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Plan for an Aquatic Invasive Species Web Portal

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15 December 2005

Ms. Melissa Pearson
National Sea Grant Office
National Oceanic and Atmospheric Administration
Silver Spring, MD 20910

Dear Ms. Pearson:

Enclosed is our report entitled *Plan for an Aquatic Invasive Species Web Portal*. It was written at the NOAA National Sea Grant Office during the period 24 October 2005 through 15 December 2005. Preliminary work was completed in Worcester, Massachusetts, prior to our arrival in Washington D.C. Copies of this report are simultaneously being submitted to Professors Tahar El-Korchi and Brigitte Servatius for evaluation. Upon faculty review, the original copy of this report will be catalogued in the Gordon Library at Worcester Polytechnic Institute. We appreciate all of the help that you and the rest of the NSGO have given us throughout the project.

Sincerely,

_____
Christopher D. Korzeniowski

_____
Michael J. McKinstry

_____
Christopher J. Serrano

Plan for an Aquatic Invasive Species Web Portal

An Interactive Qualifying Project
submitted to the faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
by

_____   _____   _____
Christopher D. Korzeniowski   Michael J. McKinstry   Christopher J. Serrano

In Cooperation With:
Melissa Pearson
National Oceanic and Atmospheric Administration Sea Grant

15 December 2005

Approved:

_____
Professor Tahar El-Korchi

_____
Professor Brigitte Servatius

Abstract

This report, prepared for NOAA, presents recommendations for an aquatic invasive species (AIS) central web portal and an analysis of existing AIS databases. We gathered data from federal agencies and private entities through interviews, questionnaires, and surveys. The information compiled from our research was used to determine and justify the details of our recommendations.

Authorship

Each section of this report was a collaborative effort and was written and edited by all three team members. The directory database documentation and coding (Appendix E) was written by Chris Korzeniowski. All tables within this document were original, created by the WPI project team using survey data. All figures were created in Microsoft Excel or adapted from screenshots of online resources using Adobe Photoshop.

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1.   Executive Summary

Invasive species are a growing environmental and economic problem. Efforts to control the problem are inefficient, due in part to ineffective methods of information transfer among federal agencies, non-federal organizations, and the public. The internet is an ideal means of providing extensive and up to date information on the rapidly changing issues regarding invasive species, but current web-based information is scattered among several separate resources. There is a lack of cooperation between federal agencies and organizations, and it is difficult for users to find what they need.

Many online invasive species resources consist of databases of various types of information, depending on the mission of the agency or organization. Some other resources aim to provide access to all invasive species databases (or other resources) from one location, acting as a portal from which a user may access any type of site they may be looking for. One such site is http://www.invasivespecies.gov, run by the National Invasive Species Council. However, the design of the site has been deemed inefficient and difficult to navigate.

Our project was concerned with meeting the needs of users of online aquatic invasive species (AIS) resources. The objective was to determine how to combine users' needs with technical capabilities, with the final report including recommendations regarding a central AIS web portal. The recommendations would then be considered for the redesign of http://www.invasivespecies.gov.

The research phase of our project consisted of communicating with database managers and users to gather information about the needs of federal agencies and users. Since our project was concerned with the design of a federally run AIS web portal, we

first interviewed those in charge of federal AIS databases. We used questionnaires to find out the opinions of project managers, researchers, and non-federal database owners. Online surveys were another important resource, providing opinions from hundreds of users. Also, we researched what online resources are currently available, which provided us with insight to the technical aspects of the project.

A major component of the research findings consists of suggestions for improving current AIS resources. The surveys provided data from a wide variety of users regarding suggestions for improvement, while the interviews and questionnaires provided more in-depth responses with reasons and discussions to support the opinions. Our findings showed that the navigation methods of the site: search, menus, and hyperlinks, needed improvement in order to deliver the most useful content to the user. For the search feature, there is a need for more options in order to narrow down searches, and a need for the user to find data from the most relevant AIS database. Additionally NISbase (Non-Indigenous Species Database, www.nisbase.org), a distributed database system, should be included as a search option or at the very least linked from the web portal. For the menu system, the categories need to be redefined in a logical manner, with a clear display of subcategories, in order for the site to be easily navigable. Details and examples of potential ways the site could be broken down are included in this report. For links, we recommended what should be linked and how it should be done in a way that does not overwhelm the user by placing too many links in one location or confuse the user by dividing the links into too many subcategories. Along the same lines, the visual layout of the main site must not be overly complex, but not so simple that the user cannot find the information that they need.

Our findings also included additional features that could be linked from the web portal or developed as a new feature, including merged fact sheets, species distribution maps, species identification tools, and image searches and other multimedia tools. The interviews provided the most useful information regarding additional or new features, since many of the interviewees worked directly with such features. Questionnaire and survey data helped in determining which of the features would be used the most. For the most part, these types of features are currently available or in development. Our report includes what agency is developing each feature, and recommendations of how to implement or link the feature to the main site if it is worthwhile to do so.

Another outcome of our project was a Microsoft Access database including information about several AIS databases, such as the owner, the URL, the geographic location, the type of data stored, and the intended audience. This directory database could be used to determine what databases exist of a certain type, with the ability to narrow down databases by aforementioned categories. Further development was not necessary for the goals of this project, and due to the time constraints of the project it is left as a work in progress. We recommend that if the database is going to be used outside of this project, it should be expanded upon to include more databases and more types of categories.

In addition to further development of the directory database, we recommend to consider funding since this project was not concerned with actual numbers for costs. A lack of adequate funding may limit the implementation of some recommended features, or substantial funding may allow for implementation of lower priority features. We suggest the use of cost-benefit analysis to determine if there should be any changes to

parts of our recommendations. Putting the results of this project into perspective with real figures for costs will lead to better preparation for the development of the web portal.

2.   Introduction

Nature is divided into regions by "natural barriers" (Bright, 1998, p. 19). Natural barriers are terrain such as oceans, rivers, or mountain ranges that prevent the migration of various species. The Earth's major barriers were created millions of years ago when the tectonic plates in the Earth's crust moved apart, separating much of the life on the planet. The various species then grew and evolved independently, unable to migrate past these barriers. However, human activity and the development of new technologies are leading to the destruction of these barriers (Bright, 1998).

Ecosystems are fragile and the introduction of any new species could drastically upset their balance. While this was not a significant problem in the past, today people and cargo are transported around the globe via ships and aircraft on a daily basis. Every time one of these transports enters or leaves an area, it risks transporting species to new environments. If the species propagates, it could potentially cause the extinction of indigenous organisms, and the result is a drastic decrease in the diversity of life within the environment.

In addition to the negative ecological impact, invasive species cause a number of problems that affect the economy and industry worldwide. For instance, the fishing and agriculture industries are affected when species of plants and animals that are used as food sources become scarce or instinct due to invasive species. As for the federal response, the United States government spends over $137 billion on invasive species monitoring and control per year (Ecological Society of America, 2004).

Baskin (2002) wrote that there are problems in the United States' attempts to control invasive species. The problem is not a lack of effort by agencies but a lack of

coordination of efforts. Executive Order 13112 established the National Invasive Species Council (NISC), as described by Invasivespeciesinfo.gov (Executive Order 13112, 1999) to unite the United States' efforts to control invasive species.

The NISC has charged the National Oceanic and Atmospheric Administration (NOAA), along with the Fish and Wildlife Service, with the responsibility for the control and management of marine and coastal invasive species (National Invasive Species Council, 2001, p. 55). NOAA, formed in 1970, unites the nation's environmental efforts (NOAA History, 2004). NOAA has the broad goal of trying "to predict environmental changes on a wide range of time and space scales in order to protect life and property, and provide industry and government decision-makers with a reliable base of scientific information" (NOAA History, 2004).

Despite the efforts of many organizations such as NOAA, however, the invasive species problem continues to persist worldwide. One of the biggest setbacks to the efforts to minimize the threat of these invasions is currently the lack of a centralized database or resource on the subject matter. Such a resource would assist with education and coordination of efforts. Bright (1998) explains:

> Information on exotics is badly fragmented – it is scattered about in hundreds of technical newsletters and publications, in professional discussion groups, and among cadres of regulators. That makes it very difficult for outsiders to get their bearings in the field, or for insiders to keep themselves current. On any level of activity, from international negotiations to management of a particular natural area, fragmentation of the knowledge base can be an obstacle to progress. So a highly efficient way to catalyze progress would be to develop a comprehensive, readily accessible, global pool of information on exotics (p. 209).

The goal of this project is to make recommendations regarding the creation of a central resource. The Sea Grant coordinates college and regional expertise to perform

research pertaining to America's coast. Due to its mission to protect America's coast (see Appendix A), Sea Grant's research and projects pertain to aquatic invasive species. Therefore, this project will be concerned with aquatic invasive species as a subset of the entire invasive species problem.

Currently, there are many databases on invasive species created by various involved parties. These databases and other portals are referenced by one web portal, http://www.invasivespeciesinfo.gov. The site is not optimally designed to be a central web portal for these resources. A user may have to visit several separate databases for information and still not find all that they are looking for. Therefore, the final outcome of this project is a recommendation for a web portal that helps coordinate efforts as well as providing functionality to various stakeholders.

The development of this recommendation involved researching each agency's role in invasive species management, as well as the databases each agency manages. The research of the databases included the needs of the database users and how information within each database is used by its host agency. This information was used to determine how available information could be organized in one central location while considering the goals of the agencies and the needs of the database users. The development of the recommendation took into consideration aspects such as the site layout, navigation methods, types of content, and cost.

The proposed recommendations may be used to improve the site, allowing for a more efficient information resource. The information resource will foster greater shared knowledge and assist in coordinating responses. The knowledge and coordination will lead to an increase in the efficiency of agency efforts regarding invasive species. The

planned central web portal will also be useful to all types of interested people, from the general public to professionals in the field. This will lead to communication and cooperation among all parties involved with invasive species efforts, and the reduction of environmental and economic consequences of invasive species.

3.   Background

3.1.   *A Threat to the Environment*

Ecosystems are fragile and can be easily damaged. Biological invasions cause destructive effects in the ecosystem in which they occur. Invasions often cause the functional extinction of many native species in an area, reducing biodiversity on the planet and hindering the natural evolution process.

Natural barriers, as Bright (1998) refers to them, were created millions of years ago when the surface of the planet shifted (p. 18). These shifts produced vast basins, valleys, and large mountain ranges that separate the planet into geographical locations. As life evolved on earth, so too has the earth evolved to become what it is today. Natural barriers separated the developing species, locking them into their current geographical locations and allowing them to grow and further evolve independently in their respective environments. "Barriers determine where organisms live and how ecosystems are created. Barriers prevent species from spreading into new locations and help determine their natural range" (Moore, Lerner, Blanton, 1998, p. 5).

While mountains and valleys are forms of natural barriers, many other types of barriers keep species in their native ranges as well. Small barriers such as a fallen tree or a small stream created in a season with exceptionally strong rains can be just as effective. Biological barriers, such as inadequate food supply, intolerable climates, disease, or predatory organisms in the area, for example may also keep a species that has moved into a new environment from surviving there. (Moore *et al.,* 1998) The barriers that separate ecosystems, especially smaller ones like streams, are not static; they are constantly moving and fluctuating over time.

Each ecosystem that develops is unique. Life within each of the boundaries adapts to its own environment. Competition, food chains, and hierarchies develop and there is a balance within nature. While ecosystems are diverse and unique, they are also fragile. The introduction of a new opportunistic species to one of these environments could be devastating.

Organisms have been known to cross natural boundaries due to natural processes such as migration or severe changes in weather. Such instances are rare and usually not a great threat. Bright (1998) describes what is known as the "tens rule" (p. 23). Approximately 10% of non-native species introduced to new environments are able to survive in their new habitats, and only about 10% of those are able to flourish to the point where they upset the balance of the existing ecosystem. Therefore, non-native species are hardly a threat when introduced to their new environment by natural means.

The real threat from invasive species comes from when non-indigenous species are introduced through human intervention. What was once considered, "'impossible migration' is now not only possible, but common" (Bright, 1998, p. 20). Human technology has advanced, allowing thousands of people to cross natural barriers every day. These crossings are vital to human society, which is globalizing more and more. However, humans are allowing species to move further beyond their natural borders than they have ever traveled, and at a much faster rate. With every shipment of goods from one country to another, or plane full of tourists heading off to an exotic island for a vacation getaway, there is a risk that unwelcome foreign species will cross a natural barrier.

Essentially, humanity is creating a new "hyper-Pangaea" where species are brought across natural barriers and disrupting other ecosystems (Bright, 1998). This process damages the biodiversity of life on Earth. The exponential advances in travel, trade, industry, and technology are working to undo what nature took millions of years to create. The hardier 1% of the species that are crossing natural barriers through human aid (usually referred to as generalists or weeds) and flourish in the new geographical location are pushing native species to extinction.

The loss of biodiversity on Earth through invasions by non-native species is a large problem. Bright (1998) believes it is "the least predictable of all the major forms of environmental disruption," (p. 28) and "it may also be the hardest to fix" (Bright, 1998, p. 28). Bright (1998) is not satisfied with current efforts to control invasive species. He believes there are not enough international treaties on attempting to conserve the environment and prevent bioinvasions, and is disappointed in the lack of any centralized resources on the subject. He would ultimately like to see a central web portal which would include information about all varieties of invasive species worldwide (Bright, 1998).

The transportation of species across natural barriers is not the only human threat to the biodiversity of the planet. Ecotones are the boundary area of ecosystems, where the neighboring environments join and interact. They move and shift as the balance within each of the small communities in a geographic area changes.

Aquatic ecotones are the areas where land and water meet. These areas are usually "especially rich in flora and fauna" (Naiman *et al.*, 1990, p. 263). Aquatic ecotones are important because they regulate water flow and filter runoff entering the

system. However, humans are destroying many of these ecotones "to improve aquatic systems for navigation and flood control, and terrestrial systems for agriculture" (Naiman *et al.*, 1990, p. 227).

The destruction of aquatic ecotones has a negative impact on the environment, reducing the biodiversity of life in the affected areas. Studies have shown, "32% fewer species in agricultural lands along the Sacramento River, California, USA, from which the adjacent riparian vegetation had been removed" (Naiman *et al.*, 1990, p. 10). As Bright (1998) points out, the loss of biodiversity caused by the destruction of agricultural and aquatic ecosystems by mankind makes these areas even more vulnerable to future attacks by invasive species as the balance has already been disrupted. If an invasive species were introduced into an already vulnerable area, the consequences could be devastating to the entire ecosystem.

3.2. *Case Studies*

Aquatic invasive species in the United States are only a small representation of all of the invasive species in the world, yet they are a very serious and costly problem on their own. The zebra mussel costs an estimated $100 million annually, the Asian clam causes damage costing around $1 billion per year, and the shipworm *teredo navalis* costs around $205 million per year (Pimentel, 2002).

Although it is not the costliest, the zebra mussel is one of the most well known invasive species in the United States. SGNIS (2005) reveals the original site of the mussel was the Caspian and Aral seas. It invaded Europe during the 1700's (Tammi, 1999), but was not seen until America in June, 1988 (Closs *et al.* 2004). According to Closs *et al.* (2004), the first mussel discovered in America's waters was in a small lake

between Lake Huron and Lake Erie. Finding one organism, however, does not necessarily mean an invasion has taken place. Closs *et al.* (2004) state that an invasion could fail, "for a variety of reasons, including unsuitable environmental conditions, insufficient resources, or simply too few initial colonists" (p 191). While we know today that the zebra mussels were not the last of a small group nor recently introduced, scientists at that time could not be sure and had to conduct field research to determine the extent of the problem (Closs *et al.* 2004).

Closs *et al.* (2004) describe the survey that established that the mussels were breeding. Ten survey sites were selected in Lake St Clair. The shell length of zebra mussels was measured to determine "[t]ime since initial colonization and the frequency of successful breeding events" (Closs *et al.*, 2004, p. 192). The survey showed the zebra mussels were in four out of the ten sites and "well established" (Closs *et al.*, 2004, p. 193).

Once the presence of zebra mussels was established, researchers attempted to learn how they spread and how far they had spread, in an effort to develop a control program. The researchers also wanted to determine where the zebra mussel might invade next. According to Closs *et al.*, scientists looked at studies of the species already done in Europe to create an expected distribution for the future. They discovered the zebra mussel could theoretically invade much of the United States. However, when factors such as water hardness were taken into account, the invasion area was lessened. Closs *et al.* stated that, "Strayer (1991) suggested that low dissolved calcium levels in many waters across North America might limit the abundance of the invader" (Closs *et al.*, 2004, p. 195).

Zebra mussels can only invade areas they can reach. Closs *et al.* (2004) report that "almost 200 years of range expansion in Europe demonstrated that zebra mussels are spread by the downstream drift of planktonic larvae, and through the deliberate or accidental transport of adults or larvae by humans" (p. 195). Thus, it was expected when the zebra mussels were discovered over the years moving downstream from Lake St Clair. Before long the zebra mussels had established colonies all along the Mississippi River, downstream from Lake Michigan, and downstream from Lake St Clair (Closs *et al.*, 2004).

Once researchers knew the scope of the problem, they attempted to find out how the zebra mussels would impact their new environments. Much can be learned just from knowing the biology of zebra mussels. Closs *et al.* (2004) reported that zebra mussels eat phytoplankton, bacteria, and small zooplankton. From this, scientists developed a hypothesis (among others) that quantities of such prey would decrease in successful invasions. When the prey disappeared, the water clarity would increase and other plants would become more abundant. Closs *et al.* (2004) add that the zebra mussel invaded "some of the most intensively utilized and studied waterbodies in the world" (p. 199). Thus, scientists were able to easily study lakes where the zebra mussels had invaded and test their hypotheses. According to Closs *et al.* (2004), the initial results confirmed the hypothesis regarding decrease of prey and associated increases in water clarity and plant population. Controlled experiments in enclosed tanks concluded that the hypotheses were correct in how zebra mussels affect a body of water and its related ecosystem.

A second example of invasive species in action is the recent invasion of the lionfish along the Eastern coast of the United States. According to Hare and Whitfield

(2003) the lionfish is a venomous fish native to the Indian and Western Pacific Oceans, however the species was introduced to the Atlantic Ocean after being released from aquariums in the U.S. The lionfish can now be found all along the southeast border of the United States, some areas of the Caribbean, and young lionfish have even been spotted as far north as New York.

Currently, nothing is being done about the lionfish invasion and there has been almost no funding distributed to research the problem. Hale and Whitfield (2003) believe that there is very little that could be done. It would be extremely costly and dangerous to attempt to remove the lionfish, and it is very unlikely that such an attempt would succeed. It is believed that the lionfish population will continue to grow, and since it is venomous, eventually many divers and fishers will come in contact with it and will need to be hospitalized. It is unknown how the lionfish will affect the populations of native fish in the area, and Hale and Whitfield (2003) believe that it is essential to continue observing the populations of the lionfish while monitoring the status of native species. They also believe that educational programs on the dangers of this species, along with the threat of aquatic invasive species and aquarium trade in general should be implemented. They think that local hospitals should also be warned of the presence of this new species and prepared to treat victims.

3.3. *Federal Response*

In the past, the vast majority of federal efforts to control invasive species have only been a response to the most economically significant situations. Only recently has there been a united effort to control the problem proactively. The Federal Interagency Committee for the Management of Noxious and Exotic Weeds and the Aquatic Nuisance

Species Task Force (ANSTF) are attempts to create a more united and cooperative effort for invasive species monitoring and control in the United States. Additionally, a recent group formed for a united effort is the National Invasive Species Council (NISC). The NISC was established in 1999 by Executive Order 13112 on Invasive Species (Order), and it is the first group to be responsible for every type of invasive species issue (Environmental Law Institute, 2002, p. 20).

The NISC is divided into subcommittees of Leadership and Coordination, Prevention, Early Detection and Rapid Response, Control and Management, Restoration, International Cooperation, Research, Information Management, and Education and Public Awareness. The primary goal under the Information Management subcommittee is the creation of a single useful online resource for invasive species information.

> Although there are many sources of information concerning invasive species, incompatible database formats and other factors impede information sharing. The [National Invasive Species] Council is currently developing an information "gateway" accessible through the Council's website – www.invasivespecies.gov. The long-term goal is to provide accessible, accurate, referenced, up-to-date, comprehensive, and comprehensible information that will be useful to local, State, tribal, and Federal managers, scientists, policy-makers, teachers, students, and others. (National Invasive Species Council, 2001, p. 8)

The initial plans for http://www.invasivespecies.gov included posting case studies of control efforts, a locator of U.S. invasive species occurrences, and linkages to various invasive species websites and databases (National Invasive Species Council, 2001, p. 8).

Additionally, the National Invasive Species Council has released progress reports, updating the status of their management plan. The first progress report, released in October of 2003, updates the status of each planned task that was listed in the initial management plan, and many of the information management goals listed above have

been accomplished. In the second progress report, released in July of 2005, the following update on the status of the www.invasivespecies.gov website is listed:

> NISC's website is hosted and maintained by NAL and is among the most comprehensive web-based resources on the topic. It consists of 500 pages and is linked to a large number of unique invasive species resources. In FY 2004, 7 additional success stories from ARS, 17 additional species profiles, and information concerning domestic and international meetings was added to the site. To assist with the on-going improvements to the site, a website redesign report was finalized October of 2003.
> (National Invasive Species Council, 2005, p. 17)

Another update in the July 2005 progress report is that the NISC website has been successfully linked to many other invasive species websites and databases including the National Weed Database and the Sea Grant Non-Indigenous Species database (National Invasive Species Council, 2005, p. 18).

3.4. *An Example of Global Response*

Aside from the federal level, much is being done worldwide to prevent generalists from invading and damaging the biodiversity of the planet. Researchers, private companies, and non-profit organizations all have roles in invasive species management. For example, Baskin (2002) wrote about how scientists in South Africa had spent many years discussing whether invasive species were creating a major impact, and only recently have they unified and started devising ways to combat the problem. A unified program now exists in South Africa to attempt to monitor and control invasive species, such as one tree, which absorbs so much water that the rest of the ecosystem is starved. To restore order to the environment, teams of people climb mountains and chop down these invading trees, being careful not to rain seeds down on the ground below. Other various efforts are being made by researchers and organizations in order to help manage the invasive species problem.

