The Multi-state Aquatic Resources Information System

An Internet system to access fisheries information in the upper midwestern United States

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ABSTRACT

Traditionally, state agencies in the United States have invested millions of dollars to collect information on fish populations. Management of fisheries resources often necessitates the sharing of this information across political boundaries. Federal agencies need to share information on fish populations across political boundaries to complete the congressional mandates of the Resource Planning Act (U.S. Forest Service) and Resource Conservation Act (Natural Resources Conservation Service). Further, these data are needed for other analyses such as proposed listings under the Endangered Species Management Act and examinations of possible climate change effects. Since 1994, Illinois, Iowa, Michigan, Minnesota, Ohio, Wisconsin, the U.S. Fish and Wildlife Service, the U.S. Forest Service, the U.S. Geological Survey Biological Resources Division (formerly National Biological Survey), and the Natural Resources Conservation Service have collaborated to develop a system to share these data. The Multi-state Aquatic Resources Information System (MARIS) uses the World Wide Web to provide access to state-maintained fisheries datasets from lakes as well as share standardized summaries with end users. Partners in MARIS have developed three standard lake datasets for access. Lake datasets contain data on physical, chemical, catch-per-unit effort, and metadata about each collection. Through this project, the user has access to thousands of fish records across the upper Midwest. As the MARIS project evolves, access to more-diverse fisheries information will become available.

he need for data sharing and information technology to manage large datasets has long been recognized in fisheries management (Clark et al. 1977). Assessing fisheries on a nationwide or regionwide basis has been limited by restricted access to broad databases caused, in part, by the absence of incentives to promote information sharing across political borders. Access to datasets that are temporally and spatially extensive would allow a more holistic description of the U.S. fisheries resources and facilitate the implementation of an ecosystem-based approach to decision making.

Many federal agencies have been mandated to produce assessments of U.S. biological resources. The U.S. Forest Service (FS), through the 1974 Forest and Rangeland Renewable Resources Planning Act (RPA), is mandated to produce a comprehensive assessment of the country's fish and wildlife resources (Flather and Hoekstra 1989). Similarly, through the 1977 Soil and Water Resource Conservation Act (RCA), the Natural Resources Conservation Service (NRCS) is required to appraise these resources (Soil Conservation Service 1987). Other federal agencies such as the Biological Resources Division (BRD) of the U.S. Geological Survey (GS) and the U.S. Fish and Wildlife Service (FWS) also need access to large information sets that may transcend political boundaries to determine the status and trends of species (LaRoe et al. 1995).

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State resource management agencies have a long history of data collection and have accumulated vast datasets on the resources under their management jurisdiction. Because state agencies have traditionally emphasized data collection, few resources have been devoted to data management and distribution. Consequently, many state fisheries agencies are struggling to develop comprehensive database systems to incorporate and access historical datasets. Furthermore, there has been little impetus to share data across political boundaries. With the ability to access and share large amounts of data, managers should be able to make decisions about joint resources among states based on multijurisdictional information (Schnute and Richards 1994).

Early Project Development

Although the need to share data across political boundaries has been important for a long time, the first regional initiative to investigate the feasibility of implementing such a system began in the upper Midwest in 1989. The resulting report (Loftus and Waldon 1992) of this pilot study concluded the following:

(1) Increased sophistication in data handling and communication technology, combined with a movement to manage aquatic systems on watershed scales (as opposed to political boundaries), is creating a definite need to standardize some commonly shared aquatic resource information.

(2) State and federal agencies are clearly interested in pursuing this, and they recognize that the technical barriers to shared information systems can be overcome.

(3) State agencies collect and analyze a vast amount of data that currently cannot be used to quantify status and trends of aquatic species.

(4) States would need financial assistance to undertake new initiatives to expand the utility of their data beyond their geographic borders (such as on a watershed or ecosystem basis).

