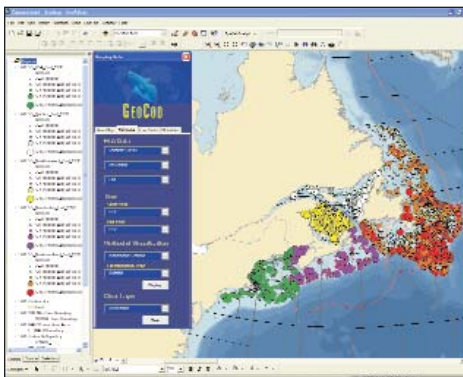


GIS for the sustainable management of fish stocks



With nearly 18,000 students, Memorial University of Newfoundland is the largest university in Atlantic Canada. Its department of Geography offers bachelor, master's, and PhD degrees where students can specialize in GISciences (GIS, Cartography, and Remote Sensing). In addition to these degrees, Memorial University offers an undergraduate diploma in GISciences where students can add practical experiences to their academic training. GIS technology is utilized extensively for teaching and research purposes. Research in GIS within the department of Geography ranges from modelling the impact of climate change on vegetation, supporting conservation of endangered marine species, and analyzing the seabed morphology to identifying structures related to oil and gas reservoirs.



Proportional symbols map produced by the GeoCod system showing the abundance of Cod in Atlantic Canada in 1992.

The marine environment plays an important role in Canadian society. More than 71% of the world's surface is covered by oceans. Canada has the world's longest coastline, the second largest continental shelf, and about 23% of the population lives in coastal communities, many depending on the sea to make a living. Worldwide, more than 1 billion people rely on the ocean for food. Canada's oceans generate a considerable number of jobs and economic activity. However, the United Nations has estimated that more than 75% of the world's fish stocks are either fully exploited or overexploited. Eastern Canada, and more specifically Newfoundland and Labrador, is one of the major world regions that has experienced extensive overfishing. In addition to overfishing, it has been suggested that climate change has also had a negative impact on fish stock dynamics. To date, more than 40,000 jobs have

been lost due to the closure of the Northern cod fishery in Newfoundland in the 1992 moratorium. This has been compared to the effect of closing every manufacturing plant in Ontario.

The GeoCod project is a 2-year research project spearheaded by Memorial University and co-funded by the Canadian GEOIDE Network of Centres of Excellence and the Canadian Center for Fisheries Innovations (CCFI) that began in January 2006. The project is focused on the North West Atlantic region of Canada and aims to provide a comprehensive picture of marine fish and invertebrate distribution and abundance for these biological species, cod, capelin, shrimp, and crab, through the use of GIS.

A major part of this project focuses on the development of a GIS-based decision support tool that has been developed as an extension to ArcGIS. The prototype of the extension will be made available to the different partners of the project, which include Fisheries and Oceans Canada, Fisheries and Aquaculture Newfoundland, and the World Wildlife Fund. In turn, these partners will be able to use this GIS-based tool to analyze and visualize the database compiled to better understand fish dynamics in the study area over the last few decades.

"Decision-makers in fisheries management traditionally relied upon statistics, tables, charts, and other data sources, and haven't fully utilized the power of GIS to conduct spatial analysis which provides the framework for a more comprehensive understanding of fisheries data," said Dr. Rodolphe Devillers, GeoCod Project Leader, Memorial University.

The Department of Fisheries and Oceans Canada (DFO) has been collecting data in Canadian waters for decades to assess the state of fish stocks. The database compiled in the GeoCod project to date includes oceanographic data (temperature, salinity, and nutrients), biological data (Canadian and US Fisheries scientific surveys as well as Fisheries observer program information) for the four biological species, and remote sensing data (sea-surface temperature and biological productivity). Prior to leveraging GIS to analyze these data, analysis was done by employing traditional statistical techniques that do not have a spatial dimension. Project stakeholders decided that GIS and its associated spatial characteristics offer more effective means by which the spatial context of

fisheries-related data can be most rigorously examined.

"GIS allows us to integrate heterogeneous fisheries and environmental data into a single data model that has made it suitable for subsequent analyses and visualization," said Dr. Devillers.

Original datasets have been delivered in various formats (Excel spreadsheets, text files, etc.) and have been integrated in a common data model. All of the fisheries data have been integrated into a single geodatabase, storing both the data and the associated metadata. Many other datasets related to the environment and fisheries management units were also collected. Fisheries data typically include observations made at sea at a specific location and at a specific time of the year. The kriging tools available with ArcGIS Spatial Analyst and Geostatistical Analyst have been used to interpolate the sample locations to generate continuous surfaces of the fish abundance. An extension for ArcMap was developed in Visual Basic and adds several functions that allow users to select the data they want to visualize (fish species, region, year), choose between the sample locations or the interpolated surfaces, produce thematic maps of fish distribution and abundance, and produce animated maps of changes in abundance through time. Users are also able to compare spatial and temporal changes in fisheries data, explore the data for potential relationships between changes in fish occurrence/abundance and changes in the physical environment.

"Our application is so user-friendly that almost anyone can analyze and visualize fisheries information geographically," added Dr. Devillers. "The spatial analysis characteristics of the application represent a significant leap forward with respect to being able to more effectively communicate fisheries information. We expect that it will be a powerful decision-support tool that will contribute to the fight against declining fish stocks in our oceans."

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