3.5. *Information Architecture*

Information architecture (IA) is the process of organizing a site such that information is easy to find, thereby making it an important aspect of successful web development. According to Subramanian (2004), "[i]nformation architecture is all about looking at the big picture, then breaking it down into manageable bits of information for your users" (Subramanian, 2004). When used in a website, IA should be the first step taken in order to have a well-planned project and a well-organized website. Nolan (2005) describes information architecture as, "the process of creating a plan and a structure for the information that a Web site will contain" (Nolan, 2005). Information architecture is usually a straightforward process, simply guided by common sense. However, when complex content is involved, such as what would be involved in a site architecture plan for an invasive species web portal, the plan needs to be more specific in order for the site to work well.

When developing a plan, Nolan (2005) lists the most important factors as the audience, content, and navigation structure. The audience is important in that it will help determine what features of the site will be most useful. Likewise, the content of the site must be tailored to what the user needs. The navigation structure is important because it is what links the audience and the content together. The site must be designed so that the user can access the content in an efficient manner. Multiple methods of navigation improve efficiency because users may know exactly where they want to go or they may only want to browse. Keeping the factors of the audience, content, and navigation structure in mind promotes the development of a successful website in terms of delivering the information that users need.

4. Methodology

Several different research techniques and methods have proven to be useful in accomplishing the goals of this project. Some of the various aspects that need to be considered for the site architecture plan include informational needs of organizations and users, technological capabilities, budgets, existing content, and legal issues. Interviewing is a good method for gathering this type of information from the agencies involved first hand. Surveys are helpful in getting a closer and more detailed look at what users want and need from invasive species databases and web portals. Database research provides insight as to what is already online and operational in terms of databases and portals to databases. Lastly, the feature analysis method has been used to analyze possible recommendations to be included in the final report.

4.1. *Interviews*

Our first priority in our research was to interview representatives from the various organizations or agencies maintaining aquatic invasive species (AIS) databases. An interview is defined by Berg (2004) as "a conversation with a purpose" (p. 75). We chose to use interviews because it allowed us to talk one on one with experts in the field and gain knowledge on the problem first hand.

There are many types of interviews, ranging from very formal and structured to very free and conversational in nature. We developed what are known as semi-structured interviews as they have many advantages over structured interviews for the purposes of our project. In a semi-structured interview, a list of general questions is prepared and asked. However, the interviewer is not required to read from this list as if it were a script. The interview should be fairly informal and conversational in nature (Berg, 2004).

The semi-structured interviews allowed for more of a conversational flow to take place rather than a scripted question and answer session. The benefit of having a more natural and conversational flow to our research is that additional impromptu or probing questions could be inserted. As a result, we could gain additional insight to the topic without having to follow a structured scripted interview from the very beginning. We could also change questions based on how the interview was going in terms of how much the interviewee knew about certain topics. As Maxwell (2005) says, "[unstructured interviews] trade generalizability and comparability for internal validity and contextual understanding" (p. 80).

We preferred to do most of our interviewing in person, because "telephone interviews lack face-to-face nonverbal cues that researchers use to pace their interviews and determine the direction to move in" (Berg, 2004, p. 93). However, only two of the people from our primary contact list were local. Therefore, we planned on conducting the rest of our interviews over the phone.

We decided that interview questions would be asked by one person, and the response written or typed by the other two members of the group. With this method in place, we could produce notes that were thorough and accurate, since we could compare both sets of notes after the interview was complete. For phone interviews that were conducted in our own office, a laptop computer's microphone was available which was used to record the conversation to aid in getting all of the information more accurately than written notes alone. Recording via a laptop computer allowed the interview to be saved as a computer file, which could then be easily saved, transferred as needed, and played back at later times, thereby providing a convenient means of transcription.

The first people who we chose to interview were those who attended an AIS Database Summit, held 12-14 September 2005 in Ohio. The attendees of this summit were chosen because they are all interested in forming a central source of online information for AIS. They are all experts in the field and would be able to provide us with the most useful information about AIS databases as well as their thoughts and opinions of a central AIS web portal. Since there were ten databases represented at this summit, our plan was to interview one of the key members working on each database in order to begin getting opinions and ideas from many of the most knowledgeable sources.

Each person that we interviewed works with a different database and has varying degrees of expertise. We created customized interviews based on each interviewee's, background knowledge, position and how they worked with their database. This allowed us to obtain information that was specific to each situation. The information that we expected to gather from these interviews would be essential to our goal of compiling and organizing data from all of the agencies involved with AIS databases. Additionally, we planned to obtain contact information for our second round of questioning.

4.2. Questionnaires

Questionnaires are very similar to interviews, but there is not a one-on-one conversation involved. In addition, the questions are more structured than our semi-structured interview questions. After our interview contacts were determined, there were hundreds of additional people who work with invasive species databases who could serve as secondary contacts. We concluded that interviewing these secondary contacts would have been an inefficient method due to the short seven-week time constraints on the project. A concise emailed questionnaire was much more efficient. Sending

questionnaires through email allowed us to communicate with many contacts at once and get the information we needed without scheduling and conducting individual interviews.

The secondary contacts who we asked to fill out our questionnaire were grouped into two categories, people who manage databases, and database users. These groups were chosen in order for us to obtain and compare opinions from different types of people who may use the AIS web portal. We planned to send questionnaires to as many people as we could easily get in touch with, without spending more time than our schedule allowed for obtaining additional contact information. Some of the contact information of the questionnaire participants was obtained from our liaison and people we had previously contacted through the interview process. We were able to gather additional contact information by browsing database websites and looking up information about the people who run the sites. We sent requests to complete our questionnaire to fifty people.

The topics in our questionnaires were the same as in the interviews. We mainly wanted to get opinions on the current state of information, the needs of stakeholders and users, and what the subjects would like to see in the future. These opinions would serve to reinforce the validity of our interview data as well as potentially provide some counterarguments. Since the questionnaire contacts knew less than the interview subjects about efforts to create a centralized AIS portal, we asked questions that were less technical than the interview questions.

4.3. Surveys

Surveys have several advantages over interviews. A survey allows results to be obtained from more people in a shorter amount of time than a series of interviews. With

internet surveys, there is a higher level of anonymity, which may result in more open and honest responses (Berg, 2004). There is access to a larger amount of contacts as well. Berg (2004) says that surveys can, "take advantage of the geographical reach offered by the Web, as well as the fact that data can potentially be collected all hours of the day or night" (p. 59).

Surveys were used to obtain feedback on various aspects of AIS database websites from users' perspectives. Such aspects include who the user is, what the user needs from the site, how well the user has been able to obtain the information on the site, and what else the user would like to see from the site. Our survey sample was AIS database users or potential users.

We had originally planned to develop our own survey, however we quickly learned that posting a survey was not possible because of government regulations which prohibit a non-federal survey to be hosted on a federal site. Including a survey via hyperlink was a possible solution to this problem, but required a great deal of time to be approved. We decided that this idea was not feasible considering our very strict seven-week schedule in which we needed to get this information.

After some research and contacting several people, we were able to obtain results from two preexisting surveys and one case study. Time was not an issue with pre-existing surveys, since the surveys were already approved, online, and amassing data. All of these sources asked potential users questions similar to what we would have asked ourselves if we had been able to create our own survey, so they were well suited for this project. Ultimately, using pre-existing survey data allowed us to focus on the analyzing

the users' opinions rather than red tape and legal issues, and proved more useful to us than creating an original survey would have.

4.4. Database Research

Database research is archival research that analyzes existing databases. It involves defining a set of characteristics and determining which of these characteristics each database has. Berg (2004) suggests that a common and easy way to handle this type of data is, "[to] reduce the data to computerizable form and enter them into a database" (p. 37). The information we gather about the characteristics of each AIS database is gathered and put into a database of its own.

Once this classification database is complete, it can then be analyzed and examined using computer software such as Microsoft Access or Business Objects Crystal Reports to look for patterns. The software can output the data in displays. Displays show "transformed groupings of data" (Berg, 2004, p. 39). Displays can include graphs or structured, printed reports, but include any structured display of the data. Creating a classification database of the AIS databases allows for selective examination of the individual characteristics of the databases in relation to each other, such as the geographic areas a set of databases focuses on, or the types of information stored within a given set of databases.

The main benefit of the classification database is that it will aid in the choices that need to be made for the web portal's organizational structure and navigation system. The classification database can also help researchers, database administrators, and the general public. Researchers will be able to use the database as a reference to find information about the subjects they need. They will be able to use the database to find only databases

with information or features they are interested in without having to know about all of the databases already in existence, thereby saving a step in their research and gathering sources more quickly. Database administrators will be able to find databases with similar characteristics to their own database. This could promote data-sharing agreements and enhance existing databases. The general public can use the database to discover databases containing specific content that they are in need of and possible to determine which databases are tailored to the public.

The database research was conducted by examining informational websites for the databases and questioning database managers. Websites were chosen because often the information about the database was summarized on a single informational page, aiding in determining the characteristics of the database quickly and easily.

4.5. Feature Analysis

During our research, we came across many potential features or ideas that could be implemented into the website architecture plan. In order to determine which of these features should be included in our report, we decided to go through a process of ranking options within each feature. The process is essentially a discussion of the pros and cons of each option, reinforcing the arguments in our discussion with our research data.

There are two aspects to the discussion of each option. One aspect is from the perspective of the users of invasive species online resources. Our research that is concerned with user feedback will allow us to determine which options are considered important and which ones are less desirable. The other perspective is from the technical standpoint. It is necessary to consider resources and technical capabilities in order to determine if any given option is truly worthwhile to implement. Even the most desirable

features are impossible to include if the required technology or funding is unavailable. The goal of feature analysis is to integrate these two points of view in such a way that each option can be given a priority rating. The high priority options will be included in the site architecture plan.

5. Results

5.1. Interviews of AIS Database Administrators

Since most of our interviewees were not from the area, all but three interviews were conducted over the phone. Only the interviews with Michelle Harmon and Karen Eason, Amy Painter, and Dean Wilkinson were conducted in person. We began each interview by introducing ourselves and telling the interviewee about our project with NOAA, including a brief synopsis of our problem statement so that everyone knew the important background details right from the beginning. We asked interviewees what their role was in their agency and how they worked with their agency's database. This allowed us to gain some background on each person. This background allowed us to judge the interviewee's level of expertise, how technical we should get with the interview questions, and what would or would not be appropriate to ask in that situation.

Once introductions and basic background information were discussed, we began asking interviewees about the database they worked with. We asked them what the main goal or purpose of the site was, how often the site was updated, what the intended audience was, if they had any plans for future upgrades or improvements, and how (if at all) they could see their database working in conjunction with other AIS databases in this portal. We also asked the interviewees if they had ever used the www.invasivespecies.gov or NISbase (Non-Indigenous Species Database, www.nisbase.org) websites and their opinions on each if they had any. We asked for their opinions on what features or information should be included in a central AIS portal and whether or not there would be any legal issues regarding the sharing of information between government agencies. Finally, we asked if there was any additional information

that they could provide to help us with our research, and if they knew of anyone else who could help us. Though some of the specific questions were unique to each interview, the general format of the interview remained the same and can be found in Appendix B.

5.1.1. NIASDWG Interviews

The members of the Non-Indigenous Aquatic Species Database Working Group (NIASDWG) were our primary contacts for interviews. As mentioned in Section 4.1, these people were experts who work with some of the larger government AIS databases. They held a summit last September in Ohio where they discussed the need for a central information source on invasive species. The members also attempted to determine the availability of resources for such a project and how much information, if any, overlapped or was duplicated between the ten databases represented. In addition, the database working group discussed possible improvements and upgrades for NISbase. The members of this group knew about the goals of our project and were a suitable group of primary contacts. The following are summaries of interviews with several of the NIASDWG members present at last September's summit.

Marco Tontodonati: 31 October 2005

Marco Tontodonati is one of the web administrators at the International Joint Commission (see IJC Appendix A for more information), and is in charge of the upkeep and maintenance of the Great Lakes—St. Lawrence Research Inventory, a database of projects in the Great Lakes region. The goal of this database is to collect information about any research project in the Great Lakes - St. Lawrence Region, including the types of project, who is funding it, and what the main interests of the project are.

The intended audience of this particular database includes researchers, students, and various agencies that might be interested in funding these types of projects. Although no specific user statistics were available, Tontodonati informed us that the site is widely used. Projects are constantly added to and updated in the database. He intends to add a counter to the database in the near future so the number of hits can be tracked.

Tontodonati believes that the IJC database is very useful, and will continue to be as long as it is kept up to date. However, there have been a few problems: when the database was created, agencies doing projects in the Great Lakes region were asked to upload the project data into the database so that everyone could access the information. Uploading was never mandatory and many projects were not entered. Some of the interns working with Tontodonati have entered missing projects themselves, but the task remains incomplete. The database would be much more effective if agencies took the time to enter project information themselves.

Tontodonati expressed that he would be very interested in seeing a central AIS web portal created. Ideally, information from this inventory along with similar project databases hosted by other agencies will be shared and linked together through one portal. This way, a project could be entered into a centralized database once and shared amongst many researchers. This would make searching for project details easier and reduce the amount of duplication.

Tontodonati explained that there is minimal information overlap between the ten databases present at the summit, since various organizations use their information differently. For example, the Great Lakes St. Lawrence Research Inventory (GLSLRI) database collects information regarding funding that others do not, and likewise other

databases collect information that the IJC database does not. This is very good, because it means if the central portal were created to include information from all of these databases, there would be little overlapping duplicate information. Regarding potential features, he mentioned that he would like to see different searchable fields in a distributed database, where projects could be searched by primary investigator, agency, region, funding, body of water, start and end dates, etc.

David Raikow: 1 November 2005

David Raikow works with the NOAA National Center for Research on Aquatic Invasive Species (NCRAIS), a division of the NOAA Great Lakes Environmental Research Laboratory (see GLERL Appendix A). Raikow is a research aquatic biologist and the project leader for the Great Lakes Aquatic Non-indigenous Species Information System (GLANSIS). Raikow developed the idea for GLANSIS because, although there were databases with information on AIS, none focused on the Great Lakes region and thus it was often difficult for people to find information on Great Lakes AIS.

GLANSIS is intended to be a one-stop resource for Great Lakes AIS information. GLANSIS is still under construction and not yet operational; a simple list of the known non-indigenous species in the Great Lakes is all that is currently online. The database is a collaborative effort between NOAA and the USGS. The agencies are looking to combine information from USGS's Non-indigenous Aquatic Species (NAS) database and SERC's National Exotic Marine & Estuarine Species Information System (NEMESIS) database. NEMESIS is well organized into many specific data fields, while the data within NAS is displayed in the form of narrative paragraphs. The paragraph structure of NAS was not ideal, however it was used as the basis over the more organized data fields

of NEMESIS because NEMESIS was not designed to handle the entry of new data and NAS allowed for immediate data entry.

USGS already has many fact sheets containing species information, so there is no need to spend time developing something that already exists, or as Raikow put it, "reinvent the wheel." Interns at GLERL are in the process of updating these fact sheets and adding new ones for the few species that are not already there. Once the fact sheets have been updated and there is content to work with, GLERL plans to work on the final product with funding from a grant that they received for the GLANSIS project.

GLERL plans to interface with NISbase in the future. Since GLANSIS is technically a subset of the NAS database, however, Raikow was still unsure how exactly this would work. What he would like to do is add a new "search by region" dropdown box on NISbase that would redirect to GLANSIS when the Great Lakes region is selected. Raikow said that his team is working with NAS to avoid any overlap or duplication of information, so this should not be a problem once GLANSIS comes online.

Raikow would like to see different ways of searching for information on a central AIS portal other than just keywords. He would also like to see options such as a search by distribution or by policy. This would allow people to focus their searches and narrow down some of the results so they get more relevant data and do not have to sift through as much information.

Raikow noted the importance of keeping information up to date. He would not want to see someone go through the effort of creating a good-looking, comprehensive AIS tool only for it to become useless almost immediately due to a lack of updates. This is why he likes the idea of using NISbase as a base for a central portal for information.

NISbase does not contain any information on its own. Instead, it draws information from outside sources. As long as these individual sources remain up to date, the portal will be also. One central database would be much harder to keep updated than many smaller ones linked through a portal with a similar structure.

Raikow noted that it is difficult to obtain funding for any projects like these databases. The progress on GLANSIS has been very slow. The developers have a plan and infrastructure established and know what they want to do to bring the database online. However, since the AIS databases are not considered a high priority, the funding needed to complete GLANSIS has proven difficult to obtain..

Mark Einstein: 2 November 2005

Mark Einstein is the chief web officer and lead programmer of the Sea Grant Non-indigenous Species Site (SGNIS) with the Illinois-Indiana Sea Grant. He also works with Sea Grant on research and outreach products. SGNIS is a bibliographical reference resource. It contains both peer reviewed and grey literature. Grey literature is literature that has not undergone peer review. Each entry is reviewed by someone with SGNIS and tagged appropriately so that it can be found through a search. The database currently has over 50 searchable keywords and new keywords are added as needed. For the most part, he believes that SGNIS is up to date. They are slowly adding new species and information. He informed us that SGNIS received approximately 610,000 hits last month alone.

Einstein has a more technical role than our other interviewees do. Therefore, we focused our questions more on the SGNIS database and statistical information and did not ask as many questions pertaining directly to AIS or features that researchers might be

looking for from the portal. He believes that search filters were a good way to remove unwanted results, but they increase the risk of not returning any results if too many are used.

Michelle Harmon and Karen Eason: 3 November 2005

Michelle Harmon and Karen Eason work at the National Ocean Service (NOS) within NOAA. Michelle Harmon is a physical scientist, who represents NCCOS and NOS on NOAA's invasive species program and coordinates a number of projects. Karen Eason is an invasive species specialist, and the lead in the early detection of invasive species program. They are currently working on a database called EDIS. EDIS is still under development and is not operational at this time. It is only a checklist now; it will eventually turn into a searchable database. The NCCOS is currently closing out a pilot project in Hawaii, and is moving on to the Gulf of Mexico region where a large amount of AIS information has been collected. There are over twenty years of data in the Gulf of Mexico to work with. Harmon and Eason would eventually like to cooperate with NISbase, but they have no set time in mind. Their main priority is to get the EDIS database up and running for now.

While they are working on creating the database, they are trying to combine resources and work with Greg Ruiz at SERC and Pam Fuller at USGS to avoid any possible overlap of information. They also do not feel that there should be any legal issues or red tape to deal with regarding interagency data sharing agreements as long as each agency wants to cooperate and share the information. The main concern is that each agency's seal be on the information that it owns so that there is no confusion as to where each piece came from. They did mention, however, that one possible problem with the

bibliographic databases may be the inability to provide abstracts or full text documents due to copyright issues.

Both Harmon and Eason had many ideas on what types of information and features should be included in a central portal. They would like to see the final product as one central location with information on how to protect against and control the invasive species problem in the future. They would also like to see a search feature that allows users to filter results into common categories such as data type (species, bibliographic information, projects) or by what the information is needed for (research, management, literature). A section on regulations at federal and state levels was another suggested feature.

They both agreed that NISbase is a good start for a central portal as it is already online and functional. It has already been funded and its creators have dealt with all of the development issues involved in creating a distributed database search engine. NISbase is also capable of keeping information from each agency separated and labeled, making it easy for the user to tell where each piece came from. Their only concern with using NISbase as a starting point for the creation of such a portal is that NISbase already has its own identity that users are familiar with, but the working group wants this portal to have a new identity. They also mentioned that the issues of apparent and real data overlaps and duplication have to be dealt with before and during the creation of any such portal.

Brian Steves: 7 November 2005

Brian Steves is one of the creators and lead programmers of NISbase. Steves developed NISbase because there was a need for a common AIS search page for

researchers and managers. NISbase works through custom XML recording. Users enter a search term or phrase and then NISbase goes into whichever databases the user requested and pulls out any pertinent information. The XML results from the databases are then translated into a merged HTML fact sheet that is displayed for the user (see Figure 5.1).
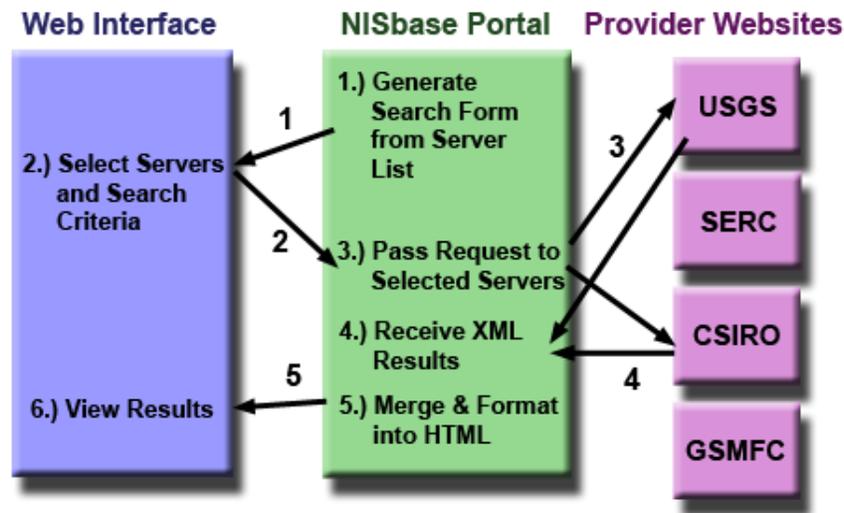
Figure 5.1: NISbase organization
Adapted from: SERC, http://www.nisbase.org/nisbase/documentation.html, December 2005

Steves informed us that all of the databases working in conjunction with NISbase have an ad hoc agreement to share their data. All of the data is clearly labeled as to where it came from and which agency owns each part, so there have been no legal problems or red tape to deal with regarding the information sharing. They also do all of their own hosting so that was not an issue either.

