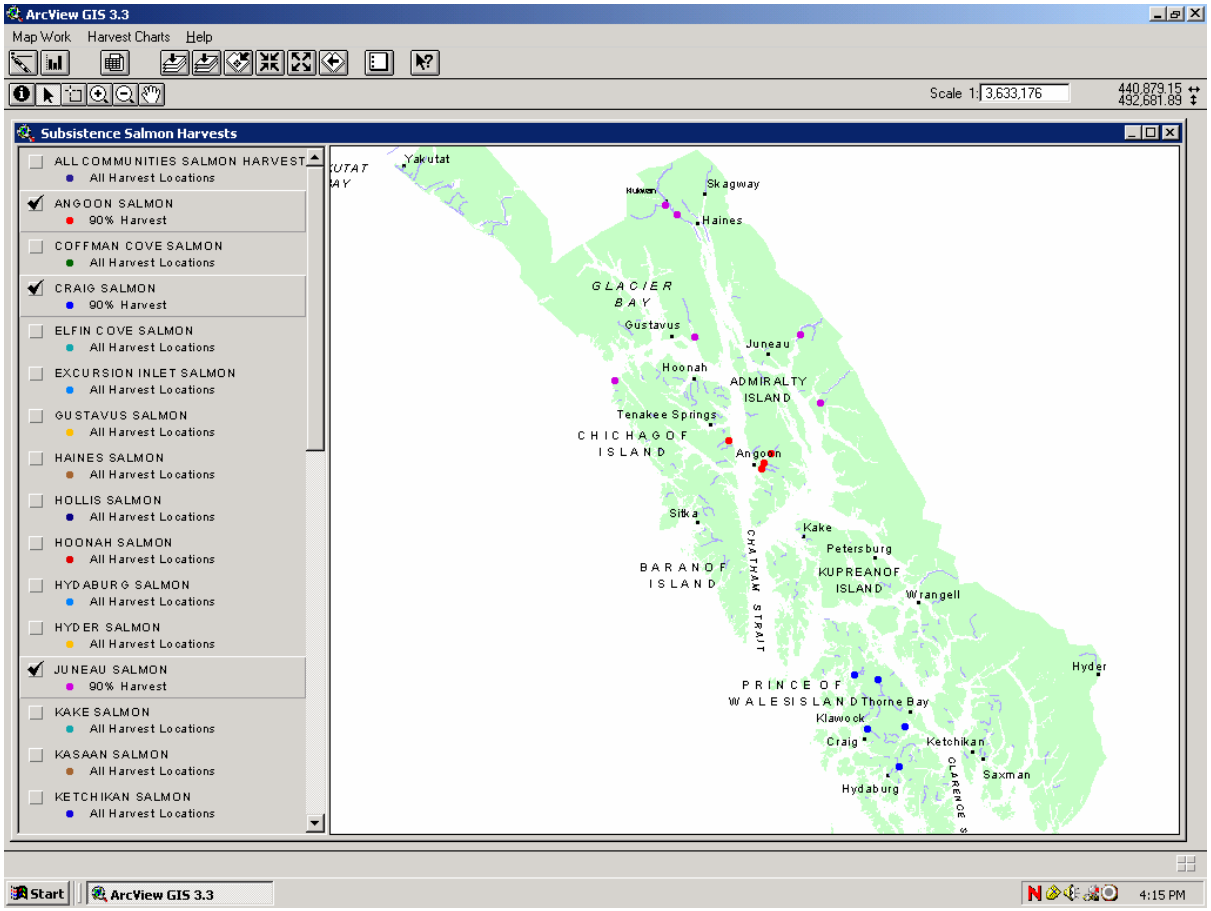


Figure 6. The Excel File opened for Sitka, Showing Harvest By Year

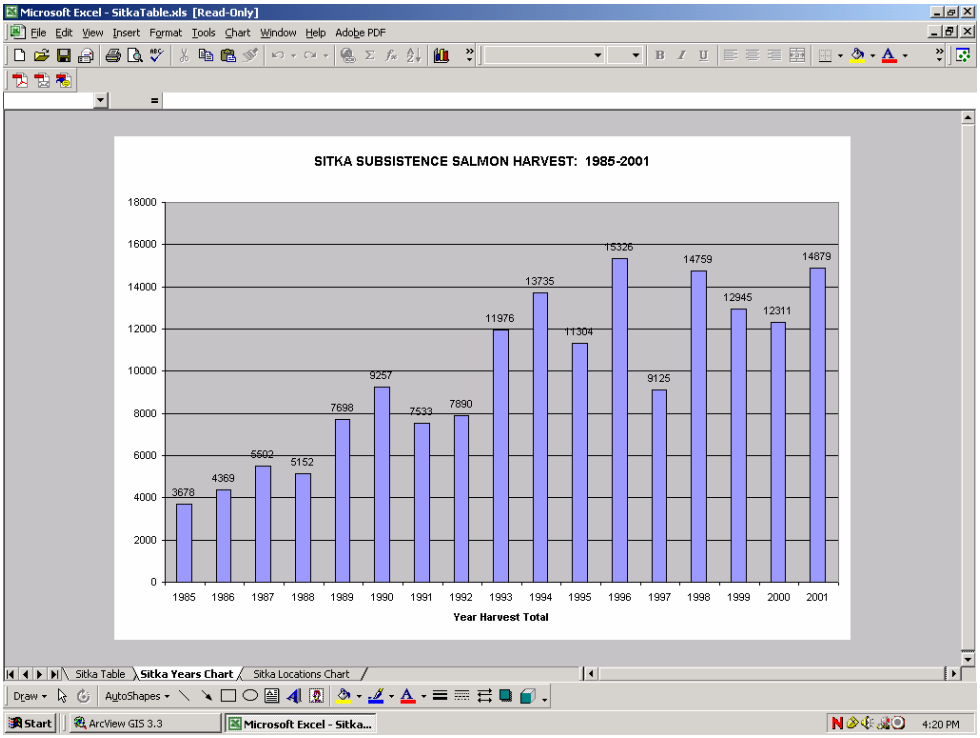


Figure 7. The Excel File for