These conclusions led to the development of a one-day workshop in November 1993 to discuss how state, federal, and nonprofit organizations begin implementing a national fisheries information system. The workshop, sponsored by the FS, NRCS, and FWS and organized by the Sport Fishing Institute (SFI), was attended by personnel from state agencies in Colorado, Idaho, Minnesota, New Mexico, Nebraska, New York, Ohio, Oregon, Texas, Virginia, and Wisconsin as well as representatives of the Pacific Marine Fisheries Commission and the American Fisheries Society (AFS). The workshop sought to identify the roles of state, federal, and nongovernmental organizations and to define the current needs and benefits of a large-scale quantitative fisheries information system. This workshop also identified the actions necessary to advance this initiative (Loftus 1994).

The workshop concluded that a shared system should be advanced, and actions needed included the specification of a compatible core set of information from current state systems, the formation of steering and technical Committees, and the identification of federal funding mechanisms (Loftus 1994). Attendees recognized that states may already possess information to develop a system to help meet federal needs but that states lacked funding and incentives to integrate systems across political boundaries and, in some cases, to develop electronic data systems.

Although the fisheries information system workshop identified a need and willingness to develop access to quantitative fisheries information nationwide, because of broad geographic distances and management styles among states, attendees thought a small regional effort might effectively implement this project. Five state departments of natural resources (Illinois, Iowa, Michigan, Minnesota, and Wisconsin), in conjunction with the sponsoring federal (FWS, FS, GS-BRD, and NRCS) and nongovernmental agencies (SFI), met in December 1994 to discuss implementation of a regional project.

The Multi-state Aquatic Resources Information System (MARIS)

At the 1994 meeting, federal agencies outlined their needs for regional fisheries information. In addition, they asked participating states for information about current data systems and needs to implement access to current fisheries information. During this and a subsequent meeting in March 1995, the consortium of state and federal agencies developed a proposal to provide access to state databases through the World Wide Web (WWW). The National Biological Service's State Partnership Program funded this proposal to implement a regional system; the FS, FWS, and NRCS provided additional funds. The MARIS project started in July 1995 by defining how access would occur, what information would be provided, and how the system would be implemented. Federal agencies provided the funding; state agencies provided the data; and SFI coordinated the effort. All partners provided technical expertise to implement the system.

MARIS Implementation

The MARIS Steering Committee, composed of representatives from each state, the federal partners, and SFI [later to become the American Sportfishing Association (ASA)], decided that the best way to facilitate access to datasets was to develop common summary datasets that each state could populate with current data and house on its own WWW servers (Fig. 1). Access to this information would be provided by developing a MARIS home page that would allow users to access data from the datasets. The query would be sent from the MARIS "server" to each state server to collect the data. The data then would be collated and sent back to the user. This would allow for easy maintenance and validation of state datasets.

Successful implementation of a system would focus on common, easily defined datasets that could be populated with information already available on state systems. For example, participants decided to concentrate on providing information on inland lakes in the upper Midwest because of resource availability and definition of lake boundaries as distinct spatial units. Information was split into three datasets: information on lake physical characteristics, chemical characteristics, and species catch-per-unit effort. From these information sets a

species collection list also could be built. Illinois, Minnesota, and Wisconsin had data available to produce these datasets and proceeded to develop the summary datasets. Iowa and Michigan started constructing statewide databases that would eventually link to this project.

System Specifications

The MARIS Committee contracted with the University of Illinois Geographic Modeling Systems (GMS) Laboratory to produce a MARIS WWW page, develop the necessary architecture to access this information, provide the Computer Graphics Interface (CGI) applications to support query forms and open-ended queries regarding the databases, investigate other tools such as a geographic interface to the datasets, and guide the metadata structure (MARIS 1997). Access to the MARIS prototype WWW page has been provided through the following site: http://www.gis.uiuc.edu/maris/. The prototype web page uses Open Database Connectivity (ODBC) tools to link to state databases (Fig. 1). Users can construct specialized queries or use standard queries to access information. Each state has standard sampling guidelines that will be described in the metadata section for use in interpretating data and will be provided with the data to the end user.