NISbase as it stands now is very useful. Steves says that it could be improved but currently links the databases very well. He hopes to continue to expand NISbase and continue adding new databases, information, and features. A bibliographic search was recently added, along with the ability to search for species by attributes other than just name, such as location and type (fish, algae, etc.). The developers are also planning to

add some new mapping features in the near future, and are working on finalizing the merged fact sheet feature.

Steves has run into a few problems keeping up with the development of the site. Aquatic invasive species are just a small subset of all invasive species, and various organizations and agencies dealing with terrestrial invasive species have been looking for Steves' help developing distributed databases and websites as well. These other projects have been drawing much of his time and attention lately which does not allow him to spend as much time as he would like with NISbase.

Pam Fuller: 8 November 2005

Pam Fuller, of the USGS, maintains the NAS database on the USGS site. The purpose of this database is to track the distribution of new freshwater AIS introductions and to supply photos and information on each species to the user. The audience of this site is mainly researchers, resource management people, students, and the general public. Fuller informed us that the site is heavily used, and that there is very little information overlap with other databases. The most similar database would be SERC's species database, which is more focused on the history of each species rather than the distribution.

Not only does Fuller maintain NAS, but she is also one of the developers of NISbase along with Greg Ruiz and Brian Steves. NISbase is currently the closest website to an AIS portal in existence. It operates as a distributed database system. It is capable of taking search queries from users and searching multiple databases for potential results. The site is capable of searching these databases for fact sheets and bibliographic information at this time. Fuller said that a projects section is in development as well so

that users can see what types of research are being done and who is doing it. Another feature currently planned for development on NISbase is a distributed map system. The technical aspects of the merged fact sheet feature are complete for the most part and they are just making it look nice. In the future, the NISbase developers would also like to add more databases and query tools once they get enough funding. Fuller believes that AIS databases are under funded and need more money in order to maximize their effectiveness.

Regarding a central AIS portal, Fuller would like to see flexible search options that allow users to search by topics such as taxonomy, region, and type of information (project, reference, etc). She would also like to see better data integration and customized maps and fact sheets that could be made at any time to show users only the information that they are interested in. According to her, everyone she has worked with so far has been willing to share their information so long as their agencies' seal is displayed with the information so that users know which agency owns or was responsible for contributing it. There have been no legal issues or red tape during the creation of NISbase. The only problems that have developed thus far have been technical. According to Fuller, there are many interested people in line to get their database incorporated into the NISbase portal.

Chuck O'Neill: 17 November 2005

Chuck O'Neill is the statewide invasive species specialist and the director of the ANS Clearinghouse database. The ANS Clearinghouse database is an online card catalogue for the library at New York State University. This catalogue is a Microsoft Access database that is updated weekly with any new papers that the library has received.

Due to copyright issues, the Clearinghouse database is unable to put the abstracts of the papers online; instead, they pay graduate students to read the works and write annotations for use on the site. O'Neill told us that approximately 24% of the people using this database are researchers, 22% are working for government agencies, 15% work for electric utilities or water treatment facilities, 13% are educators and students, 5% work in industry, and the remaining percentage fit into some "other" category and is unknown.

The ANS Clearinghouse started out as a zebra mussel library. Therefore, it has extensive bibliographical information on zebra mussels, along with a calendar of events, links to other sites and projects involving zebra mussels, and distribution maps of the zebra mussel population. Since its start, however, thirty-two new invasive species have been added along with extensive keyword listings for each.

The database has a dropdown box making it searchable by species, title, author, and keywords. The search engine also gives full citations for all results. In general, users are having no difficulties finding the information they need. O'Neill believes that this search feature is fairly complete and says there are no plans to expand upon it in the future. He referred to the Clearinghouse database as an "invasive species Google" where students can search for literature online and then go to the library to pick it up. O'Neill said that they plan to continue adding species to the library as funding allows. Adding new species to a lending library tends to be expensive since hard copies of everything must be purchased. He said that funding was one of their biggest problems that the library is facing and that it is difficult to pay for programming and new features on a "bare bones budget."

The Clearinghouse has a loose sharing agreement with SERC. They are listed as contributors on each other's respective websites. O'Neill is currently trying to get the Clearinghouse data linked into NISbase. He said that he is wide open to the idea of sharing information and working with others.

One feature that O'Neill would like to see in a centralized portal is more information about the agencies involved. Currently on NISbase, the acronym for each contributor is listed in the search feature, but much of the general public does not know what the acronyms stand for or knows little about the agency. O'Neill thinks that users would get more out of the site if a one-sentence description or more were added under each agency's name.

O'Neill thinks that the portal we recommend should be clean and simple to use. He uses www.invasivespecies.gov often and still cannot find much of the information he is looking for. If someone, who uses the site frequently and knows a lot about the subject has difficulty, an average first time user with little AIS background would most likely run into similar problems.

O'Neill also mentioned that it might be a good idea if various databases could be separated based on the database's owner. For example, keeping the federally or state funded databases in one section and educational (.edu) or nonprofit organizations (.org) in another. Unless this was done right it may make information more difficult to find; government databases often have a different focus than databases run by a college or university, and there is also a potential quality or credibility issue with anything that is not federally funded.

The last note that O'Neill made is that portals often bring up information within the portal from other websites, but many do not let you link to the actual site where the information came from in a new window. He did not like this because as he searches online, he moves further into the portal looking for information, and often times when he wants to go back to an older section he must hit the back button many times. If information were to pop up in a new window or tab instead of just moving forward in the same browser it would be a lot easier to go backwards later if necessary.

5.1.2. Secondary Interviews

The first six interviews allowed us to talk to members associated with all but one of the agencies associated with NIASDWG. We tried several times to get an interview with a representative from the Ohio Sea Grant, but were unable to do so. This is not a problem at all, as we learned about almost all of the databases represented at the summit and received great feedback from the interviews we were able to schedule. We were also able to schedule two interviews with additional contacts that were not present at last September's summit. Both of these contacts were local and we were able to interview them in person. The following sections summarize our secondary interviews.

Amy Painter: 8 November 2005

Amy Painter works at the National Sea Grant Office. She is currently working on the development of the National Information Management System (NIMS). It is very similar to the database that Ohio Sea Grant (who we were unable to contact) has created, but will exist on a national level.

NIMS will allow Sea Grant to enter all of their research and outreach projects into a central database. All of these projects can then be searched for in the database. Results

information and annual reports will be available and can be tracked by anyone. This database should increase the public awareness of Sea Grant projects, decrease project overlap, encourage people to work together and share information, as well as to provide a standardized way of reporting project results.

Dean Wilkinson: 14 November 2005

Dean Wilkinson is the NOAA invasive species coordinator working at the NISC office. He does external work for NOAA, promotes interagency coordination, and does internal management work with the NOS, OAR, and Fisheries line offices. He also works with the ANSTF and the NISC.

Wilkinson's main concern with the information issue today is the proliferation of databases. Instead of creating a single master database with all AIS information, many small groups of people have gotten together and made their own. Since little can be done about this matter now, he believes that what is necessary is an efficient system of linkages that effectively connects the good AIS databases together in one location. There are five core features that he thinks are necessary to include to create a good centralized source of information on AIS.

The first thing that Wilkinson believes should be included in such a portal is a section of "occurrence" databases. This would be comprised of databases like NEMESIS, NAS, GLANSIS, and EDIS. NEMESIS, NAS, and GLANSIS, contain AIS species information and EDIS tracks the occurrence of new invasions. Between these databases fact sheets and information on species origins, history, and distribution can be found.

The second feature that Wilkinson thinks that a portal must have is some sort of species identification tool. There are few adequate aquatic species ID systems out currently, however there are several meant to aid in plant identification that could be used as models. A few examples are the Army Corps of Engineers' Plant Management Information System (PMIS) and the University of Florida's APIRS plant identification tool. PMIS shows the user several pictures, asks questions about the plant, and attempts to identify it. Once the plant has been identified as invasive, the system can then tell you an appropriate herbicide to use in order to eradicate it based on the conditions in the surrounding environment.

The third feature that Wilkinson believes to be important is a section on what is being done to control the problem. There are many treatment options for aquatic plants, however there are not as many effective solutions for controlling other types of invasive aquatic organisms. The northern snakehead, for example, was introduced to a pond in Crofton Maryland area a few years ago. Wilkinson explained to us how this pond was poisoned and it was believed that the entire snakehead population had been killed. A second lake in Montgomery County was drained a short time later when a single snakehead was found in its waters. He said that the snakehead has been discovered in the Potomac River in Washington D.C. Since it is impossible to drain or poison a river there are very few possible solutions. Right now all that can be done is to fish out as many snakeheads as possible, however a recent news article seems to think that the snakehead population in the Potomac is on the rise and there is little more that can be done about the problem (Williamson, 2005). Scientists are now just attempting to monitor the situation and hoping that the snakehead does not upset the native bass and fishing industry

(Williamson, 2005). Wilkinson believes that it is important to give users, especially the ones in management, access to the information on control options available and what is being done to solve the problem elsewhere.

The next feature that Wilkinson would like to see incorporated into the portal is a bibliographic resource database similar to what SGNIS and the ANS Clearinghouse offer. A more centralized version of this would allow users to search for peer reviewed and grey literature and find information on invasive species more easily. He would also like to see more abstracts or summaries of peer reviewed literature on this type of site, as going through many full text documents is a very long process.

Finally, Wilkinson mentioned that a projects database section would be ideal. He said that Sea Grant sponsors research on many AIS projects, but the principle investigators (PI's) are never required to report back with their findings. He would like to see a central database of all Sea Grant sponsored research containing information on who did each project, what they were researching, their findings and results, along with contact information. Several smaller databases like this already exist like the projects database at the Ohio Sea Grant, AIRD at SERC, and the GLSLRI that IJC created. Amy Painter at the National Sea Grant Office is also working on developing NIMS which would expand upon the Ohio Sea Grant database and make it work nationally for all of the Sea Grant divisions.

Wilkinson does not believe that every database available should be added into this central portal, he would rather see quality over quantity. Ideally, he would like for a few of the best examples of government funded databases in each of these categories to be

included and nothing more. This way there can be some quality assurance and reduced risk of information overlap.

Wilkinson noted that he is an occasional user of the databases currently available and gets frustrated when he cannot find the information he needs. He also said that the major weakness of many databases is that the creators are very slow in getting information updated. He said that they try to be complete and spend a lot of time filling in all of the data fields before making the information available so that by the time it is up on the database he usually already knows about it. There are now over 230 exotics in the San Francisco Bay that have not been added into these databases yet. He believes that these databases would be much more useful if they were updated more in a more timely manner.

Essentially Wilkinson does not want to see the creation of more databases; rather he wants to see an effort to get all new information incorporated into a limited number of large high quality databases, which are already in existence, and are linked together in one convenient location.

5.2.   Questionnaire Results

Over the course of our interviewing, we were able to start making a list of potential secondary contacts. Our liaison also provided us with a list of secondary sources that we might want to talk to, and we found a several names through our own research online as well. We had planned to contact all of these secondary sources through an email questionnaire. This was a good method of reaching a large group of people all at once without having to set up many individual interviews.

When we created the questionnaires, we had to keep in mind that these secondary contacts did not necessarily know as much in-depth information in our areas of focus as our primary interview candidates. Therefore, the questions were fairly general and straightforward. Since there were two main groups of people to contact, database managers and database users, we decided that it would be best to create two different versions of the questionnaire. The first group consisted of those who manage smaller non-government funded databases, and resource managers and researchers who would be potential users of the final product of this project. The first four sections in this chapter represent the opinions of the first group, who we asked more technical questions due to their expertise in the database field. The last four sections are the responses from our potential users. We asked these people their opinions on current AIS databases that they use for research and their ideas for future improvements.

For database managers, we asked what the general goal or purpose of the database was, and if there were any issues or problems keeping the site maintained and up to date. For researchers, we asked about the databases or search engines they were currently using, their opinions of them, and the types of information they searched for most often. We then asked their opinion on whether or not information on AIS was scattered or hard to find. We also asked their opinion of www.invasivespecies.gov and NISbase. Finally, we asked them if they would use a centralized portal if one was created, and how often, along with any ideas for features that they would like to see incorporated. We chose questions from this master list and custom tailored a questionnaire for each person that agreed to take our questionnaire based on their knowledge and experience in the field. An example of a typical questionnaire is available in Appendix B.

5.2.1. Jim Graham

Jim Graham agrees that information on invasive species is difficult to find. He believes most of the information is available on paper or known to a select few researchers, but is not available on the internet.

Graham is familiar with NISbase and has worked with Fuller (see Section 5.1.6) in the past. He believes that NISbase is a good first step; however, it is not complete enough. It has raised public awareness, but is slow, does not provide analysis features, has low-resolution information, and currently does not have living maps. He also believes that the system on the National Institute for Invasive Species Science (NIISS, http://www.niiss.org) site could add features that NISbase lacks.

Graham said that the NIISS had conducted a series of user interviews, and the top features that people were looking for were current distribution maps, early warnings of bioinvasions, information on effective treatments of the problem, and a forecasting feature to predict future distribution. Graham does not believe that any portal linking many databases could provide these features. He also does not believe that one centralized database could possibly store all of the information that users need.

Graham believes that the only way to suit users' needs efficiently is to create one centralized database interfaced with other systems. This central database should be able to pull new data out of databases into itself on a regular basis. These smaller databases should also be able to pull information that they need off of this master database.

5.2.2. Kaveh Rassoulzadegan

Kaveh Rassoulzadegan develops "optimized data storing and integration strategies, to lighten end-users steps for adding/retrieving datasets." Rassoulzadegan

works for the Mediterranean Science Commission (http://www.ciesm.org/), a NISbase data provider. He works closely with Brian Steves to improve and update the quality of the information and ease of use of NISbase.

Since Rassoulzadegan works directly with NISbase, he was able to tell us more about how it works. Users of NISbase enter search criteria in order to find certain information. NISbase then queries the individual databases. These databases return the information to the NISbase engine via XML. NISbase displays the results for the user in an "html-like result page." Figure 5.1 displays a visual representation of how this process works.

Rassoulzadegan believes that what users need most from a centralized AIS portal are ergonomics and performance. He feels that useful information, like AIS data, is difficult to sort efficiently. Like Graham, Rassoulzadegan believes that the best way to deliver these would be a hybrid database structure, with both a main central database and several smaller distributed databases.

5.2.3. Devin Bartley

Devin Bartley works to provide a registry of AIS introductions internationally. Like many of the other database managers we talked to, he has had many difficulties adding records to keep the database up to date with high quality data. He told us that he agrees that information on AIS is scattered and difficult to find currently, but the situation is improving.

After looking through the www.invasivespecies.gov website, he noted that he did not believe the information was complete. He said that many of the links lead to information that is too general. Bartley also believed the site is organized in a strange

way, possibly because it is a government site and has a different emphasis than sites that focus on the ecological impacts of AIS. After a few searches on NISbase, he felt that it was also incomplete and more distribution information should be available.

5.2.4. Ron Lukens

Ron Lukens is the assistant director at the Gulf States Marine Fisheries Commission and is in charge of a small AIS database (http://www.gsmfc.org). He believes that information on AIS is scattered, which is why NISbase was created. The Gulf States Marine Fisheries Commission is a NISbase data provider. NISbase was designed to allow users to access many databases conveniently from one location. Lukens believes that NISbase works very well as it is now and that more databases should be incorporated.

Lukens said that one centralized database would be the ideal way of storing information, as it would be much cleaner and easier for users to operate. However, a single centralized database is simply not feasible. People are not willing to give up their information that they base their careers on in order for a central database to succeed. Lukens believes that a distributed database such as NISbase is the next best solution. It is an easy way to link all of the information in one location in an efficient manner. He would like to see more funding and support for NISbase in the future so that it can continue to grow and be even more useful to users.

5.2.5. Dan Thomas

Dan Thomas is the president of the Great Lakes Sport Fishing Council and a potential user of the proposed centralized AIS portal. In the past, he used online tools

such as SGNIS, state DNR sites, and Google to research AIS. He usually looks for fact sheets, articles, and pictures.

Currently, Thomas does not have much trouble finding the information he needs on Google, but if an efficient centralized AIS data source were available, he said that he would use it for all of his information searches. The most important features that he would like to see from such a portal would be informative fact sheets and pictures.

5.2.6. Marilyn Leland

Marilyn Leland is the deputy director of the Prince William Sound Regional Citizens' Advisory Council. She reviews everything that the council publishes, including the information on their website (http://www.pwsrcac.org/). The agency's main goal is to teach the public about AIS.

Leland does not have a problem with the amount of information currently available and believes it is easy to find large amounts of AIS information online. However, the problem with current AIS information is that it is difficult to sort through it all and find exactly what she needs.

Leland is unfamiliar with NISbase, but would be interested in seeing a centralized information source for AIS information. She would mostly be interested in seeing information on laws and regulations regarding AIS as well as information on current technologies and treatment methods. Leland said that a good search feature would also be ideal.

5.2.7. Cindy Kolar

Cindy Kolar was a research scientist until very recently and spent a lot of time using online AIS databases to find information. She is currently the assistant program coordinator at the USGS Invasive Species Program. She mostly uses the NAS and Fishbase databases for her research and usually looks for distribution maps and biological information. She is usually is capable of finding most of the information that she is looking for between these two sites and Google. Kolar noted that she had wanted to be able to sort NAS information by species common name, and this feature has recently been implemented. She also finds Fishbase useful but would like the categories more clearly defined.

Kolar told us that regardless of how easy it is to navigate a site, it is very difficult to find all of the information that she is looking for from one source. She does not believe the information is hard to find; it is just not in one convenient location. She would very much like to see a centralized all-inclusive location with all of the biological, ecological, physiological, and distribution information for AIS, but she believes that it would be difficult to link some databases due to their very different structures (e.g. NAS uses a paragraph format, while Fishbase uses specific fields).

Until recently, Kolar has not been overly impressed with the www.invasivespecies.gov website, but it has now become a very useful information source. The feature that she likes most about the site is the ability to link to various laws and regulations regarding AIS.

Kolar is familiar with NISbase and believes that the idea behind it is very good. She has rarely been able to get it to work fully. Since she mostly looks for information

particular to freshwater fish, the NAS website has proven to be just as useful for her research. If a reliable central resource were created, she would definitely use it, as long as it could find the information she needed quickly without long search times.

5.2.8. Michael Slimak

Michael Slimak was the last in our potential database user class of respondents who responded to our questionnaire. He is a science manager at the EPA in one of the research offices. Like most of our contacts, he has found information on AIS to be scattered and hard to find. He was not familiar with NISbase. He would use a central portal for AIS information for his research if a reliable one were available. He would mostly like to get maps and status information, natural history, and control methods for AIS from such a resource.

5.3. Survey Results

The survey data included in this section helped us to get a better idea of who the users of invasive species sites are and what they are looking for, as well as their opinions on the resources that are currently available. We were also able to use some of their suggestions for future improvements and upgrades. Any of these ideas and opinions that were common among many users and are feasible would be considered and discussed in our final recommendations for the site architecture plan.

5.3.1. NAL Survey

There is a pop-up survey on www.invasivespecies.gov. Foresee Results, a company that develops website satisfaction surveys, developed the code and hosts the survey. The National Agriculture Library (NAL) developed the questions. The survey

focuses on the issues of: quality of the information, ease of use, and what features should be added to the current site. The full list of survey questions is included in Appendix D. The survey has been online since January 2004 and is still collecting data as of December 2005. The site has an average of 254,668 hits per month from December 2004 to November 2005 (Invasive Species Info, 2005).

We received the raw survey data from Susan McCarthy, a technical information specialist who works for the National Agriculture Library and is overseeing the survey data. The survey results have been divided into samples of set numbers of results. This is done automatically by the Foresee Results software for the purpose of monitoring trends among many samples. There are 227 samples total as of December 2005, with typically 306 survey results per sample. Once 306 people have taken the survey, the next sample begins. The samples are numbered in chronological order, with sample 227 being the most recent as of December 2005.

There is no option to combine data from all of the samples into one set of results. Thus, we focused on only the most recent samples for our analysis. There is little variation within results from one sample to the next. We averaged the results of the past five samples in order to obtain accurate results. Given our time constraints, averaging five samples was more practical than taking an average of all 227 samples. The five samples provided us with results from 1,530 users, which make an average that does not vary significantly from the average of all 227 samples. Results from the relevant questions from the average of the past five samples are included below.

According to the results in Table 5.1, students and the general public make up a large part of the users of www.invasivespecies.gov. Also significant are post-secondary

education faculty and staff (9.76%) and business or industry employees (7.74%). This

information shows that many different groups of people use the site. All of these people

should be considered when designing an effective layout.

Table 5.1: NAL User Roles

Which **best describes** your role in coming to our site?		
Answers	**Number of Responses**	**Percent of Responses**
American tribal representative	73	3.48%
Business/industry employee	161	7.74%
College/university faculty/staff	203	9.76%
Elementary/secondary educator	83	3.98%
Farmer, rancher or other agricultural producer	89	4.28%
Federal government (nonUSDA) employee	79	3.76%
General Public	391	18.92%
Librarian or Information Specialist	104	5.08%
News media representative	39	1.84%
Nonprofit organization representative	76	3.66%
State or local government representative	72	3.46%
Student	398	19.28%
Other	307	14.72%

Adapted from: The USDA's National Agriculture Library survey data

The results in Table 5.2 show that when users did have difficulty using the search

feature, the problems stemmed from a number of issues. It is important to note that

45.26% of users reported difficulty in using the search feature. The most common issue

was that the user was not sure what words to use in the search. Note the difference

between "The results were not relevant to my search terms" and "The results were not relevant to my needs." Although the two options are similar, the former implies that the problem is mainly the search engine, whereas the latter implies that the problem is the mainly the actual information available on the site.

Table 5.2: NAL Search Difficulties

Did you **encounter difficulties with the Search feature**, and if so, what was the primary issue?		
Answers	**Number of Responses**	**Percent of Responses**
I did not encounter any difficulties with the search feature	837	54.74%
Too many results	71	4.64%
I was not sure what words to use in my search	138	9.04%
The descriptions/abstracts were not helpful	75	4.90%
The results were not relevant to my search terms	55	3.58%
The search turned up no results	89	5.84%
The results were not relevant to my needs	78	5.08%
Search speed was too slow	44	2.88%
Other	142	9.30%

Adapted from: The USDA's National Agriculture Library survey data

In Table 5.3, feedback on the topic of website navigation is covered. In total, 40.26% of users reported some kind of difficulty in navigating the site, which is nearly as many as users who had difficulty with the search feature (45.26%). One of the main issues here is users having difficulty finding related information (9.36%). An additional issue is users being unable to find specific content (7.60%). Another problem is with the links, with 5.36% of the users not being able to determine the best link they should have clicked on, and 5.80% ending up at an unexpected location on the site.