Haines, Showing Harvest By Location

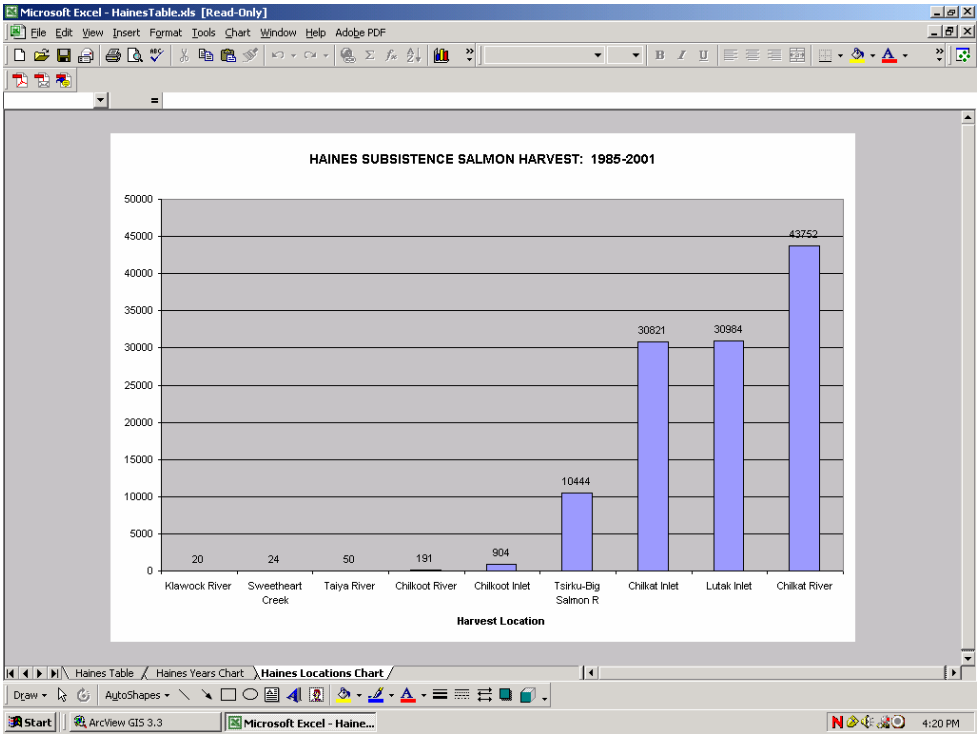


Figure 8. Map of locations with Customary and Traditional Fish Uses: State C&T Designations for Sockeye