The system uses standard Structured Query Language (SQL) to develop and send queries through a CGI interface to each state database. The state server interprets the query using ODBC links on its WWW servers, compiles the requested data, and sends them back to the MARIS server. The MARIS server compiles results received from all state servers and sends them back to the user. The use of ODBC-compliant databases allows each state to maintain information systems in different software packages.

The MARIS home page is structured with three possible interfaces to the data: public inquiry, member inquiry, and map-based inquiry. The public inquiry is structured to allow the novice user access to information about fisheries and public access sites in each state through a menu-driven interface. The member inquiry allows advanced users to write SQL statements to access all fields available in the datasets. The map-based access to the datasets, still under development, will allow users to bound an area on a map and ask for data from within that area.

The MARIS home page also includes a data information page, which describes the variables included within each of the three datasets. This page also links to each state's metadata descriptions. Other features provided on the MARIS home page include information about the participants, a description of the system, and other related sites.

What Have We Learned?
Administrative support

The current success of the MARIS project in implementing access to quantitative fisheries databases across political boundaries can be attributed to a number of factors. First, both state and federal agencies expressed a willingness to participate in this effort. Furthermore, all agencies involved committed staff time and funding beyond initial grant amounts to complete it. Preliminary funding provided by the FS and NRCS during the early 1990s was integral to keeping the project alive. Funding from the FWS and the large partnership grant received from the NBS State Partnership Program helped jump-start the regional effort. All agencies involved willingly worked together toward a common goal, and the federal agencies supported funding it. The federal agencies also were willing to allow states to take

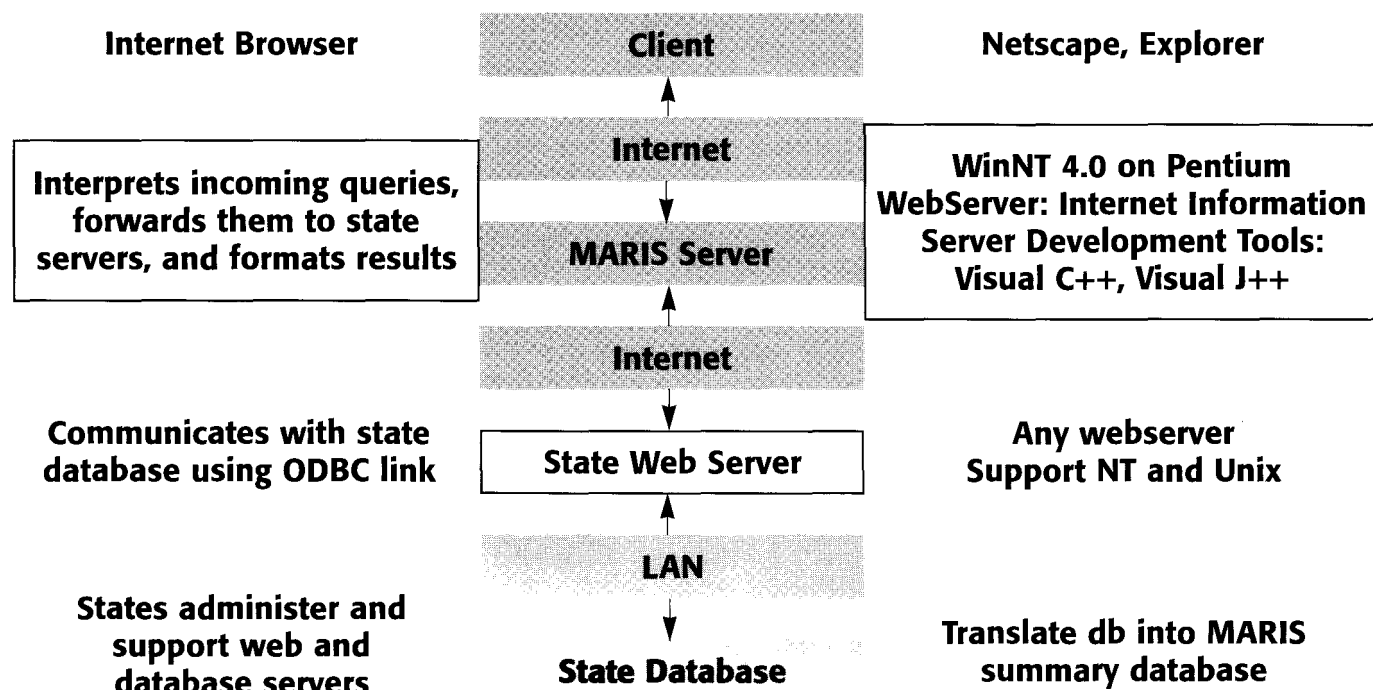| Internet Browser	**Client**	Netscape, Explorer
	↑	
	Internet	**WinNT 4.0 on Pentium**
Interprets incoming queries, forwards them to state servers, and formats results	↓	**WebServer: Internet Information Server Development Tools: Visual C++, Visual J++**
	MARIS Server	
	↑	
	Internet	
	↓	
Communicates with state database using ODBC link	**State Web Server**	**Any webserver Support NT and Unix**
	↑	
	LAN	
States administer and support web and database servers	↓	**Translate db into MARIS summary database**
	State Database	