Table 5.3: NAL Navigation Difficulties

Did you **encounter difficulties navigating the site**, and if so, what was the primary issue?		
Answers	Number of Responses	Percent of Responses
I did not encounter any difficulties navigating the site	913	59.74%
Could not determine the best link on most pages	82	5.36%
Links did not take me where I expected	89	5.80%
Technical difficulties (e.g., broken links, error messages, etc.)	34	2.22%
Too many links or navigational choices	49	3.20%
Links/icons/labels are difficult to understand	23	1.50%
Navigated to the general area but could not find the specific content I needed	116	7.60%
Difficulty finding related information	143	9.36%
Other	80	5.22%

Adapted from: The USDA's National Agriculture Library survey data

When looking at the methods of navigation in Table 5.4, we can see that searching is the most popular way to navigate the site (34.72%), and a combination of methods is the second most popular way to find information (21.80%).

Table 5.4: NAL Navigation Method

How do you **prefer to navigate this site**?		
Answers	**Number of Responses**	**Percent of Responses**
Search	531	34.72%
Menu structure	242	15.80%
Text links	133	8.72%
Combination	333	21.80%
Other	70	4.58%
No preference	220	14.38%

Adapted from: The USDA's National Agriculture Library survey data

Beyond the multiple-choice questions, the survey had the fill-in question: "What else would you like to see on our site?" The data for the fill-in question was a different format than the previous questions. The data was not divided into samples. Instead, we received access to a list of 384 responses gathered from July to November 2004. We summarized the results, grouping similar responses together. The summary of the results is listed in Table 5.5.

Table 5.5: NAL Site Features

What else would you like to see on our site?	Responses	% of total	% of usable responses
No response	131	34.11%	N/A
Unusable responses	122	31.77%	N/A
Pictures: bigger/more/higher quality	26	6.77%	17.57%
More in-depth/detailed/focused information	23	5.99%	15.54%
Sort by geographic location	14	3.65%	9.46%
Links: clearly defined/less/better working/better organization/easier navigation	11	2.86%	7.43%
More species	9	2.34%	6.08%
Some form of identification tool	7	1.82%	4.73%
Treatment options/management/pesticide information/etc.	7	1.82%	4.73%
Merged fact sheets/brief info tables	5	1.30%	3.38%
Other invasives: terrestrial/medicinal/weird/mammals/etc	5	1.30%	3.38%
Fewer pop-ups	4	1.04%	2.70%
Search filters	3	0.78%	2.03%
Comprehensive lists of species/databases	3	0.78%	2.03%
Fewer technical descriptions	3	0.78%	2.03%
Laws by state/legal cases/legal information	3	0.78%	2.03%
Contact information/phone numbers	2	0.52%	1.35%
Links for teachers	2	0.52%	1.35%
Citation information	2	0.52%	1.35%
Comics/fun stuff/less boring	2	0.52%	1.35%
Journal articles/abstracts/summaries	2	0.52%	1.35%
Current news	2	0.52%	1.35%
Case studies	1	0.26%	0.68%
Product info	1	0.26%	0.68%
Native plant list	1	0.26%	0.68%
Easier site map	1	0.26%	0.68%
Forecasting	1	0.26%	0.68%
NISC meeting minutes	1	0.26%	0.68%
General intro	1	0.26%	0.68%
Distribution info/destructive area	1	0.26%	0.68%
Improved search engine	1	0.26%	0.68%
Life cycles/diseases	1	0.26%	0.68%
History	1	0.26%	0.68%
FAQ/questions page	1	0.26%	0.68%
Statistics	1	0.26%	0.68%
Total usable suggestions	148		
Number of subjects	384		

Compiled from: The USDA's National Agriculture Library survey data

Disregarding responses that were irrelevant or could not be interpreted, pictures

were the most requested area for improvement (17.57% of usable responses). The next

most requested improvement was more in-depth, detailed, or focused information (15.54% of usable responses). There were also many requests for specific pieces of information, such as more species information (6.08% of usable responses) or various forms of management and control information (4.73% of usable responses). Navigational issues were also a main part of the results, with several users requesting better links, changes in the way information is sorted, and search filtering options.

In Figure 5.2, the responses from Table 5.5 have been grouped into broader categories in order to look at the results in more general terms. We defined the categories to show the results in an easy, straightforward manner. Figure 5.2 shows a pie chart of the results after they were grouped into categories. When grouped in this manner, the biggest comment users made falls into the category of informational needs, which include requests for more detailed information as well as requests for specific types of information. This way of presenting the data is less specific, but it demonstrates that the main concern among users is actually with informational needs, and multimedia (mainly pictures) is the second priority, along with site navigation.
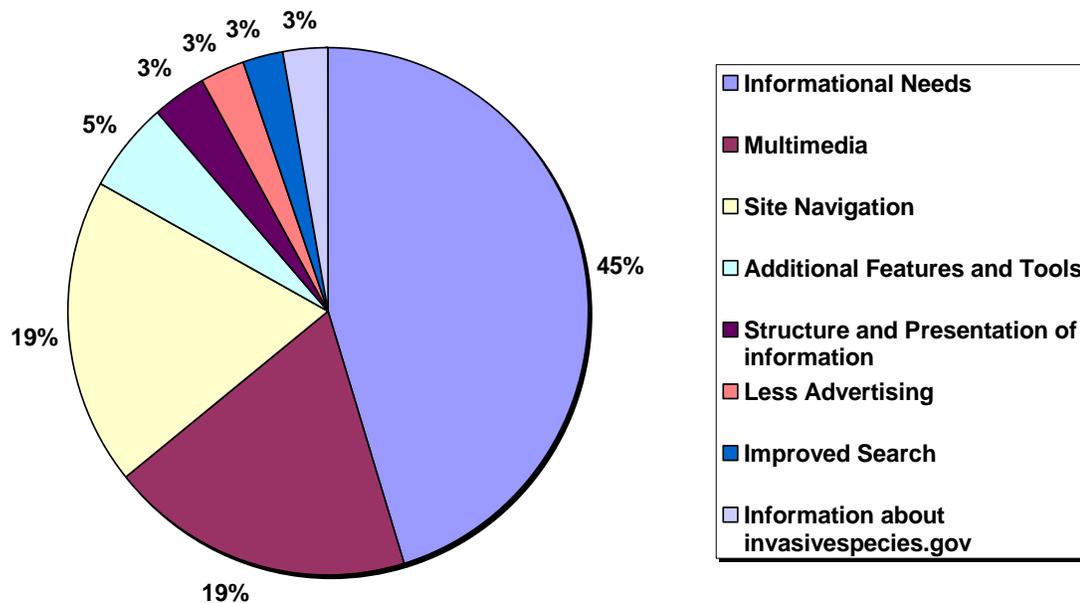
Figure 5.2: NAL Categorized Open-Ended Responses
Adapted from: The USDA's National Agriculture Library survey data

5.3.2. Invasivespecies.gov Student Survey

Along with the data from the NAL's popup survey, Susan McCarthy provided us with additional results from a survey conducted by the University of Arizona in the Fall semester of 2002. The subjects were thirteen graduate students studying rangeland management, completing an analysis of www.invasivespecies.gov as part of their course. The students were divided into five groups, three groups of three and two groups of two, with all groups giving a general evaluation of the main page and each group evaluating specific areas within the website. This resource provides us not only with additional opinions on the current www.invasivespecies.gov site, but with opinions which apply to what users are looking for from any type of online invasive species resource.

For the main page, all of the groups made comments about the navigation of the site. Overall, the groups considered the page easy to navigate, but there were some criticisms of the links on the site. On the navigation bar on the right side of the site, the site is broken down into the categories of "What's New," "Species Profiles," "Geographic Information," "News and Events," "Laws and Regulations," "Resources," "Manager's Tool Kit," "Databases," and "Vectors and Pathways." Each category is broken down further into subcategories. Some students recommended that there should be more main categories so that there are not too many sub-categories, while others suggested a drop-down menu for each category. Another recommendation was to include a visual cue as to where a user is located within the site to improve the ease of navigation.

Students recommended several additional features that they would like to see on the website. One such recommendation was the inclusion of current events on the homepage, which would be updated on a daily basis. Another recommendation was that under the Species Profiles area of the site, there should be summaries of the species listed on the page. The summaries could be stored on the site internally, and then if a user would like to continue researching the species, there would be links to additional information from an external resource. Also, students felt that a statement of the purpose of the site would be an important addition to the site.

As far as visual aspects are concerned, some students commented that the green color scheme is associated with health, whereas an orange or red color scheme may be more appropriate to represent the urgency of the situation. One of the other groups made the comment that the color scheme was drab.

5.3.3. SGNIS Survey

In addition to the National Agriculture Library's survey, we found a similar survey on the Sea Grant Non-Indigenous Species (SGNIS) database. The SGNIS site and database is a good representation of AIS sites and databases in general. Though our project is not concerned specifically with the use of SGNIS, examining the survey provided us with additional feedback regarding the use of AIS database sites.

Angela Archer, one of the web specialists working on SGNIS, provided us with the results from the survey. There were eighty-five responses in total. The survey was up for one year from November 2004 to November 2005. The survey is set to appear randomly, thus most users did not see it. The site receives 19,768 hits per day as of December 2005 (WebTrends, 2005). Some of the questions pertained specifically to SGNIS and were not relevant enough to our research to qualify for discussion, therefore those questions have been omitted from this chapter. The results of the remaining questions are included below. All questions and results from this survey, including those that were omitted from this chapter, are located in Appendix D.

This first question helped us get an idea of how many users from foreign countries may use an American invasive species database. This information helped us when considering recommendations for website features that may make the site more accessible to international users. As displayed in Table 5.6, the majority of users of the site were from the United States (81.18%). There were, however, users from several foreign countries represented in the survey, although aside from Canada and Italy (three users and two users, respectively), there was only one person from each other foreign country.

Table 5.6: SGNIS Country of Origin Breakdown

1. What country are you from? (fill in)		
USA	69	81.18%
Canada	3	3.53%
Italy	2	2.35%
England	1	1.18%
Germany	1	1.18%
China	1	1.18%
Vietnam	1	1.18%
Ireland	1	1.18%
Russia	1	1.18%
Belarus	1	1.18%
Brazil	1	1.18%
N/A	3	3.53%

Adapted from: SGNIS survey data

Table 5.7 shows the responses to the second survey question, which focuses on the job position of the users. This data has provided us with information about what types of users visit the site. Researchers (30.59%), students (22.35% total), and educators (11.76%) are the largest groups represented by this survey.

Table 5.7: SGNIS Job Position Results

2. What is your current job position?		
Researcher	26	30.59%
Undergraduate Student	13	15.29%
Educator	10	11.76%
Resource Manager	5	5.88%
Outreach Professional	3	3.53%
Administrator	3	3.53%
Graduate Student	3	3.53%
Information Technologist	2	2.35%
N/A	7	8.24%
Other (specified below)	14	16.47%
Librarian	*3*	*3.53%*
Consultant	*2*	*2.35%*
Consultant (fish biologist)	*1*	*1.18%*
DVM fish pathologist	*1*	*1.18%*
Environmental engineer	*1*	*1.18%*
Environmental scientist	*1*	*1.18%*
Legislative fellow	*1*	*1.18%*
Master scheduler	*1*	*1.18%*
Stakeholder/outdoor writer	*1*	*1.18%*
Student	*1*	*1.18%*
Zebra mussel	*1*	*1.18%*

Adapted from: SGNIS survey data

Table 5.8 displays the results from a similar type of question. We can see that 36.47% of users are from a university, which includes students, faculty, and staff. The second major group of employment is the government, with federal employees making up 21.18% of those who completed the survey.

Table 5.8: SGNIS Employer Results

3. How would you best describe your employer?		
University	31	36.47%
Governmental Agency	18	21.18%
Consulting Firm	9	10.59%
Industry	5	5.88%
Non-governmental Agency	3	3.53%
Water Utility	1	1.18%
N/A	3	3.53%
Other (specified below)	15	17.65%
Student	*2*	*2.35%*
FAO	*1*	*1.18%*
High School	*1*	*1.18%*
International Trade	*1*	*1.18%*
Nonprofit	*1*	*1.18%*
Public High School	*1*	*1.18%*
Public School District	*1*	*1.18%*
Restaurant	*1*	*1.18%*
Self	*1*	*1.18%*
Student Teacher	*1*	*1.18%*
US house of reps	*1*	*1.18%*
N/A	*3*	*3.53%*

Adapted from: SGNIS survey data

Database users look for a wide variety of information relating to invasive species for their particular purposes. With the results in Table 5.12, we can see that "environmental impact" describes what 52.94% of the users are looking for. The question in Table 5.12 specified to choose up to two options, however sixteen users provided chose three options, eight users chose four, and four users chose five. Thirty-eight users chose two options and nineteen users chose only one option. We believe that the fact that some users chose more options than others is not an issue, since some users could be looking for only one type of information while others could be looking for several.

Table 5.9: SGNIS Keywords

7. Which of these keywords best describe the type of information you are seeking from a web-based resource? (Please choose up to 2)		
Environmental impact	45	52.94%
Prevention	21	24.71%
Monitoring	20	23.53%
Population dynamics	20	23.53%
Economic impact	18	21.18%
Dispersal mechanism	16	18.82%
Aquatic plant management	15	17.65%
Ballast water	12	14.12%
Colonization	12	14.12%
Other, please provide	16	18.82%
Distribution	*2*	*2.35%*
Macrofowling	*1*	*1.18%*
Project	*1*	*1.18%*
Control	*1*	*1.18%*
Pipe fish	*1*	*1.18%*
Species information	*1*	*1.18%*
Sell, trade, plant extract, botanical	*1*	*1.18%*
Life history	*3*	*3.53%*
Treatment management	*1*	*1.18%*
Non-indigenous species	*1*	*1.18%*
Education resources	*2*	*2.35%*
Information quality	*1*	*1.18%*

Adapted from: SGNIS survey data

Table 5.13 demonstrates that most users (55.29%) do in fact come to the site looking for information about the species listed as options, which are the most common invasive species. The most popular are the zebra mussel (54.12%), the Round Goby (20%) and the European watermilfoil (16.47%). Note that 27.06% of the users were looking for a species not listed as one of the common options.

Table 5.10: SGNIS Species Search Rates

8. For which species do you most frequently seek web-based information? (check all that apply)		
Zebra Mussel	46	54.12%
Round Goby	17	20.00%
European Watermilfoil	14	16.47%
Asian Carp (Bighead, Black, Silver)	10	11.76%
Sea Lamprey	10	11.76%
Purple Loosestrife	9	10.59%
Rusty crayfish	8	9.41%
European Green Crab	4	4.71%
Ruffe	4	4.71%
N/A	15	17.65%
Other (specified below)	23	27.06%
Any/all	*4*	*4.71%*
Asian death fish	*1*	*1.18%*
Asian shore crab	*1*	*1.18%*
Asian Veined Whelk, Repana Venosa	*1*	*1.18%*
Asiatic clam	*1*	*1.18%*
Corbicula	*1*	*1.18%*
Eurasian watermilfoil	*1*	*1.18%*
Great lakes invasives	*1*	*1.18%*
Limnopera fortunei	*1*	*1.18%*
Marenzelleria	*1*	*1.18%*
New Zealand Mud Snail	*2*	*2.35%*
Nutria	*1*	*1.18%*
Cogongrass	*1*	*1.18%*
Popcorn tree	*1*	*1.18%*
Other invasive plants	*1*	*1.18%*
Pipe fish	*1*	*1.18%*
potomocorbula amurensis	*1*	*1.18%*
Spiny water flea	*1*	*1.18%*
Fishhook water flea	*1*	*1.18%*

Adapted from: SGNIS survey data

5.4. Database Research Results

We created a directory database to store information about the AIS databases we encountered during our studies. The minutes from the AIS NIASDWG Database Summit, described in Section 5.1.1, provided our initial data. The resulting database is a proof of concept and shows how databases can be sorted and viewed by type. Section 8.2 describes recommendations for further improvements.

Microsoft Access possesses features that made it a useful tool for creating a directory database to record information about AIS databases. Access is a relational database program, meaning an Access database programmer can design relationships between tables to keep data accurate. In addition, Access database programmers can create forms and reports to manipulate and show the data within a database. These forms and reports are stored inside the database. Appendix E contains a detailed, low-level description of the database on the contents within.

Categories group and associate the AIS databases within the directory database. Categories are broad descriptive terms of AIS databases, such as the AIS database content or the intended audience of the AIS database. Associating AIS databases with categories allows directory database reports to group together AIS databases by shared characteristics, such as the audience of the AIS database, location of the AIS database, and content within the AIS database, which are the fields used with the initial data. We chose categories as we entered databases into our directory database, but a user can modify categories at any time in the future.

To add an AIS database to the directory database, a user first uses the AIS Database Entry form, described in more detail later in this section. The user then uses a

category manipulation form to associate the database with a category. These records are later retrieved by generating a report through the Generate Report Form, discussed later.
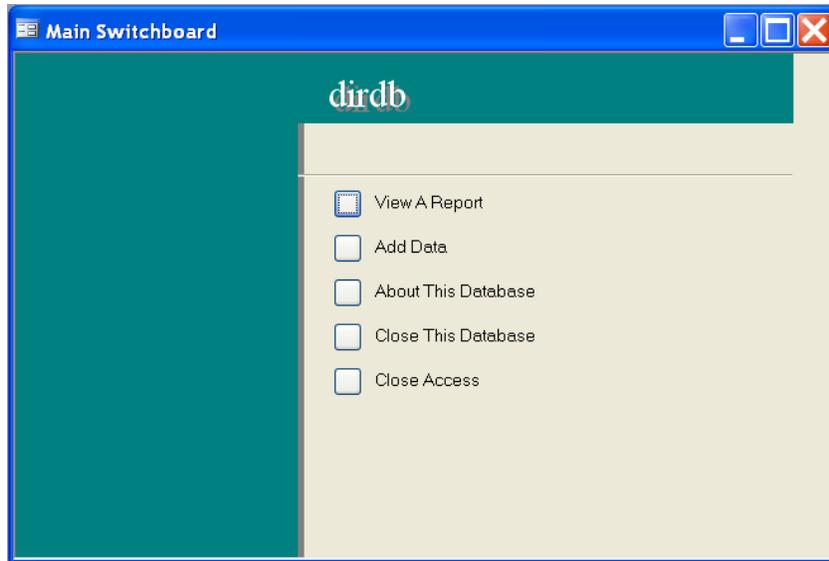
Figure 5.3: Database Main Menu

We designed the opening menu of the directory database for clarity so that users would not get lost in forms or make changes to the data that they did not intend to make. A screenshot of the menu is included as Figure 5.3. We created the menu using the Access Switchboard Utility. The menu directed users to the necessary forms to create, alter, and delete information.
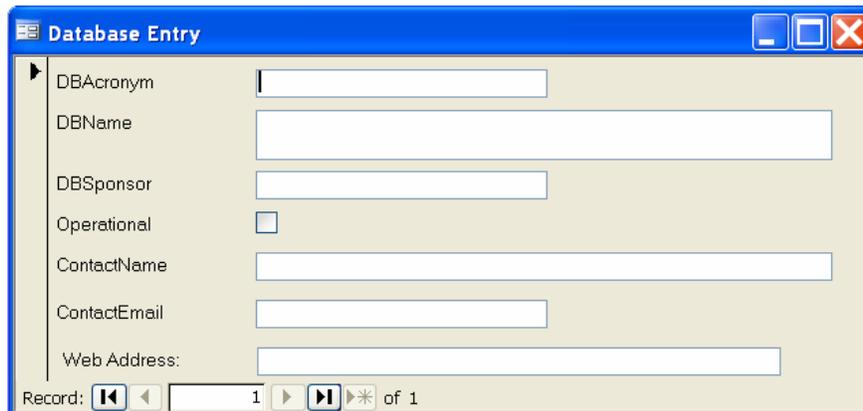
Figure 5.4: AIS Database Entry Form

The AIS Database Entry Form shown in Figure 5.4 manages the table of AIS databases. Users can add, change, and remove AIS database listings from the directory

database with this form. Users cannot enter or change category information using this form to make the form clear and easy to use. Too much data on one form would be complex and difficult to use.

Figure 5.5: A category manipulation form

A category manipulation form, shown in Figure 5.5, allows the user to alter the categories in the directory database and the categories' associations with the AIS databases in the system. Advanced users need the ability to modify the categories when they enter a new AIS database into the directory database and cannot associate it with existing categories.
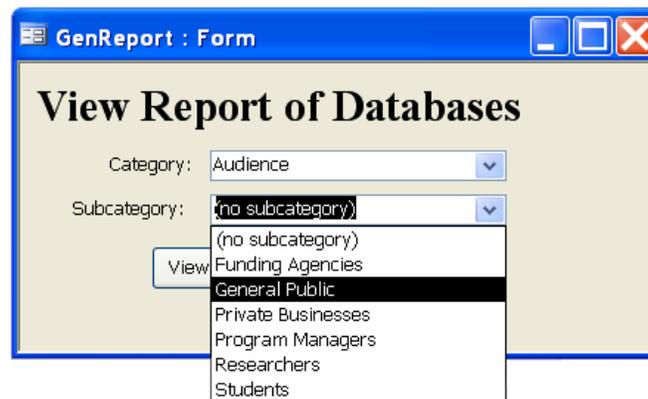
Figure 5.6: Report Generation Form

Figure 5.7: Sample Report

In order to make the directory database usable and useful, users need the ability to search and browse the data contained within the directory database. The Generate Report Form shown in Figure 5.6 generates a report; an example report is shown in Figure 5.7. The form asks the user to specify a category to use when sorting AIS databases. In Figure 5.7, the report has sorted AIS databases by the audience category. Under the "General Public" header are the databases that are associated with the "General Public" category. If the user does not select a category, the report lists all the AIS databases in the directory databases in no specific order.