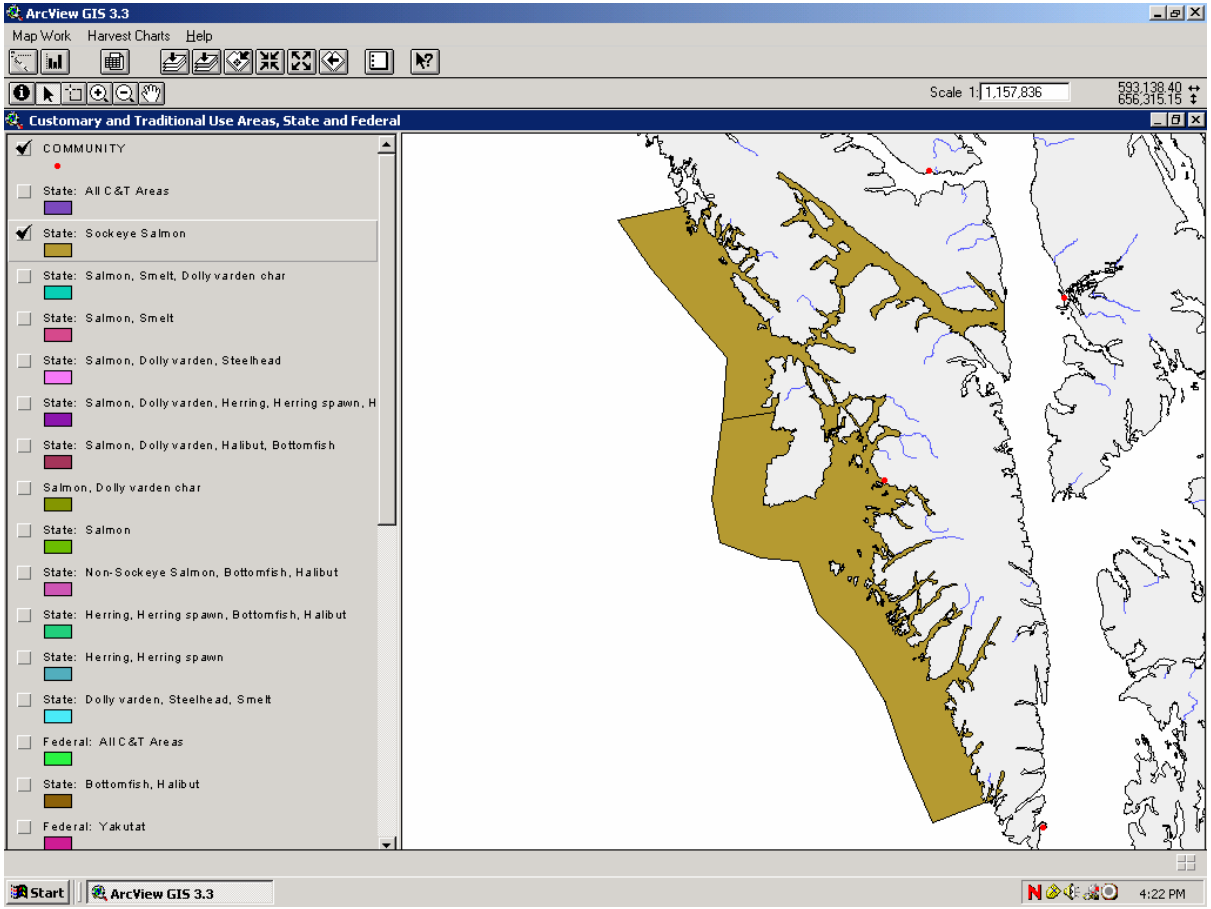
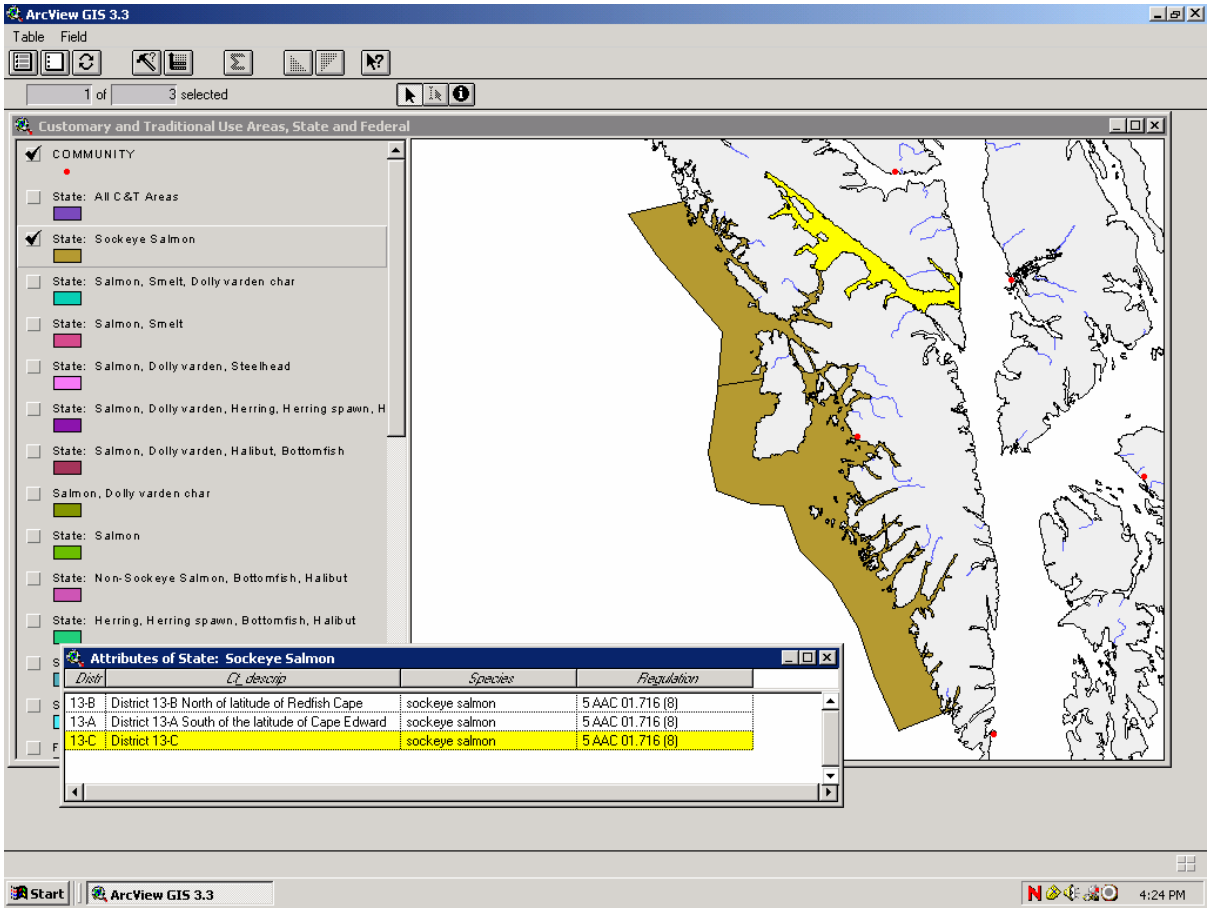


Figure 9. Map of Areas with State C&T Uses for Sockeye, Table Opened, with Map Feature "District 13-C" Selected



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