Figure 1 shows the method by which the Multi-state Aquatic Resources Information System collects data from state World Wide Web servers received from end users wating access to these data.

the lead in developing and implementing the system, thus enabling states to design the system to address their needs and concerns. This approach allows states to maintain control of their data and easily update the system. This strategy is very cost-effective since federal agencies gain access to a wealth of state agency data without incurring the large costs of initiating new data collection, and state agencies benefit by receiving the funding to enhance existing datasets or create new data systems.

Definable Datasets

Second, this project was successful because it concentrated on a small, definable set of information that could be easily provided. The purpose of the project was to provide access to state datasets, stored in different structures and formats, through a singular interface. With the concentration of effort focused on solving the accessibility problem, it was necessary to develop information sets that were easily defined and could be developed by the states with minimal effort. By developing the concept and linking mechanisms, data integration into the system should be a matter of defining the material that is in the datasets and creating the summary data structure. Other systems such as PACFISH (Loftus 1994) also have successfully provided summary information but have concentrated on creating centralized databases from state systems.

Inherent Differences

Third, this project recognized the inherent differences among state data collection methodologies and information systems. The project concentrated on producing a standard reporting form that would collect data from individual state systems. The creation of common species "look-up tables" to address differences in species coding among the states and the advent of Internet tools such as ODBC drivers have lessened the integration differences among information systems. The compatibility of microcomputer software also has minimized problems with database integration. However, data users will need to be cognizant of the differences in data collection among the states and be cautious about interpretation. Past data integration efforts that tried to standardize data collection methodology or information systems were not accepted. States had invested large amounts of capital in developing data collection methodology and information systems to meet their needs. Efforts that advocated changing these systems were not conducive to internal state priorities and goals, and were hard to integrate into existing state programs. Now, even when data were collected using different methods, as long as some standardization occurred within the state, and methodology was documented in the metadata, the summary data should be able to provide useful insights into fisheries resources in the upper Midwest.

Data Ownership and Security

An important issue surrounding the development of collaborative datasets has been ownership and security over the uses of these data. State agencies collected all of the data for the MARIS system, and as such the data are subject to open-record laws of the individual states. Further, all available data are covered under the Freedom of Information Act. Therefore, these data have always been available to any person wanting

to have a copy of them, although the information was largely contained in paper files or inaccessible data systems. Before MARIS, the true nature of data availability was never widely known by the public. The MARIS project represents a significant improvement in data accessibility. However, because of improved access to a wide variety of fisheries information, some professionals are concerned about misuse and faulty data analyses. Still, each state maintains ownership of the data put into the MARIS system. For example, Minnesota maintains copyright of data collected during state-funded surveys. There also is an inherent one- to two-year time lag in entering and posting data to the MARIS system. Further, each state populates the MARIS database from larger state databases, thereby protecting master databases from widespread access by unknown users. Concern about anglers targeting fragile fisheries and species of concern may be lessened by time delays, state data ownership, and protection of master databases. Finally, each state has different laws regarding the distribution and dissemination of information about threatened and endangered species, and will be able to withhold critical information about them. Certainly, an opportunity to misuse these data exists, but the benefits of sharing data should outweigh these instances. States are obligated to make information available to partners and publics interested in fisheries resources.