6. Analysis and Discussion of Features

In our research, we have determined several features and decisions to be made regarding an aquatic invasive species (AIS) web portal and the site www.invasivespecies.gov. We divided the features into three categories to organize our analysis and discussion and distinguish key differences. There are basic features (Section 6.1) that are included or sometimes necessary for most formal websites. The advanced options (Section 6.2) are decisions on how to implement features that are important to the site. Optional features (Section 6.3) are suggestions that are not essential to the use of the site, but would be beneficial as a future development or as an externally linked resource (i. e. a resource that is not hosted in the same place as the main website). We have included the list of features and options in outline form in Appendix F.

6.1. Basic Features

Throughout our research we have learned that there are many features that are necessary to make up the basic structure of any website. Basic features, such as a home page or a help section, should be included as part of the main site architecture in any informational site. There is relatively little time and resources that go into the creation of these basic features. In this section examines the possible structures for each of these features and discuss the options that would contribute to the overall portal architecture and make the site informative and easy to use. This information was used when conclusions and final recommendations were made.

To begin with, every site has a home page, the first page that a user will see upon entering the site. This serves two main purposes: to provide the user with a proper overview of the site, and to provide a method of accessing other areas of the site. The

overview of the site should include information about the purpose of the site as well as information on how to use it. The methods of accessing the site's features could include any combination of links, menus, and search boxes.

One of the links on the main page should link to an "about us" page. This section could be very useful for people who would like to know more about work behind the scenes of the website. It could contain some sort of mission statement with information about the purpose of the site and the creators' goals. It would also be a good place to explicitly state which agency or agencies own or maintain the portal and a brief overview of each could be given. In the case of this portal, some information on Executive Order 13112 and the history of the NISC should be included, just as it is included in the current www.invasivespecies.gov site. In addition, there should be contact information for the people involved. This would allow users to contact the experts personally if they need additional information for a project and would aid in citations for any references they may need to make.

Another feature that has been requested by people that filled out our questionnaires and surveys is a page containing information on laws and regulations regarding AIS. Dean Wilkinson mentioned the importance of keeping away from "vigilante control." Invasive species are a very serious threat, but people should not attempt to go out and eradicate them on their own without full knowledge of the laws. For example, many states have laws prohibiting the use of certain herbicides and poisons. There should be a page with general laws or cases involving AIS for those that are interested, and links to external legal sites that give specific laws by state or region.

Along with information on laws and regulations, users may want to see current events information. A current events page or section would allow people to read news articles on invasive species and learn about current threats in their area. This would educate the members of the public that may be using the site as to the seriousness of the problem. Spreading this information may also prevent injury or even death. For example news articles about the lionfish, telling where the species has invaded, warning that the fish is very poisonous, and possibly containing information on who to contact if someone comes into contact with the venom would be very useful. It would inform fishermen that used the site how to be more careful and prevent any serious injuries. In addition, adding this feature would allow users to learn about control and treatment options being used to solve the invasions in different regions.

A feature that would be useful to many users is a page with additional links to external resources. This page would be a good place to link to the individual agency databases. Links to other organizations or agencies that own databases that are not included within the portal, would be a valuable resource. This page may also be a good place to link other general invasive species informational websites that do not contain databases. These should be organized efficiently into appropriate categories and a little background information on each link should be provided so that users can find the sites they are looking for easily.

A method of gathering user feedback is a useful tool that many web site owners use to evaluate how effective the site is and whether or not the goals are being met. This feature could be implemented in the form of a pop-up survey, similar to the NAL survey currently on invasivespecies.gov, a survey directly on the page, or just a general comment

form. Four of the one hundred forty-eight usable responses to the survey on invasivespecies.gov noted in the fill-in comment section that one of the main things they did not like about the site was that the survey kept popping up. A simple comment form on a feedback page might be a better way to get user feedback. This would allow people with suggestions for improvement or compliments to address them to the webmaster without annoying or interrupting those that just want to find information and be on their way and do not wish to make any comments or fill out a lengthy survey.

Another basic feature which is present on almost every informational site and is very useful to users is a help page. This page could contain a list of frequently asked questions pertaining to AIS, databases, how distributed databases work, or how to use the site effectively. An email question form would also be an excellent feature to include here. This would allow users to ask specific questions that may not already be in the FAQ section.

All of the features mentioned in this section are already implemented on www.invasivespecies.gov in some manner. Therefore, we are not recommending any new developments, only stating that we do in fact recommend the inclusion of the features when the site redesign takes place.

6.2. Advanced Options

Once the basic options had been defined, we developed a list of methods of implementing the main site components. In this section, we have discussed the advanced options. Unlike the basic features in the previous section, one option may negate the need for another option, or we may choose to suggest a specific combination of options.

6.2.1. Search engine

There are three main options for the web portal's search feature: an internal search engine built specifically for the portal, an entirely external engine supported by some other agency and used by this portal, or a combination of the two. In the case of www.invasivespecies.gov, there is an internal search already developed, but it is very basic. There are no advanced search options to narrow down searches or increase relevancy of results. Inktomi Search, makers of web search products, developed the search. As a result, there are limited options for making changes or customizations to the search feature since it is a generic tool for use on many types of sites, not specifically on www.invasivespecies.gov. As far as external search features are concerned, there are several links on www.invasivespecies.gov to sites where searches can be performed, but the links to the sites are difficult to find. For example, the NISbase link is included among many other links to other unrelated databases. There is no external search feature prominently displayed on the site.

An external search feature would involve using NISbase, Google, or some other previously developed engine on the invasive species portal site. The search box could be on a page within the web portal, and upon searching, the user would be led to the results page on the external site. Another possible implementation of an external search is to use links to other databases' search pages. Linking to pre-existing search engines or using them within the portal site would require very little time to set up and almost no additional funding since the search engines are funded by their creators and hosts.

In comparison to an external search engine, designing an internal search engine would require much more time, work, and funding because it would involve finding a

better search tool (as opposed to Inktomi Search) or starting from scratch. A new engine would most likely go through many development and technical problems too. An internal engine, however, would allow the portal to develop more of its own identity separate from the other databases' search features, which Karen Eason and Michelle Harmon stressed as being a very important issue.

The best option would be to improve the internal search feature while presenting an external search as an option. NISbase is an excellent tool that was highly praised by all of our contacts during the course of this project. Thus, we highly recommend including the ability to query NISbase directly from the main page of the web portal. We believe a completely new internal search engine is necessary only if there is no way to improve the current search engine.

The improved internal search engine should include search filters (by geographic location, for example) so that users can narrow down search results and filter out unwanted information efficiently. Ideally, the engine should eventually be able to search other databases, similar to the way NISbase works. However, if such a feature is desired, a collaborative effort with NISbase would be a better option than trying to develop a separate but similar resource. We recommend integrating NISbase into the main site as more than just a link if the NISbase creators are willing to work on such a development.

6.2.2. Search Filtering Options

Our interview, survey, and questionnaire results all contain ideas and opinions on how an effective search engine could be created and implemented. Most of these ideas involved a type of search filtering ability that would allow users to get at the information they required quicker without having to sort through unwanted data.

Search by User Type

One way to narrow down search results would be to customize data based on the type of user. Karen Eason and Michelle Harmon mentioned that this would be a good filter to include in the portal. This filter would allow users to select which category they fit best: student, researcher, resource manager, public, etc. and search results would be reordered to fit what they would most likely be looking for. For example, in-depth technical journal articles on the zebra mussel might be very useful for a researcher but would not be as pertinent to a high school student doing a paper. A student would benefit more from a basic fact sheet for background information. One downside of this feature is sorting information into groups such as these could be subjective. A student could be doing a paper on control options for AIS, but the information closely related to his topic could be grouped under the "resource managers" category. Since the student selected "student" as user type, resource manager search results would be omitted.

Search by Database

Another option for filtering of results is a search by database. A feature similar to this is already being used by NISbase. A list of all of the databases incorporated into the portal along with a brief description would be given, and check boxes would be placed next to each database name. When entering a keyword search, the user could then simply check one, many, or all of the databases, depending on which ones they wish to query. If someone were looking for AIS journal articles or other bibliographic information, they would most likely not want to search NEMESIS or NAS, since those are species databases. Entries from SGNIS or the ANS Clearinghouse would be more relevant, since these databases contain bibliographic information. The user could simply check only the

boxes for those two databases and only those two databases would be queried, eliminating many unwanted results.

A search by database feature would be very useful to users looking for specific information. From all of our research we do not see any negative aspects to this option, as long as adequate summaries of each database are provided so that users know which databases to check. Chuck O'Neill mentioned the need for background information for specific agencies and the databases they host, even if it was only a sentence, for nonprofessionals who are not familiar with the agencies.

Search by Geographic Region

Approximately 9.4% of the usable comments from the NAL survey were requests for the ability to see invasive species information by county, state, or region. Other survey respondents wanted to see laws and regulations, specifically by state., Dean Wilkinson and Marilyn Leland supported this option. Marco Tontodonati noted that a central projects database for all AIS projects that is searchable by region or body of water would be an excellent resource.

The ability to search for a species by region would be very useful and easy to implement, and is supported by many people already. There are very few, if any, negative aspects to implementing this option. If the portal planned to go international or expand, more regions could be added easily.

Search by Data Type

One feature that did receive a lot of support from our interviewees and other contacts was an ability to search by data type. The consensus was that some sort of dropdown box or checklist that allowed users to search by topics such as projects,

bibliographic resources, species information, policy, fact sheets, maps, or images would be very useful.

David Raikow mentioned the need for different ways of searching for information to avoid sifting through data, such as policy or ecology searches. Karen Eason and Michelle Harmon also expressed an interest in the ability to sort search results by data type into categories such as species, bibliographic, research, and projects. In addition, Pam Fuller mentioned the need for flexible search options. Along with these interview results, 3% of our usable NAL survey responses mentioned a need for improved search features. Marilyn Leland added that she often finds too much information when doing research, and would like some way of narrowing down the results.

This feature would not be too difficult or time consuming to implement. Whole databases could be tagged by what information they contain (e.g. GLSLRI tagged as a projects database). Then only those databases that contain the information type that the user requests are queried. Overall, this feature has a great deal of support and would make it much easier for users looking for specific types of information to find what they are looking for with less sifting through results. In addition, if users are unsure of how to define their search options or if they do want a variety of information, they do not have to make a selection in this area; results from all data types will be displayed so that there will not be a large risk of users missing potentially valuable information.

Search by Species Type

A search by species type could be broken down into general species types (e.g. freshwater, salt water, estuarine) or more specific types, such as taxonomic family or genus. Allowing users to select specific groups of AIS that they are interested in will

narrow down the results that they get from the search. Narrowed results would reduce the time spent searching by making it so users do not have to sift through as much unwanted information.

Source Quality

Another idea that Chuck O'Neill brought up was to separate information by source quality. For example, he would like to see government funded databases in a separate section than quasi-government or educational databases. This feature would be good for researchers trying to get the highest quality information, or avoid a certain bias. Due to federal laws, all government databases must comply with strict regulations regarding quality and accuracy, whereas with other sources this may not be the case. The government-funded databases might also have slightly different goals and views than a database funded by a university or nonprofit organization.

There are several negative aspects to O'Neill's idea. This type of feature may in fact separate information too much and make the information users need harder to find. If a student was searching only government databases for information that was contained on a nonprofit organization's database, he or she might not find the required information. If there was some sort of quality assurance involved in the database selection process to begin with, and only high quality databases with accurate information were added to the portal, this should not really be a problem. Overall, this feature does not seem to be as useful as others are and was not highly supported from our research. The possible negative effects of users not being able to find information as easily also seem to outweigh any potential benefits.

Search Filtering Options: Overall

The final search architecture could include one of these features, a combination of many of the more valuable features, or none at all. Since these features are valuable tools to help the user find what is needed, we recommend that when the internal search develops filtering capabilities, that it does have search by user, region, and data types.

6.2.3. Menu Categorization

It is very important that the portal have an orderly, easy to use menu structure. A good menu structure combined with an effective, user-friendly search engine would make the site much easier to navigate. First-time users should be able to look at the portal once and, regardless of their knowledge of the subject, find basic introductions and background on the AIS problem. They should also be able to find information about the agencies involved, help/comment and FAQ pages, and a direct link to the search area without having to look around or go through several levels of links or submenus.

The NBII (National Biological Information Infrastructure) website currently has an efficient menu setup. From the main page, users can easily navigate to sections where they can search NBII, contact the webmaster, learn about the agency, read about current events, and find information by region or the biological field it relates to. The invasive species section of this page (a link off of the home page) is also split up into many easier to manage categories, such as data, maps, models, control and sightings. Breaking sections of the site up and allowing them to be accessed from an easy to use menu would allow users to find information much more easily than if it were all included in one section or page.

Dean Wilkinson had an idea as to how the site should be set up to include all of the vital features a central portal should have, while also making it easily navigated by first time users. Essentially, his idea was to structure the menus to break the site into five major areas similar to the categories many other interviewees wanted to see as search filter options. He believed sections could be defined as: species occurrences, species identifications, projects, bibliographic information, and control options.

One way of creating the various sections would be to add these sections to the main menu on the home page. Each menu item could then lead to a subsection with an appropriate theme and its own search feature. For example, if someone wanted information on projects, he or she could click on the projects link on the menu. This would then bring the user to a projects page with some background on AIS projects, including current examples, and information about agencies leading AIS research efforts. There would then be a projects search engine. This engine would search only projects related databases. If many projects were added, including projects nationwide, the user could then search for a project by region, the agency funding the project, the researcher doing the project, or when the project began or ended.

Similar sections could be set up for bibliographic resources with a smaller search engine designed to search only bibliographic databases like SGNIS. It could have specific dropdown boxes for quality of literature, including peer reviewed only, grey, or any literature type, including magazines, journals, or books; or region the literature targets. It could also provide links to full text versions or abstracts online if available.

A third section of the site could be set up explaining current control options and techniques of treating the problem, information on how to prevent invasions with links to

various relevant organizations or products. A fourth section could contain a dichotomy tool for species identification for users who would like to find out what species they have in their area and whether or not they are in fact invasive.

The last major subject that Wilkinson mentioned could be in a fifth section off the main page. Here users could search for species-specific information by scientific or common name, search for species within a region, maps, or distribution information. The search category could search well-known species databases and pull up a merged fact sheet similar to what NISbase is working on. Here users could create custom maps for species in a region, show distribution over time, or find predictive maps for invasion forecasting.

Other sections, possibly from the optional features listed later in this chapter, or others that have not yet been thought of, could also be added into additional sections off the portal's main homepage. This system seems to be the ideal setup. Users could easily navigate their way around this portal using smaller, less cluttered search engines to find specific information, links, and current information on various aspects of the AIS problem. Since it would be a portal with several search engines rather than a database itself, it would contain no information of its own and therefore would not have to be updated except to add new databases to the collections. As long as the smaller databases remained up to date, the information within the portal would be up to date as well.

As for ownership of information, each section could have information on contributing agencies and all the information brought up on each search could have the owner's stamp or seal. A search for a book on zebra mussels would provide a result from

ANS Clearinghouse along with a link offsite directly to the ANS Clearinghouse database website.

The problem with this option is that setting up such a feature would be very costly. It would involve obtaining large amounts of funding, a great deal of programming, time to debug and develop, and cooperation and communication by all parties involved. Since funding is not always easy to come by, the feature would be very difficult to create.

6.2.4. Menu Format

A well-designed menu format will allow users to access the sections of the site without confusion. Menu formats need careful design because not all web browsers support the same technologies. If a site menu uses obscure or advanced technologies, users will not be able to navigate the site.

The simplest menu format to use has unchanging text or graphics. All web browsers support text, and most support simple images. There are very few browsers which do not support images, such as Lynx, a text-based web browser for the Unix Operating System. Users may find the text aesthetically displeasing, but almost all users will be able to navigate the site successfully. The downside is that a user may think that a site with a simple menu system is unprofessional and may move onto another site.

Adding rollover graphics and animated buttons can give life to the portal. Most (but not all) browsers support these technologies. For these users, they will see static images instead, and will still be able to navigate the site.

Dynamic menus are menus which change appearance as users require them (for example, sliding into view when the user places his or her mouse within a certain area).

The code of dynamic menus can be implemented using languages such as Javascript, Java, or Macromedia Flash ActionScript. Such a feature can display subsections of a site and highlight the section the user is currently in, making web navigation more intuitive. These menus are also the most difficult to implement from a developer's point of view, but is still a relatively simple task that any web developer should know how to implement quickly and efficiently. Though these menus require more code to be usable, the user will have a better understanding of where they are within the site. One important feature that the subjects of the Invasivespecies.gov Student Survey (see Section 5.3.2) requested was visual cues of where the user is located within the site, and dynamic menus would address this issue.

Menus are crucial to the operation of the site. They allow users to access sections of the site easily and efficiently. The menu format should be chosen before the portal is launched. Thus, we recommend deciding on a redesign of the menu as one of the first priorities. The dynamic menu system is the preferable format, as it suits the needs of any users who are able to view the menu system, and users who are unable to view the dynamic menus will see static images or text as an alternative. If dynamic menus cannot be implemented due to standards for federal websites, a simpler menu system will have to be used. This is an acceptable alternative, as long as there is some method of listing and highlighting subsections of the menu in order to give the user a visual cue as to their location within the site.

6.2.5. Amount of Database Information to Store Internally

Users need the ability to view information about the databases in use by the AIS web portal in order to determine which databases are best for their purposes. Therefore,

the web portal should include information such as titles and brief descriptions along with the links to the databases. The decision as to how much information to include in the descriptions must first be addressed.

One option for implementation of this feature is to include a minimal amount of information: AIS database titles and links to the databases. This option would be simple and straightforward to implement. However, if the portal uses this option, some users will have difficulty finding databases that best suit their needs. Therefore, this option would be easy to implement and update but would not be user-friendly.

The second option for implementation of this feature is to include a brief description along with the database titles. It is almost as easy to implement as the previous option, but relies upon the description and title to be accurate for the user to benefit from the list and find the information they seek when searching for a database. If the description is non-specific, the user still has problems finding the database they are looking for. As long as the person(s) in charge of writing the descriptions keep the users in mind, this should not be an issue.

If the directory database developed in this project is further developed and implemented on the site, it could be used to provide even more detailed information about each database to the user. Developing the directory database into a more usable format would be more difficult than the previous two options.

Overall, we recommend the inclusion of at least a brief description of each database that is either linked from the web portal or implemented in the search feature. Such a description is very important to users, and there are few setbacks and little updating necessary once the description is made. The description should be concise, as

long as it includes the name of the agency that hosts the site, the mission of the site, and the type of entries on the database.

6.2.6. Amount of Entry Information to Store Internally

It may be advantageous to the web portal to store entries within AIS databases internally on the site. This feature would involve translating the entries from multiple databases to the format that the main site would use. The alternatives to such a feature include a system where entry information is brought to the main site once a search is conducted, or no such system, where there are only links to the separate databases.

Providing only links to the databases will force users to move off-site, as is the case with the current design of www.invasivespecies.gov. O'Neill said that that is a problem when a user must dig for information through several sites. It ensures that the database agency, rather than the portal manager, is responsible for the data. However, there are reliability threats, in that if a database's server fails, the information is inaccessible.

A portal could search AIS databases upon user demand and present that data to the user. As with the previous option, the individual AIS database agencies control the accuracy of the data, not the portal maintainer. This method also introduces reliability threats because the portal connects to an external server to gather information.

Copying entire entries within the AIS databases into the web portal would require extensive planning and implementation. The implementation of this method would be a long, tedious process if all database formats needed to be converted to a single format. Furthermore, the summary information will be out of date once the database is updated. The main benefit of this option is that all data will be in one location, providing an easy

to use resource to the user. Also, this method will not have reliability issues, as the delivery of data is not dependent on the performance of other databases, only the performance of the main web portal,

From our interviews, the consensus is that the method of pulling data from multiple databases to one location is ideal. However, since the current www.invasivespecies.gov site only uses links to other databases, implementation of such a feature would be a long and costly process. NISbase developers are currently using and improving such a function. Once again, we recommend the collaboration between NISbase creators and the National Invasive Species Council (see Section 6.2.1).

6.2.7. Databases to Include in Search/Browse Features

Developing guidelines about which AIS databases will be included is important to ensure the accuracy of information included. If the guidelines are demanding, the portal will only use a few high quality AIS databases as sources. Wilkinson described his concerns with the quality of information linked to by any AIS portal. However, using a few AIS databases means relevant data to a user's research interest may not get included. It is important to decide early in development the amount of AIS databases to include.

Including only databases of a certain nature, such as databases put out by federal agencies, is a limiting option. Our questionnaire and interview results show that the quality of a database is not entirely defined by its sponsor's type. Excluding databases because of their sponsor eliminates potentially good sources of data.

A good solution is to evaluate each database individually. A checklist would be developed to rank AIS databases and judge whether they are worthy of inclusion. For example, the portal administrators can design standards about the quality of information

in AIS databases included in the portal. Another standard on this checklist would examine any possible overlap with existing AIS databases. The advantage of examining each AIS database is that the future portal uses only quality AIS databases regardless of sponsor. The actual format of the standards for quality should be derived by federal standards and therefore developed by a federal agency. Hence, our recommendation is that such a standard is created and used when determining what resources should be linked from the web portal.

6.2.8. Complexity of Layout

Through our research, we came across many aspects to the visual design of the main page, including how complex the layout for the main page should be. The complexity of a page could range from a simple layout with only a menu and a main section for the body of the page, to a page with several components including links, menus, and dynamic content.

Ideally, simplicity allows a user to begin using the site with minimal difficulty. There are only a limited number of options presented to the user and there is little chance that the user will be overwhelmed with information or unsure of where to go next. New users may be put off by the complex layout and would not want to return to the site. On the other hand, a simple site layout would not be ideal for a more advanced user. Users who know specifically what they are looking for or at least have some experience using online AIS sources may want information and resources that only a complex layout can provide.

Neither extremes of simplicity vs. complexity will solve all of the problems that a user may encounter with a site's navigation system, but some compromise between the

two should handle most issues. The current www.invasivespecies.gov site is neither too simplistic nor overly complex. The layout of the site is broken down in Figure 6.1. The main body of the site consists of an introduction to the site, background on invasive species, and an invasive species of the month as an example. These areas are concise and the information is relevant to first time users. The navigation consists of three sets of menus, on the top, right, and bottom.
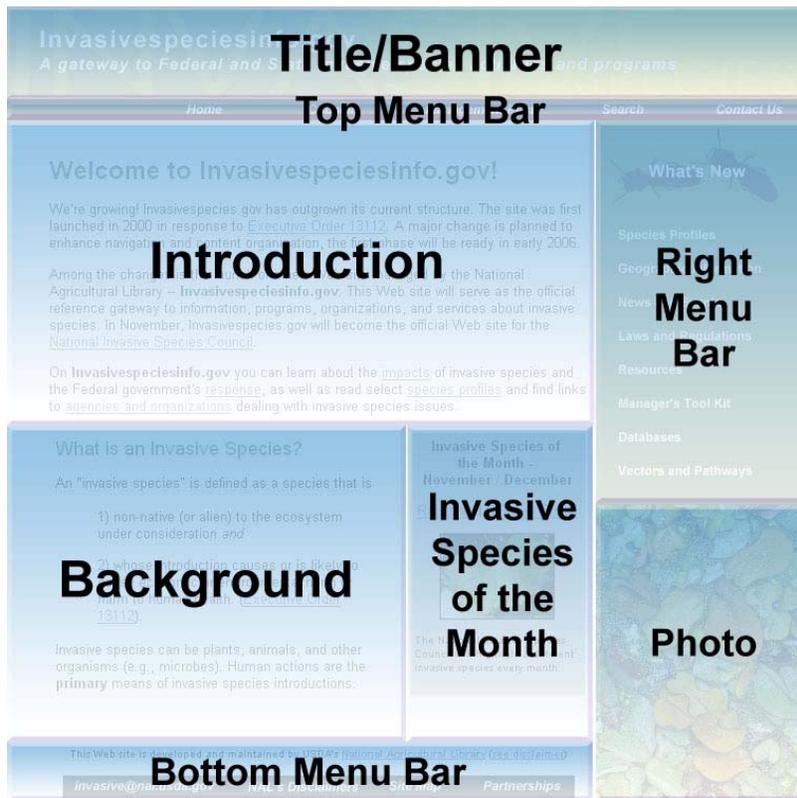
Figure 6.1: InvasiveSpecies.gov Main Page Layout
Source: Adapted from the USDA's National Agriculture Library, http://www.invasivespecies.gov, December 2005

Referring back to the University of Arizona student survey (Section 5.3.2), the students said that in general the site was easy to navigate. The problems the students did encounter dealt with the naming, not the positioning, of links or menu items. As for the amount of links that should be presented, some students said that there should be more menu items in order to make each item more specific, while others said that there should

be less items on the main menu but more subcategories. There is no unanimous consensus as to whether more or less is better.

A simple site layout does not necessarily imply that the amount of content will be compromised, only that the content will lie deeper within the site's structure. This is not an issue if the site's navigation system is properly organized so that the user does not have to travel to several pages before reaching the information he or she needs. Considering all this, we have determined that the benefits of a simple site layout outweigh any problems it presents. For the www.invasivespecies.gov site, we have already recommended changes to menu categories (see Section 6.2.3.), but for the simplicity of the site design, we also recommend the integration of the top and right menu bars into one menu. Other aspects of the site layout are not overly complex or confusing, so we do not suggest any other major changes to the layout.

6.2.9. Link Navigation

Link navigation within the portal can be handled a number of ways. The most common way is for the link to load the destination site within the same window when the user clicks it. Other sites prefer the option of opening links in new windows or tabs. One last option would be to open the link within a frame in the same window. Chuck O'Neill expressed his opinion during our interview with him, when he mentioned not liking to have to hit the back button repeatedly. He would most likely prefer an architecture where links offsite open in a new window in order to avoid this.

Other than the aforementioned comment, we did not receive any strong opinions regarding link navigation methods. There is no serious positive or negative effect on the overall site quality for any of the options; it is only a matter of preference. It is very easy

to implement any of these types of links, and no more so for any one than the others. If the links that open in the same window by default were implemented, it should not be an inconvenience to users, since opening a link in a new window manually is an option for most users. None of these forms of linking would detrimentally affect the overall quality or navigability of the website. We recommend that the type of link navigation be kept consistent throughout the entire portal, however there is no reason to convert to any one type of link navigation over another.

6.2.10.   Color Scheme

In order to design a site which is aesthetically pleasing, the color scheme should be taken into consideration. A color scheme should not only be visually pleasing, but should also properly represent the agency or organization that runs the website. On www.invasivespecies.gov, there is a green theme, which works well to represent the site since the color green is associated with the environment. However, in the University of Arizona student survey (Section 5.3.2), one group of students suggested a red or orange color scheme to represent the urgency of the invasive species problem. Another group thought that the colors were too dull.

Three renderings of the www.invasivespecies.gov home page appear in Figure 6.2. The background image shows the actual color scheme of www.invasivespecies.gov. The foreground image demonstrates what a more vibrant version of the site would look like, and the middle image shows what the site would look like with a red and orange color scheme.
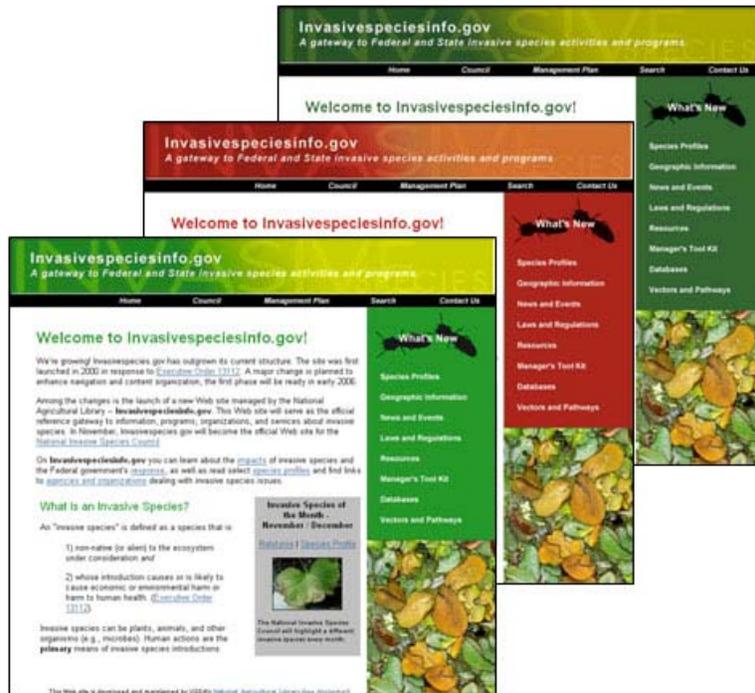
Figure 6.2: InvasiveSpecies.gov Color Scheme
Source: Adapted from the USDA's National Agriculture Library, http://www.invasivespecies.gov,
December 2005

There are many combinations and variations available when choosing a color scheme, and although many users prefer certain colors, the decision will ultimately be subjective. As long as the colors are aesthetically pleasing and the colors represent the content, the color scheme is appropriate. For the purposes of this project, we are presenting the aforementioned suggestions for consideration, without making the subjective decision of which to implement.

6.2.11.   Site Map Page Format

The site map page has been considered a basic feature in Section 6.1, but there are a few different methods to implement it. The site map could be completely text-based, or there could be a visual representation of the site. The www.invasivespecies.gov site map is text-based in an outline form, with each item as a clickable link.

As previously stated, a group of Invasivespecies.gov Student Survey respondents suggested that users should be able to see where they are located in the site with some form of a visual cue. A site map in graphic form would be able to provide such a feature. On the other hand, a graphic representation of the entire site may not be necessary if the site is to remain simple and straightforward in its design, as suggested. Though a graphic site map could show how all of the pages are grouped and linked in a visually appealing way, it may be excessive for a site that is not complex. The format of the current site map on www.invasivespecies.gov is simply outlining all of the pages on the site. It does its job of breaking the site down into sections and subsections, and there is little need to redesign of the format of the site map.

6.3. Optional Features

Through our research, we encountered many suggestions for additional features beyond the main site components. We will give each optional feature a priority rating. Most of these features are not currently available on the www.invasivespecies.gov website, but some are in development elsewhere. Therefore, the following features may not be a priority to include at all, or we may suggest including the feature as an external resource. If the inclusion of the feature as an external resource is suggested, it may be done via hyperlink or menu from the main site, unless otherwise noted. The optional features are discussed below.

6.3.1. Merged Fact Sheets

Merged fact sheets combine information on a particular species from many AIS databases into a single web page that presents all the relevant information. Users query

the portal, which then pulls sections of information from multiple sources and displays a comprehensive report on one page. This report includes species facts, distribution information, maps, and photographs. The merged fact sheet saves users time because they can find everything they need in one location and do not need to track down data one bit at a time from multiple online resources.

Other organizations are seeing the potential in merged fact sheets and creating the technology for their own usage. Brian Steves is developing this feature for use with NISbase, but it has not been released to the public. Fuller added that the technical aspect of development is completed and the current focus of work is aesthetics and appearance.

Using a pre-existing merged fact sheet engine is easier to implement and requires fewer resources than developing a new internal fact sheet engine. The downside is that the portal has no control over the source of data that NISbase chooses to use. Users may require data that is available elsewhere on the site but not see that information on the merged fact sheet.

Developing a new fact sheet engine for use in the portal allows for better integration between portal components. Drawing data from the same data sources uniformly to the portal provides the user with the same information throughout the portal and simplifies a user's use of the portal.

Merged fact sheets are an important feature to help the portal become an innovative resource. Researchers such as Slimak and Kolar, among others, expressed a desire for a centralized information resource. Using an external merged fact sheet feature will simplify the time to get the portal online and would require few additional resources. Since the idea of merged fact sheets was highly praised by our contacts, we believe that a

collaboration with NISbase developers for the use of this type of technology to be a very high priority.

6.3.2. Species Distribution Maps

A popular feature requested by our contacts is a mapping system that allows the user to see where invasive species are located. According to Jim Graham (see Section 5.2.1), his interviews with users of the National Institute of Invasive Species Science (NIISS) showed that "getting maps of current invasive species distributions" was the most requested feature. Cindy Kolar (see Section 5.2.7) says that she looks for maps most often, and Michael Slimak (see Section 5.2.8) lists "status of the invader (e.g. maps)" as one of the primary formats of information for which he searches.

There are several maps of invasive species distributions among separate websites. Many of them are static images using data from set time periods. Examples of sites with those types of maps include the Aquatic Nuisance Species Clearinghouse (http://www.aquaticinvaders.org/nan_maps.cfm) and the Adirondack Park Aquatic Invasive Plant Project (http://www.adkinvasives.com/Aquatic/Maps/Maps.asp).

An improvement to a set of static image maps is a dynamic, customizable map. Distribution maps that are more interactive are not as common, but there are some resources available. The Great Lakes Information Network (GLIN) hosts a map made with Macromedia Flash in which the user can select one of four species and then watch as the distribution in the state of Michigan increases from year to year (http://www.great-lakes.net/envt/flora-fauna/invasive/timeseries.html). Although it is interactive, the options are very limited and it only includes data from Michigan.

Currently there is an interactive distribution map feature on the Marine Invader Database, http://www.marineid.org (See Figure 6.3). That map is the most dynamic of any maps we have come across in our research. Its features include the ability to select what type of species to display and what part of the map to display, including the amount of zoom. A user may also select the source of the records and what years to include on the map. The developers of NISbase are also working on a distribution map system.
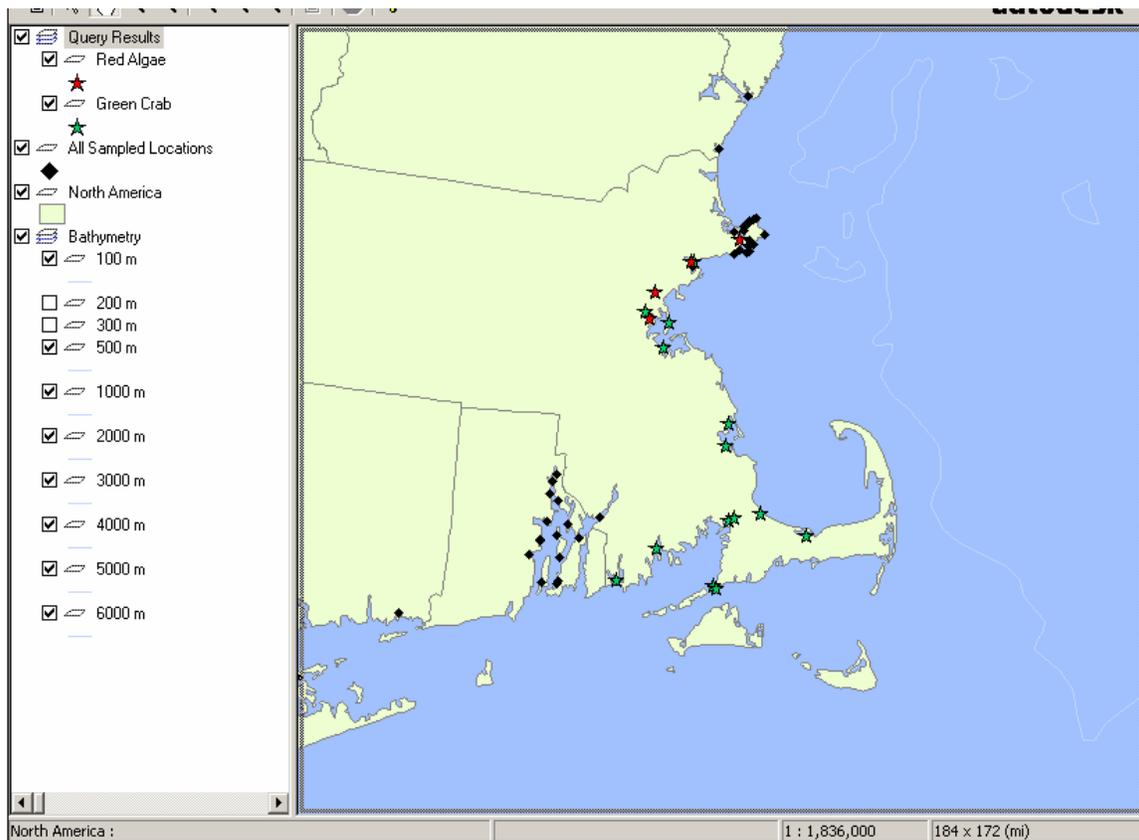
Figure 6.3: Distribution of Green Crab (Green) & Red Algae (Red) along MA Coast
Source: www.marineid.org, 2005

With many distribution maps in various locations on the internet, the best way to suit users' needs would be to combine the maps in some way. Ideally, one comprehensive and interactive map would combine all data from all of the maps that are available. However, that may require the creation of an entirely new mapping system, or at the very least, the translation of all data sets from other sources into a single map's data

format. Both of these methods would require a programmer or even a whole development team, which would be very costly and time-consuming. A more viable solution would simply be to include all of the mapping resources within the proposed species distribution and mapping section of the web portal via hyperlinks. Since our research shows that distribution maps are very useful, we suggest that a separate page be devoted to the collection of invasive species map-related resources.

6.3.3. Forecasting Maps

Forecasting maps would use the information gathered from trends in invasive species migration in order to make predictions by mapping out where invasive species would spread if the current trends continue. Ideally, it would factor in weather-related information such as water temperature and storm patterns in order to make accurate predictions. Forecasting maps can be considered one step beyond distribution maps since in order to provide predictions, some of the information required includes the current distribution of species.

Referring back to the interviews with users of the NIISS site, "early warnings of encroaching invasive species" was the second most requested feature. In addition, the questionnaire respondents who are looking for distribution maps would most likely use the forecasting maps as well; it is closely related and can be considered an improved form of distribution maps.

Currently, there is a forecasting system in development. It is a joint effort among the U.S. Geological Survey (USGS), Fort Collins Science Center, NASA Goddard Space Flight Center, and Colorado State University. It is named the National Invasive Species Forecasting System, and is planned for inclusion on the National Biological Information

Infrastructure site (NBII, http://www.nbii.gov). The target audience is primarily scientists and natural resource managers (Schnase, Stohlgren, & Smith, 2002).

Since this resource is currently in development, there is little need for a similar type of resource to be developed elsewhere. There are many costly technologies required to develop it, such as satellite imagery and radar. Therefore, even if there were no such resource in development, its development solely for the use on the invasive species portal would not be a viable option. Once the forecasting system is put on the NBII site, we recommend that the portal links to it on the same page as the other map resources.

6.3.4. Multimedia

Approximately 19% of the usable NAL survey responses were people commenting on the lack of multimedia. Specifically, the majority of the respondents (17%) wanted more, better quality, larger, or higher-resolution pictures. Kaveh Rassoulzadegan noted in his questionnaire that a way of including some sort of Google-like image search, enabling users to browse the site more visually would be useful. Dan Thomas also mentioned that he mostly searches for fact sheets and photographs and he would like to see more of these from the portal.

More images on the site would make the portal more visually pleasing for users and would aid people with identification. There are several ways that images could be added to the site. More photographs could simply be hosted on the main portal page, possibly with some sort of image search feature or browse function where users can look at pictures sorted by species or region. One downside of this method is that many large, high-resolution photographs would require a high amount of bandwidth, which would be costly.

A more viable option would be to host a few images internally, and provide a Google Image Search link for users who are looking for more pictures. Currently, www.invasivespecies.gov includes only one image on each of its species fact sheets and does include a Google Image Search link already. We recommend the addition of a few images to the site, for instance three for each invasive species profile, which will not be a costly improvement.

6.3.5. Multi-lingual Support

As Jim Graham pointed out in his questionnaire, "invasive species do not respect political boundaries." This is an international problem and must be dealt with on a global scale. Several international organizations are currently working on controlling the invasive species problem. Kaveh Rassoulzadegan works with CIESM (International Commission for the Scientific Exploration of the Mediterranean Sea) in Monaco on a database of exotic species in the Mediterranean. CIESM is currently one of the many groups contributing to NISbase. Several other international databases are also working closely with www.invasivespecies.gov and the U.S government, like INBIO in Costa Rica and the Database of Aquatic Invasive Species of Europe in Russia.

As the fight against invasive species becomes more of a unified global effort, we expect more and more users of invasive species online resources to be from countries non-English speaking countries. Of the SGNIS survey respondents, 19% were from countries outside of the United States and approximately two-thirds of those were countries where English was not the primary language. As the international audience begins to grow, features like multi-lingual support begin to become an issue. A central

portal where global information for AIS will be available should be accessible to people who do not speak English as their primary language.

There are many ways of making the portal friendlier to international users. Many sites have flags from various countries located on their main page, which a user can click to view the same page translated into that language. This would require creating many additional web pages, and the use of time and funding for translation services. Overall, since this is a portal meant for searching other databases, and contains very little of its own data, spending money on translating the main pages is not the best option.

Perhaps a better option would be to use preexisting external translators. Many sites currently have buttons that can be used to perform instant (but rough) translations of text on a site using technology from Babelfish or Google. If such a feature were incorporated into the databases as well, users could get a decent (but not entirely accurate) translation of all of the information inside and outside of the portal. The result would not be as professional as a manual translation would produce, but it would give users a general idea of the information without the government having to hire translators. This option would take very little time and resources to implement, as it is only the inclusion of a button or resources. Therefore, we recommend the inclusion of a translation button on the web portal.

6.3.6. Identification by Picture or Characteristics Page

A species identification or dichotomy tool was a feature that was popular among our contacts. Approximately 4.7% of the usable NAL survey responses mentioned wanting a way to be able to identify a species. Dean Wilkinson also mentioned the need for having an identification tool for users.

An identification tool could be set up in many different ways. The majority of identification systems in existence already consist of a series of pictures along with questions about the species. The user then compares each of these pictures to the species he or she wishes to identify and chooses the picture (or visual characteristic) that is the closest match. The questions usually start out very broad and as species are narrowed down, the questions become more specific until the species has been identified.

A tool like this would be useful to many users in the management field: people working in the fishing industry, researchers trying to identify a species they have found, etc. This system, once created, could be added to and expanded upon whenever a new species becomes a significant threat. Once a user identifies the species that they have seen, they would then be provided with links to other areas of the web where distribution information, control options, and fact sheets are available.
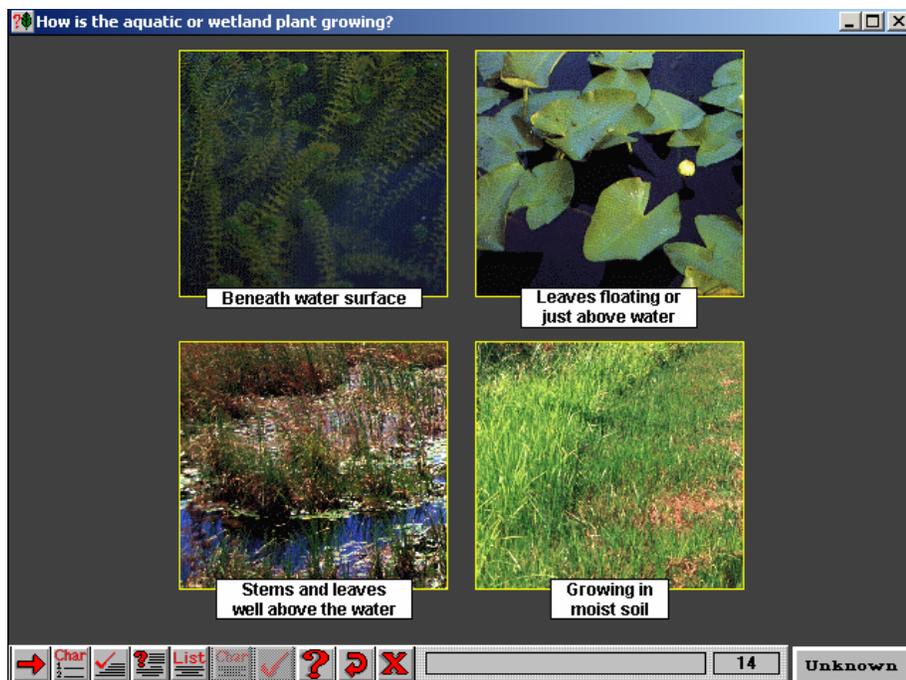
Figure 6.4: PMIS plant identification tool
Source: US Army Corp of Engineers, 2005

There are currently many plant identification tools which could be used as models for this type of feature, including PMIS (developed by the Army Corps of Engineers) shown in Figure 6.3 and APIRS (developed by the University of Florida, http://aquat1.ifas.ufl.edu/allplants.html). Developing an identification tool specifically for AIS may take quite some time and some additional funding to complete. Overall, this feature could bring many more people to the site. A species dichotomy would add a new level of interaction and possibly educate more of the public on the invasive species problem. The positive aspects outweigh the costs associated with developing such a feature. We recommend researching these types of features, using existing resources as models, and performing a cost-benefit analysis (see Section 8.1) to determine if there is enough funding to develop the feature.