Where Do We Go from Here?

Long-term Sustainability

The highest priority for the MARIS project is to develop a long-term funding mechanism that assures stability and commitments from agencies to maintain this effort. Although state agencies are dedicated to providing the initial integration system, there is a significant long-term cost associated with maintaining this information. Without stable funding to maintain data coherence, MARIS will drift back to state-specific systems that, while linked, lack any mechanism for data integration to support interjurisdictional assessments of fishery resources.

Project Expansion

Expansion of the project to other interested state, federal, and nongovernmental agencies will be important to completing the goal of a quantitative national fisheries information system. Many agencies involved in this effort have found MARIS to be an extremely beneficial and efficient way to exchange information about data systems. This effort has promoted learning among the agencies involved and has helped remove redundancies in the development of statewide information systems. The agencies also have been able to modify and adapt structures and systems from each other to meet their own goals and reduce development time and effort. The benefits associated with data integration were further explored at a national fisheries database workshop, which sought to bring together fisheries database analysts from all 50 states and other partner agencies. The February 1998 workshop, funded by the GS-BRD, attempted to assess the state of the nation's fisheries information systems. The participants in the summit concentrated on finding solutions to the following hurdles to implementing a national fisheries database system: Internet accessibility, common database structure, metadata standards, and security issues. The major recommendations

from the summit included developing a single location that had model database structures, forming a task force to address issues of metadata and standardized fisheries terminology, and creating a catalog of fisheries systems. The Steering Committee will work closely with the AFS to carry out these recommendations.

Developing access to other fisheries information sets also needs to be explored. The datasets MARIS started with, although large, are limited in scope. Creation of data summaries of length-frequencies, age-growth, creel survey, and stocking are just some examples of the data available to determine changes and efficiently manage U.S. fisheries. Developing a system to access stream information also will be necessary to fully assess the state of the nation's fisheries resources.

Planned Additions to the MARIS Home Page

Development of the MARIS home page continues. Plans for expansion include development of more standardized query interfaces to allow access to all data without the need to write SQL queries. These standardized queries will take the form of either hypertext markup language (html) forms or JAVA applets. Further refinement and development of the map-based query will allow users to pick data from individual watersheds or ecoregions. The development of metadata standards will make it easier to understand and analyze the information received from the system. Finally, other fisheries survey information such as

creel survey information, stocking records, or fish size are being examined for inclusion into the MARIS system.

The long-term administration of the MARIS project has been shifted from SFI/ASA to the Fish and Wildlife Information Exchange at Virginia Polytechnic Institute and State University. Its expertise in developing, maintaining, and accessing data systems will be integral in promoting future efforts. The MARIS web pages still will be housed at the University of Illinois, Geographic Modeling Systems Lab. With the increased interest in WWW technology, computerization, and access to data, and the need to assess fisheries resources outside of traditional political boundaries, the MARIS project and other similar efforts should be viewed as long-term commitments to conserving fisheries resources. 🐟
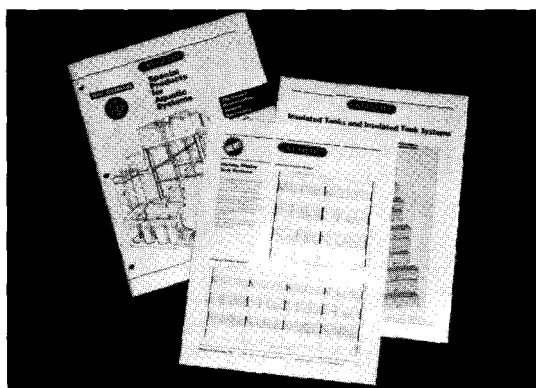
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