6.3.7. Identification by Experts Page

Along the same lines as the species identification tool was the suggestion to have an "experts database." This feature would allow users to submit pictures or questions to experts and get information species identified directly without having to search for the information themselves or use a dichotomy. The questions would first be forwarded to low level researchers in the field, and if they were unable to answer the question or identify a species then the request would be passed on to a higher level researcher or an expert on taxonomical identification.

This feature would be very helpful to the public or anyone who does not have a lot of background in the AIS field. It would allow users to easily identify species that they have found or find additional information that they require if they are unable to find it within the portal themselves.

There are some negative aspects to including such a feature. If too many people start asking questions of the experts, they may not be able to answer them in a timely manner, getting more and more backed up over time until the feature was essentially useless. These experts would also have to donate time that otherwise could be spent doing valuable research. If the experts are paid for their participation, the service may become very expensive.

Pam Fuller is currently developing a tool of this nature. However, it is unknown when the project will be complete. There is an operational expert's database on the National Biological Information Infrastructure (NBII) site (http://ein.nbii.gov). Their experts database is a directory of people who have volunteered to answer questions for users. The directory is organized into a series of links. First, the user chooses a general topic that the question fits into, and then the user chooses a more precise subtopic. Finally, a list is displayed showing all of the contacts that might be able to help in this field, along with their specific areas of expertise. Since the expert database on NBII is already operational, there is not much need to develop an additional system. We recommend its inclusion as a prominently-displayed link on the invasive species portal.

6.3.8. Alert System

An alert or early warning system provides tools for resource managers and others regarding the initial detection of an invasive species. Early warning systems are used after a single organism of a non-indigenous species is found. The systems provide tools and information on how to control the species and prevent reproduction. Resource managers find these systems useful because the system joins species and tool information

together onto one page. Managers with these resources can take action quickly to deter or prevent an invasion.

An early warning system could be developed internally for the portal. Developing the system internally would allow the system to integrate with the rest of the site more than it could if the portal used an external system. However, the system would need to be carefully designed so that the information would be refreshed as new sightings came in. Otherwise, it would soon become out of date and useless.

Eason and Harmon are currently developing an early warning system as a database. Additionally, the Nonindigenous Aquatic Species (NAS) Alert System run by USGS is currently operational at http://nas.er.usgs.gov/AlertSystem/default.asp. We recommend linking to the NAS alert system on the web portal, rather than developing a new alert system to be hosted internally.

6.3.9. Children's Section

Students make up 19.28% of the www.invasivespecies.gov survey results (see Table 5.1) and users of the SGNIS site are 15.29% undergraduate students (see Table 5.6). Children are an important part of the audience for an invasive species site that is meant for all users, professional and non-professional, young and old. Much of the information found on invasive species sites assumes a certain level of background knowledge, but a special page or group of pages targeting younger users of the site would consist of very basic information presented in a way that is interesting to young visitors of the site. Including a children's section on the invasive species portal would allow grade school students would promote awareness at an earlier age. The long-term benefit is that even if the students do not choose to continue learning about invasive species as

they continue their education, as an adult they will be more aware of the problem than they would have been if such a resource did not exist.

The negative aspect of a children's section is that there would be time and resources required to develop it, just as with any other additional feature. Fortunately, there is already a fully developed children's site as a part of the SGNIS page, at http://www.sgnis.org/kids/index.html. The site is called "Nab the Aquatic Invader" and is geared toward grades four through ten (SGNIS, 2005). The site has a detective theme, making it interesting to younger audiences.
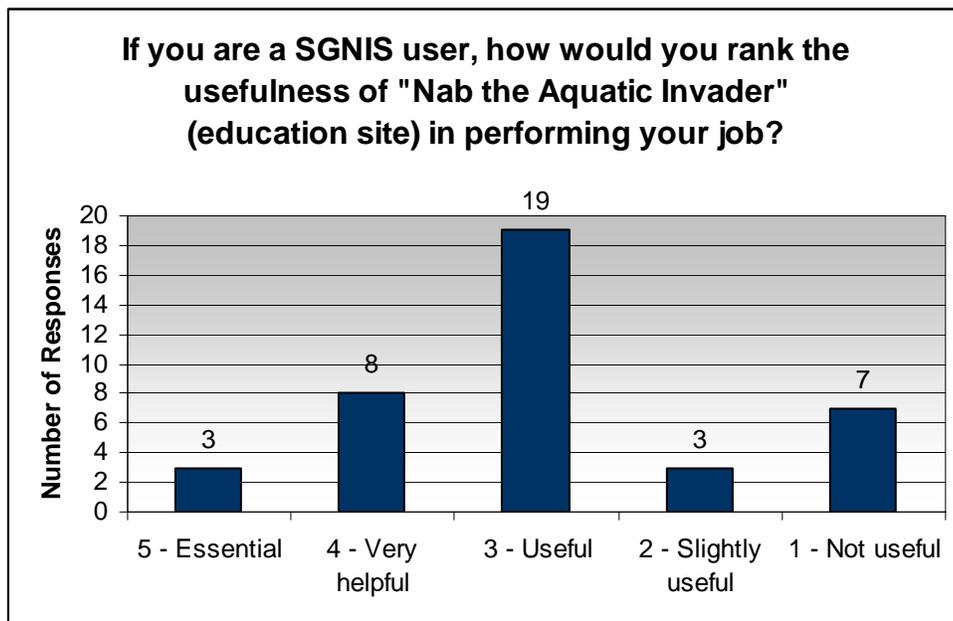
Figure 6.5: SGNIS "Nab the Aquatic Invader" Survey Results

Figure 6.4 displays results from the SGNIS survey asking users for their opinion on Nab the Aquatic Invaders. Forty users out of eighty-five responded. The results show that several users thought that the site was not useful. It is important to note, however that only thirteen of the eighty-five respondents were undergraduate students, so the target audience for the Nab the Aquatic Invaders site was not very well represented in this survey. Keeping this in mind, the results are positive as many users found the site to

be useful. Through our experience looking at the site, we believe that it works very well as an educational resource for students, and there is no need to develop a new site of its type.

There is the problem that if a user is browsing www.invasivespecies.gov, in order to find the Nab the Aquatic Invaders site, the user needs to click "Resources," then "Other Educational Resources for K-12 Students," then "Aquatic Species," then scroll down and find the link for Nab the Aquatic Invaders. This is an issue with the bigger problem of site navigation options, which were addressed in Section 6.2. The restructuring of the site's navigation system should allow the Nab the Aquatic Invaders link to be clearly visible under an "education" section.

7. Conclusions

7.1. Summary

The following outline is a summary of the recommendations we have made for the web portal in the previous chapter.

- Search Engine
    - o The web portal should include NISbase as a search option, preferably using a search box which searches NISbase directly, rather than having the user go to the NISbase main page first.
    - o The internal www.invasivespecies.gov search engine, as it stands now, needs improvement.
        - ▪ Advanced search options are needed in order to narrow down and increase relevancy of search results.
        - ▪ A method of searching external resources should be included.
- Database Implementation
    - o Implement a distributed database system.
        - ▪ The ideal method would be to combine efforts with NISbase developers.
    - o Organize databases as external links in a logical manner.
        - ▪ Make lists of resources which can be sorted by data type (species information, bibliographic info, projects, maps, etc.)
    - o Develop standards for external resource inclusion.
- Layout
    - o The main page should be simple and straightforward in design.
        - ▪ Other pages may be more dynamic and complex, depending on the purpose of the page.
- Navigation
    - o The menus should be broken down into five categories based on content
        - ▪ Species information, fact sheets
        - ▪ Species distribution, maps
        - ▪ Species identification tools
        - ▪ Control options, laws and regulations
        - ▪ Project resources
    - o Menus should clearly display the user's location within the site
        - ▪ Make it visually clear which section and subsection the user is in, using: colors, arrows, or bold text, or some other visual cue
        - ▪ In the navigation system, display the other subsections within the main section
- Optional Features
    - o Merged Fact Sheets
        - ▪ Use the NISbase (www.nisbase.org) technology in development

- Mapping Tools
  - Integrate an existing tool into the portal
    - Marine Invader Database (www.marineid.org) for distribution maps.
    - NASA-USGS Invasive Species Forecasting System (http://bp.gsfc.nasa.gov/isfs.html), in development, for forecasting maps.
- Multimedia
  - Increase the number of pictures internally for each species data sheet.
  - Continue the use of Google Image Search links
- Multi-lingual support
  - Include a page translation tool from Google (http://www.google.com), Babelfish (http://babelfish.altavista.com/), or another translation service.
- Identification Tools
  - Use PMIS or APIRS (http://aquat1.ifas.ufl.edu/allplants.html) as a model for an AIS picture identification tool.
  - ESA-NBII Ecological Information Network (http://ein.nbii.gov/) would be a good model for an expertise database.
- Alert System
  - Use external resources.
    - NAS Alert System (http://nas.er.usgs.gov/AlertSystem/default.asp) for current sightings.
    - EDIS, in development, will serve as an early warning system.
- Children's Section
  - Include link to Nab the Aquatic Invader (http://www.sgnis.org/kids/).
- Directory Database
  - Continue implementation if an unbiased party decides it is worthwhile.

7.2. *Societal Impact*

Throughout this report, we have discussed the benefits of an AIS web portal from the viewpoint of the user. In a broader perspective, there are benefits from such a portal which affect society as a whole. The resource will promote coordination between the several agencies and organizations working on the invasive species problem. With more coordination, there will be less duplication of efforts. Furthermore, the efficiency of

research will increase as researchers are able to find more of the information they need in an easier manner. With the advancements in cooperation and research, there will be more progress made in the field. As a result, there will be decreased environmental damage by invasive species, which in turn will result in lower costs in control and management efforts.

8. Recommendations

8.1. *Funding Considerations and Cost-Benefit Analysis*

From our research, we were able to complete a full feature analysis of our list of potential recommendations and improvements. We have discussed in detail how each feature would be helpful and useful to the final portal, as well as what negative aspects it might have. However, we did not have any numerical data to work with when discussing these features. We knew that certain features would cost more or take more time to implement than others, but we did not know the actual figures in dollars or hours. Since this project may not be implemented immediately, we recommend that when it is, a cost-benefit analysis should be done.

A cost-benefit analysis before the development of the portal would allow the site developers to put hard numbers on each of the features. They would be able to estimate how many resources would be necessary to complete the development of everything on the list. This information could then be used and considered along with the list of positive and negative aspects of each feature. The creators may then reevaluate priorities at a later date to determine whether the features that we believed to be valuable at the time of this writing are still valuable when the project is scheduled to be implemented.

8.2. *Database Research Development*

There are seven recommendations presented here to improve the directory database developed as part of this project. Each recommendation is unique in its necessity towards the creation of the database and putting the database onto the portal. Some recommendations must be completed before the database can be used in production while others will not cause the database to suffer terribly without them.

A web interface should be created so that the database can be stored on a central server and accessed worldwide. The web interface should allow users to view data and reports accessible from a page on the portal. Adding data from the web could be a feature for users approved by the portal or database administrators. Allowing only authorized users to enter data will give the information more credibility, since trusted persons and not persons with malicious intent enter the information. The web interface is a very important development because it allows access to the database by a very broad audience.

The existing code should be optimized before the database is posted on the Internet. As you can see from Appendix E, much of the code is repeated between various modules, and some of this repetition is not necessary. Moving the repeated code into the MiscCode module is a good solution.

The current forms used to gather data, along with the switchboard menu, work but would benefit from a redesign. Most forms rely on a user's knowledge of Access to enter and manipulate data. For example, to delete records, the user needs to right-click on the record selector – the arrow square next to a record on a form – and choose the cut option to delete the record. The user interface should be remade to allow novice Access users with possession of knowledge of a database to modify data and view reports. Among these interfaces should be a buttons for deletion so that record selectors can be removed and the interfaces will appear cleaner.

Upgrading the database to Microsoft SQL Server or MSDE (Microsoft SQL Server Desktop Engine) and an Access project file should be considered. Microsoft Access projects use an SQL server to manage the data while Access maintains the forms,

reports, and code. Compared to Microsoft Access, Microsoft SQL Server can handle and

is better at handling multiple connections from various Internet users (Microsoft 2004).

Appendix A: Agency Background

NOAA

Created in 1970, NOAA joins various environmental agencies to achieve a unified front on environmental issues (NOAA History, 2004). NOAA's goal is, "to predict environmental changes on a wide range of time and space scales in order to protect life and property, and provide industry and government decision-makers with a reliable base of scientific information" (NOAA History, 2004). Within the Department of Commerce, NOAA balances the environmental and economic aspects of invasive species.

NOAA's line-offices help serve in the Commerce Department's goal of "Stimulating Productivity and Economic Development" (NOAA History, 2004). NOAA is made up of six line offices: the office of Oceanic and Atmospheric Research (OAR), National Ocean Service (NOS), National Environmental Satellite, Data, and Information Service (NESDIS), Program Planning and Integration (PPI), National Marine Fisheries Service (NMFS), and National Weather Service (NWS). The National Sea Grant Office (NSGO) is a division of OAR. We designed Figure A.1 to show the NSGO in relation to NOAA and its line offices (omitting the other agencies within the Department of Commerce and the other subdivisions of NOAA's line offices, for simplicity) (NOAA History, 2004).
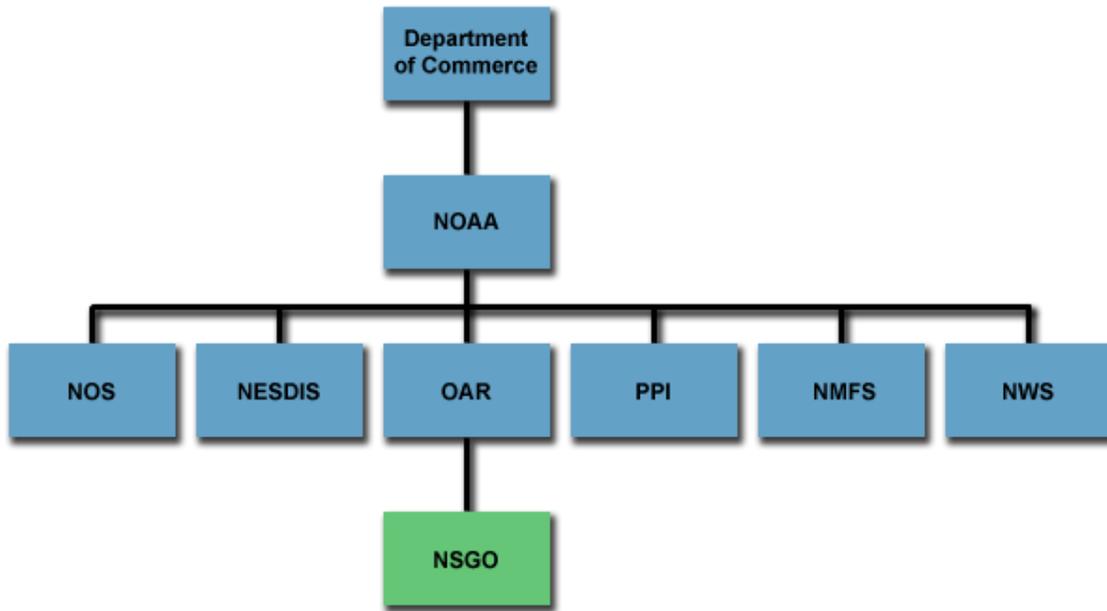
Figure A.1: NOAA Organizational Structure

Congress, in its constitutionally appointed role, determines NOAA's overall policy and budget. NOAA puts out a "blue book" each year that describes its budget request. The fiscal year 2006 blue book shows that NOAA's enacted budget has been consistently on the rise since fiscal year 2002 in operations, research, and facilities accounts (National Oceanic and Atmospheric Administration, 2005). Procurement, acquisition, and construction accounts experienced a slight dip in fiscal year 2003, but those funds have climbed since then. In each account, NOAA has requested fewer funds than were enacted last year.

NOAA's policies are set by Congress; however, NOAA's executive structure is a hierarchy within the Executive Department, with the President of the United States as the leader. Under the President are the Vice President, Secretary of Commerce, and Under Secretary of Commerce for Oceans and Atmosphere/Administrator. Underneath the Under Secretary is the Assistant Secretary of Commerce for Oceans and Atmosphere and Deputy Under Secretary for Oceans and Atmosphere. This project was completed with

aid of those in the National Sea Grant program, under the Assistant Administrator for Oceanic and Atmospheric Research, who reports to the Deputy Under Secretary for Oceans and Atmosphere (National Oceanic and Atmospheric Administration, 2005).

This project is related to NOAA's and NOAA Sea Grant's mission to "understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs" (National Oceanic and Atmospheric Administration, 2005). Unifying existing information on aquatic invasive species (AIS) will improve efficiency in research and management of the problem. There will be less overlap in AIS programs among various agencies, resulting in a more cooperative effort. Agencies will avoid duplicating efforts and instead make more progress in their specific field, resulting in more progress in the field and better use of funding. Furthermore, easy access to the extensive amounts of online resources will promote awareness of the problem among the general public.

Sea Grant

The division of OAR that deals with college-based research is Sea Grant. Sea Grant works with colleges to better understand America's coasts. The original idea comes from Dr. Athelstan Spilhaus in 1963. Interest grew until President Lyndon Johnson finally signed The National Sea Grant College and Program Act of 1966 and established the Sea Grant Program. In 1976 the act was amended to strengthen the program. Currently Sea Grant works on several areas of focus including public safety and combating aquatic invasive species. Sea Grant funds several projects that look at innovative ways to combat aquatic invasive species. (National Sea Grant Office, 2005)

Several regional offices are currently hosting AIS databases. The Illinois-Indiana and Wisconsin Sea Grants are working together with other regional offices on the Sea Grant Non-indigenous Species Site (SGNIS), which is essentially a reference database consisting of online articles, maps, and pictures having to do with AIS. The New York Sea Grant is also hosting the National ANS Clearinghouse, a card catalog for their library, and the Ohio Sea Grant is sponsoring the National Sea Grant AIS Projects Directory, which allows people to search for all of the funded projects dealing with AIS.

GLERL

The Great Lakes Environmental Research Laboratory (GLERL) was created as a subdivision of NOAA in April of 1974. As its name implies, GLERL deals mainly with the Great Lakes region. GLERL does research on aquatic invasive species, especially the zebra mussel, attempts to forecast water levels, and performs studies on climate change and how it affects the environment, along with many other things. The National Center for Research on Aquatic Invasive Species (NCRAIS) is part of GLERL. NCRAIS will eventually be host to another of the NOAA databases, the Great Lakes Aquatic Non-indigenous Species Information System (GLANSIS), which is currently under construction. GLANSIS will eventually host information on non-indigenous species in the Great Lakes region.

NCCOS

The National Centers for Coastal Ocean Science (NCCOS) was established within NOAA National Ocean Service in March of 1999. Its main mission is to "provide coastal managers with scientific information and tools needed to balance society's

environmental, social, and economic goals" (NCCOS, 2005). Currently the main goal of NCCOS is the study of "stressors" (e.g. pollution, AIS, and weather changes) and predicting how certain changes would affect an environment. The NCCOS sponsors the Aquatic Species National Inventory and Introduced Species Early Warning System database, which is currently still under construction. Once complete, this database will contain information on various species by region.

IJC

The International Joint Commission (IJC) was established in 1909 by the Boundary Waters Treaty. The council is made up of three representatives from the United States and three members from Canada whose main goal is to clean up the Great Lakes and rivers along the U.S.–Canada border and protect them from further pollution. They are also in charge of approving any construction or changes in these areas, for example the building of new dams or shore property, or changes in water level. The IJC is currently hosting The Great Lakes – St. Lawrence Research Inventory, which contains information on researchers and projects they are doing in the waters along the border (International Joint Commission, 2005).

SERC

The Smithsonian Environmental Research Center (SERC) is currently "the world's leading research center for environmental studies of the coastal zone" (Smithsonian Environmental Research Center, 2005). In 1964, Robert Lee Forrest donated a huge piece of land, what was once part of the Java dairy farm, to the Smithsonian. Since this land had many different ecosystems and was very diverse the

land was turned into what was known as the Chesapeake Center for Field Biology. This was a place where scientists working with the Smithsonian were allowed to go out on collection trips, but soon people outside the Smithsonian became interested in using this facility for their research as well. Additional outside funding allowed the Smithsonian to buy more land in the surrounding area and begin building on-site laboratories and dormitories. One barn was converted into the Rhodes River Research site for student interns.

Throughout the mid 70's and early 80's the facility continued to grow and flourish. Research was conducted on watershed, human impact on environment, and the atmosphere. In 1985, the Chesapeake Center was renamed the Smithsonian Environmental Research Center after the Smithsonian Radiation Biology Laboratory was shut down and moved onto this site. The facility has continued to expand worldwide ever since, developing educational programs for students and the general public and conducting environmental research. Today SERC owns 2800 acres of land and employs over one hundred eighty full time researchers, along with sixteen senior scientists, and many interns and graduate level students (Smithsonian Environmental Research Center, 2005).

SERC owns and maintains three of the databases discussed at the September 2005 Non-Indigenous Aquatic Species Database Working Group meeting: the National Ballast Information Clearinghouse (NBIC), the National Exotic Marine & Estuarine Species Information System (NEMESIS), and the Aquatic Invasions Research Directory (AIRD).

USGS

The United States Geological Survey (USGS) was established by congress in 1879. It is currently part of the Department of Interior and employs over ten thousand people in four hundred locations nationwide. This agency "collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems" (United States Geological Survey, 2005). Their main mission is to provide the public with information about the planet, along with preventing people and property from being harmed or damaged in any way by natural disasters, and aiding in the management of the planet's resources. The USGS currently hosts the Non-indigenous Aquatic Species (NAS) database, which contains fact sheets on the distribution of many freshwater invasive species.

USDA NAL

The National Agriculture Library (NAL) is a subdivision of the United States Department of Agriculture. Created by Abraham Lincoln in 1862, the main mission of the NAL is to "increase the availability and utilization of agricultural information for researchers, educators, policymakers, consumers of agricultural products, and the public" (National Agriculture Library, 2005). It is one of four national libraries, the others being the Libraries of Congress, Medicine, and Education. The National Agriculture Library is currently hosting the www.invasivespecies.gov website, which is planned to split into invasivespecies.gov and invasivespeciesinfo.gov. After this occurs, NAL will be hosting www.invasivespeciesinfo.gov, and although www.invasivespecies.gov will not be hosted by NAL, it will continue to be the home of National Invasive Species Council.

Project Description

Development of a site architecture plan for information exchange on aquatic invasive species.

Invasive species are those non-native species whose introduction into an ecosystem threatens the environment or human welfare. Invasive species threaten all US ecosystems, with ecological damage and control costs for all areas in excess of $130 billion/year. Invasions in aquatic ecosystems are a critical subcomponent of this problem, with estimated economic damages to our natural resources of upwards of $8.9 billion a year. In addition to economic damages to commercial interests, invasive species also cause ecological damage, with impacts from invasive species contributing to approximately 40% of aquatic species extinctions. To date, a lack of infrastructure for effective information transfer between federal agencies and to stakeholders and end users has hampered effective federal action in this field. The participants in this project will work to design a web-based format to more easily distribute invasive species information, using the subset of information on aquatic invasive species as the case study.

The federal government stores a large volume of information on invasive species at www.invasivespecies.gov and the site receives over 2 Million hits a year, however navigating to particular information within the site can be difficult. Underlying the Web site are 600 or more flat HTML files with more than 12,000 links to external resources. Continuing to manage the Web site as a series of flat files is inefficient and does not allow for dynamic and customized delivery of information. It is accepted that the site needs to move to a database structure – while preserving high level access to content by search engines (approximately 70% of users are first time users, who arrive at the site using an internet search engine). The Web site is undergoing a major redesign to meet federal and departmental requirements for content organization and presentation.

This is an opportune time to design a distributed-systems information architecture that will integrate information on aquatic invasive species from multiple sources using methods or technologies that are cost effective and ultimately applicable to the whole site. The project will evaluate user needs and technical capabilities. Project participants will work with representatives from numerous federal agencies (including NOAA, EPA, Department of Agriculture, Fish and Wildlife Service, U.S. Geological Survey, Coast Guard, Navy and others), and private entities to determine 1) their efforts in invasive species, 2) existing databases of information, 3) their own information needs, and 4) common information requested from them by stakeholders and end users. This information will then be used to design an appropriate interface architecture for implementation at the www.invasivespecies.gov site.

Point of Contact: Melissa Pearson, NOAA Ballast Water Coordinator
                      Phone: (301) 713-2451 x 190
                      E-mail: melissa.pearson@noaa.gov

Appendix B: General Interview Format

This is what we have used as a starting point for each of our interviews. We modified this general interview on a case by case basis depending on the organization/agency/database that the interviewee worked with and what their job was. For instance, if we were interviewing someone who only dealt with the web aspect of a database, we focused our questions on more of a technical aspect of the problem. Questions were added more often than they were omitted, and general questions were usually replaced with more specific ones.

Hello, this is [Chris Serrano, Mike McKinstry and Chris Korzeniowski] from the WPI Aquatic Invasive Species project that we're working on with NOAA Sea Grant. As a reminder, the goal of our project is to provide recommendations for a central invasive species web portal. We would like to ask you some questions about [database or organization/agency].

- What is your role in *the organization/agency*?

- How do you work with *the database*?

- What is the purpose of *the database*?

- Who is the intended/actual audience?

    o   What information are the users looking for?

    o   How successful would you say *the database* is in terms of delivering the information that the user needs?

- How does *this database* interface with other databases (if applicable)?

- Does any of the information on *your database* overlap with information found on other similar government databases?

- Could you describe the search feature (if applicable)?

- How up to date is *the database*?

    o Is that enough updates to keep the site informative and accurate?

- Are there any difficulties you have faced in trying to accomplish the organization's goals through *this database*?

- How would you see *this database* interacting with others that have different purposes and structures?

- Do you know of any legal issues that would be involved with *this database* being linked to other databases or being part of a web portal?

- Have you worked with NISbase?

    o If so, what are your thoughts on it?

    o Do you think that it should be incorporated into an AIS portal?

- What features would you want to see from the AIS web portal?

- Is there anything else that you would like to share with us that would be relevant to our project?

- Could you provide us with the contact information of anyone else who may be able to help in our research?

- Do you know of any other AIS databases that were not represented at the summit but are still important?

- Would it be possible for us to send you a follow-up email with any additional questions we may have?

Appendix C: General Questionnaire Format

This is a master list of potential questions to ask questionnaire respondents. We modified and removed questions on a case-by-case basis, depending on each contact's background knowledge and which group they fell into (potential user or database manager).

What kind of experience do you have with databases?

What is your position or role at your agency in terms of managing information?

Which databases do you use most often for your research? (for example NAS, NEMESIS, SGNIS?)

What type of information do you search for most often? (e.g. fact sheets, maps, distribution info, journal articles)

How useful is the information you get out of the site(s)?

How easy is it to navigate the site(s)?

If you have any difficulty finding certain information could you describe why and how you feel the problem could be resolved?

Do you find information on Aquatic Invasive Species in general to be scattered and hard to find?

What is your opinion of the quality of information and ease of use regarding the invasivespecies.gov website?

Are you familiar with NISbase?

If so, what is your opinion of it?

If a centralized web portal linking many AIS databases was created, would you use it?

How Often?

Are there any features would you like to see included in it?

Any additional information you feel would be pertinent or contact information of people who might also be willing to help would be greatly appreciated.

Appendix D: Survey Questions

Invasivespecies.gov Survey Questions

For Questions 1-13: Answers are on a scale 1-10, 1=Poor, 10=Excellent, "Don't Know" is an option

1: Please rate the quality of information on this site.

2: Please rate the freshness of content on this site.

3: Please rate the convenience of the information on this site.

4: Please rate the ability to accomplish what you wanted to on this site.

5: Please rate the usefulness of search results on this site.

6: Please rate how this site provides comprehensive search results.

7: Please rate how the search feature helps you to narrow the results to find the information you want.

8: Please rate the speed of loading the page on this site.

9: Please rate the consistency of speed on this site.

10: Please rate the reliability of site performance on this site.

11: What is your overall satisfaction with this site?

12: How well does this site meet your expectations?

13: How does this site compare to your idea of an ideal website?

For Questions 14-15: Answers are on a scale 1-10, 1=Not very likely, 10=Very likely, "Don't Know" is an option

14: How likely are you to return to this site?

15: How likely are you to recommend this site to someone else?

16: How frequently do you visit this site?
- First time
- More than once a day
- Daily

- o About once a week
- o About once a month
- o Every 6 months or more

17: If you are a USDA employee Select One:
- o Office of the Secretary
- o Main USDA Office(Communications, Dept. Admin., etc..)
- o Agricultural Marketing Service (AMS)
- o Agricultural Research Service (ARS)
- o Animal and Plant Health Inspection Service (APHIS)
- o Center for Nutrition Policy and Promotion (CNPP)
- o Coop.State Research, Education, and Extension Service
- o Economic Research Service (ERS)
- o Farm Service Agency (FSA)
- o Food and Nutrition Service (FNS)
- o Food Safety Inspection Service (FSIS)
- o Foreign Agricultural Service (FAS)
- o Forest Service (FS)
- o Grain Inspection, Packers, and Stockyards Administration
- o National Agricultural Statistics Service (NASS)
- o Natural Resources Conservation Service (NRCS)
- o Office of Community Development (OCD)
- o Risk Management Agency (RMA)
- o Rural Development (inc. Rural Business i.e. Coop. Service)
- o Other USDA Program Office

18: Which best describes your role in coming to our site?
- o American tribal representative
- o Business/industry employee
- o College/university faculty/staff
- o Elementary/secondary educator
- o Farmer, rancher or other agricultural producer
- o Federal government (nonUSDA) employee
- o General Public
- o Librarian or Information Specialist
- o News media representative
- o Nonprofit organization representative
- o State or local government representative
- o Student
- o Other

19: How did you find our site?
- o Search engine (Yahoo, Excite, Google, etc.)
- o Link from another site
- o Conference
- o Publications/Products

    o Other

20: Please specify (search engine, magazine, conference name, etc.) (fill in)

21: Which of the following best describes the highest level of education you have completed?
- Grade school or some high school
- High school graduate
- Some college/vocational school
- College graduate
- Some postgraduate school
- Graduate/professional degree

22: What is your primary reason for visiting the site today? (fill in)

23: Were you able to find the information you were seeking?
- I found all the information I needed
- I found most of the information I needed
- I found some of the information I needed
- I was unable to find any information
- Not sure yet

24: How do you prefer to navigate this site?
- Search
- Menu structure
- Text links
- Combination
- Other
- No preference

25: Did you encounter difficulties navigating the site, and if so, what was the primary issue?
- I did not encounter any difficulties navigating the site
- Could not determine the best link on most pages
- Links did not take me where I expected
- Technical difficulties (e.g., broken links, error messages, etc)
- Too many links or navigational choices
- Links/icons/labels are difficult to understand
- Navigated to the general area but could not find the specific content I needed
- Difficulty finding related information
- Other

26: Did you encounter difficulties with the Search feature, and if so, what was the primary issue?
- I did not encounter any difficulties with the search feature
- Too many results

- I was not sure what words to use in my search
- The descriptions/abstracts were not helpful
- The results were not relevant to my search terms
- The search turned up no results
- The results were not relevant to my needs
- Search speed was too slow
- Other

27: What else would you like to see on our site? (fill in)

SGNIS User Survey

USA	69	81.18%
Canada	3	3.53%
Italy	2	2.35%
England	1	1.18%
Germany	1	1.18%
China	1	1.18%
Vietnam	1	1.18%
Ireland	1	1.18%
Russia	1	1.18%
Belarus	1	1.18%
Brazil	1	1.18%
N/A	3	3.53%

Researcher	26	30.59%
Undergraduate Student	13	15.29%
Educator	10	11.76%
N/A	7	8.24%
Resource Manager	5	5.88%
Outreach Professional	3	3.53%
Administrator	3	3.53%
Graduate Student	3	3.53%
Information Technologist	2	2.35%
Other (specified below)	14	16.47%
Librarian	*3*	*3.53%*
Consultant	*2*	*2.35%*
Consultant (fish biologist)	*1*	*1.18%*
DVM fish pathologist	*1*	*1.18%*
Environmental engineer	*1*	*1.18%*
Environmental scientist	*1*	*1.18%*
Legislative fellow	*1*	*1.18%*
Master scheduler	*1*	*1.18%*
Stakeholder/outdoor writer	*1*	*1.18%*
Student	*1*	*1.18%*
Zebra mussel	*1*	*1.18%*

University	31	36.47%
Governmental Agency	18	21.18%
Consulting Firm	9	10.59%
Industry	5	5.88%
Non-governmental Agency	3	3.53%
Water Utility	1	1.18%
N/A	3	3.53%
Other (specified below)	15	17.65%
Student	*2*	*2.35%*
FAO	*1*	*1.18%*
High School	*1*	*1.18%*
International Trade	*1*	*1.18%*
Nonprofit	*1*	*1.18%*
Public High School	*1*	*1.18%*
Public School District	*1*	*1.18%*
Restaurant	*1*	*1.18%*
Self	*1*	*1.18%*
Student Teacher	*1*	*1.18%*
US house of reps	*1*	*1.18%*
N/A	*3*	*3.53%*

Yes	44	51.76%
No	38	44.71%
N/A	3	3.53%

1-3 visits/week	7	8.24%
1-3 visits/month	22	25.88%
1-3 visits/year	11	12.94%
Less than 1 visit/year	10	11.76%
N/A	35	41.18%

5 - Essential (I couldn't do my job efficiently without it!)	4	4.71%
4 - Very helpful in performing my job responsibilities	28	32.94%
3 – Useful	18	21.18%
2 - Slightly useful	0	0.00%
1 - Not useful	0	0.00%
N/A	35	41.18%

Environmental impact	45	52.94%
Prevention	21	24.71%
Monitoring	20	23.53%
Population dynamics	20	23.53%
Economic impact	18	21.18%
Dispersal mechanism	16	18.82%
Aquatic plant management	15	17.65%
Ballast water	12	14.12%
Colonization	12	14.12%
Other, please provide	16	18.82%
Distribution	*2*	*2.35%*
Macrofowling	*1*	*1.18%*
Project	*1*	*1.18%*
Control	*1*	*1.18%*
Pipe fish	*1*	*1.18%*
Species information	*1*	*1.18%*
sell, trade, plant extract, botanical	*1*	*1.18%*
Life history	*3*	*3.53%*
Treatment management	*1*	*1.18%*
Non-indigenous species	*1*	*1.18%*
Education resources	*2*	*2.35%*
Information quality	*1*	*1.18%*

Zebra Mussel		46	54.12%
Round Goby		17	20.00%
European Watermilfoil		14	16.47%
Asian Carp (Bighead, Black, Silver)		10	11.76%
Sea Lamprey		10	11.76%
Purple Loosestrife		9	10.59%
Rusty crayfish		8	9.41%
European Green Crab		4	4.71%
Ruffe		4	4.71%
N/A		15	17.65%
Other (specified below)		23	27.06%
	Any/all	*4*	*4.71%*
	Asian death fish	*1*	*1.18%*
	Asian shore crab	*1*	*1.18%*
	Asian Veined Whelk, Repana Venosa	*1*	*1.18%*
	Asiatic clam	*1*	*1.18%*
	Corbicula	*1*	*1.18%*
	Eurasian watermilfoil	*1*	*1.18%*
	Great lakes invasives	*1*	*1.18%*
	Limnopera fortunei	*1*	*1.18%*
	Marenzelleria	*1*	*1.18%*
	New Zealand Mud Snail	*2*	*2.35%*
	Nutria	*1*	*1.18%*
	Cogongrass	*1*	*1.18%*
	Popcorn tree	*1*	*1.18%*
	Other invasive plants	*1*	*1.18%*
	Pipe fish	*1*	*1.18%*
	potomocorbula amurensis	*1*	*1.18%*
	Spiny water flea	*1*	*1.18%*
	Fishhook water flea	*1*	*1.18%*

9. Are there species that you are currently working with that are not included on SGNIS, but should be? (Please provide the scientific names) (fill in)

75 null
1 have not inventoried SGNIS *(AKA doesn't know?)*
5 no
1 hemigrapsus sangueinensis
1 hemigrapus sanguineus
1 pipe fish
1 *Junk data: "uytr"*

(No question 10 included in the survey)

11. What aquatic invasive species (AIS) information do you need that is currently not on SGNIS? (fill in)

75 null
1 distribution maps for all species listed on SGNIS
1 Introduction historical data/Great Lakes
1 Limnoperna fortunei
1 policy implications and fact sheets
1 pipe fish
1 quagga mussel
1 treatment/management
1 types of minnows
1 unknown
1 *Junk data: "reey yt"*

12. Some journals charge a fee to have their publications published online. Are there particular journals that you would find most useful on SGNIS.

78 null
2 Freshwater Biology
1 biological invasions
2 none
1 none for which I don't have access
2 *Junk data: "rewr yttyr", "jglr"*

13. Please select your current browser for the web.

Internet Explorer (v. 5 and newer)	44
Internet Explorer (older than v. 5)	5
Mozilla	15
Opera	0
Netscape (v. 6 and newer)	5
Safari	7
AOL	1
Netscape 4.7	1
N/A	9
Other, please provide	4
Cox communications	*1*
Mozilla	*2*
Google	*1*

14. How do you access the Internet?

T1/LAN	41
Broadband	0
Dial-up/Modem	0
N/A	44

15. If you are a SGNIS user, how would you rank the usefulness of "Nab the Aquatic Invader" (education site) in performing your job?

5 - Essential (I couldn't do my job efficiently without it!)	3
4 - Very helpful in performing my job responsibilities	8
3 – Useful	19
2 - Slightly useful	3
1 - Not useful	7
N/A	45

16. What would make SGNIS more useful to you?
- Distribution maps for all ANS species
- Minnows
- Full text articles
- Being able to click and download documents from the site
- Pipe fish
- Journal articles
- Clipart
- Photo archive + library royalty tree
- Fix links to exotic maps
- Not having to fill out survey (2)
- Nothing… "Good site. Thank you"
- First visit… no comment
- *Junk data*

Appendix E: Database Documentation and Code

Structures

Tables

Databases – Contains a database ID and the per database information
Categories – Contains a list of category table names
<name from categories table> - Contains valid values for a category and a unique ID
      value
<name from categories table>Lnk – Contains IDs from the associated category table and
      Databases to, in effect, create a many to many link
Switchboard Items – Used by MS Access's Switchboard Manager to create the menu
      system

Reports

templateReport – Generic report format, called and altered by the GenReport form

Macros

Exit_Access – Closes the application
ShowDBwin – displays the DB window by selecting the Databases table

Modules

MiscCode – Module containing miscellaneous functions

Forms

AddAxis – Creates a new category table, junction table, and enters the information into
      categories
AddItemSubform – Used by AxisPointEditor form to alter values from a category table
AxisPointEditor – Creates and edits points in the categories tables by setting the source of
      AddItemSubform
Database Entry – Used to make changes to the Databases table
DbAxisLinksubform – Used by PlaceDBOnAxis to alter the category link tables
DropAxis – Deletes all the contents of a category table (clearing the junction table
      through the relations), removes the category from Categories, and then drops the
      category and junction tables
frmAbout – Displays information about the database
GenReport – Sets parameters for templateReport and opens it into a mode ready for
      printing
PlaceDBOnAxis – Works with DbAxisLinksubform to edit the category and link tables
Switchboard – Created by the MS Access Switchboard Utility

Menus

Main Menu

View A Report – Opens the GenReport form
Add Data – Opens the Add Data menu
About This Database – Opens the frmAbout form
Close This Database – Closes the database
Close Access – Close Access completely (via Exit_Access macro)

Add Data

Add a Database – Opens the Database Entry form in add new data mode (existing data is
    not viewable or changeable)
Put Databases in New Categories – Opens the PlaceDBOnAxis form in add new data
    mode
View a Report – Opens the GenReport form
Alter Existing Data Menu (are you sure?) – Opens the Edit Data menu
Return to Main Menu – Opens the Main Menu

Edit Data

Edit Databases – Opens the Database Entry form for editing
Edit Database Categories – Opens the PlaceDBOnAxis form for editing
Add a Category – Opens the AddAxis form
Remove a Category – Opens the DropAxis form
Change Subcategories – Opens the AxisPointEditor form
View a Report – Opens the GenReport form
Alter the Application – Uses the ShowDBwin macro to show the database window
Return to the Data Addition Menu – Opens the Add Data Menu

Code Description

Form_AddAxis

The form has events for two buttons. The close button calls the Close method of the
DoCmd object. The Create button creates SQL statements and runs them. It checks if
the table already exists. If not, it builds a create table SQL statement for the main table
and runs it. The use of an ADO command object instead of the DoCmd object's RunSQL
method allows for future upgrades to use parameters and allows the database to be
upsized into a Microsoft Access project with less effort. Next, an SQL string is built to
create the related junction table and its data constraints. Finally, it generates an insert

query to record the information into Categories, sets the command object to nothing, and exits the subroutine.

This code module also contains a TableExists function. The function receives a name as a string. It loops through the TableDefs collection of CurrentDb to see if a table exists with that name. If so, it returns true.

Form_AddItemSubform

This code module contains one public method, which takes in a string and sets the form's RecordSource property to that string. This code is unnecessary because the parent form can modify the object's RecordSource object directly.

Form_AxisPointEditor

This module starts with a load function that selects all objects in the Categories table and populates the cmbAxis combobox. In an unload event, the form clears RecordSource properties for itself and its child subform (Form_AddItemSubform) and requeries both forms. The close button is the standard template close button which calls the Close method of DoCmd.

This code module contains the TableExists but does not call it at any time. It did at once, as is visible in the now commented out code.

The bulk of the code is in the Change event of cmbAxis. It populates a new recordset based on the records in Categories to check if the category exists (there will be one category in the recordset). When the category exists, the code sets the recordset of the child subform and requeries the subform.

Form_DbAxisLinksubform

This form has one public method, SetRcdSrc. Like the function in Form_AddItemSubform, this function take a string – the new RecordSource, a table name. The code starts by testing if a blank string is being set. Otherwise, it appends Lnk to the name of the table, and sets the row source for the cmbAxisPoint combo box. Finally, it refreshes and requeries itself. This is to remove the need of the parent form to do that.

Form_DropAxis

This form, upon loading, populates the cmbAxisList combo box with the records from Categories.

Upon clicking the Delete button, the code deletes all records in the category table. It removes the junction table and then the category table, and finally removes the record from the Categories table.

Form_frmAbout

This form only contains the standard close event code.

Form_GenReport

This module is the longest of the modules in the form. The main procedure is the event code for the cmdViewReport command button.

The cmdViewReport button's Click event conditionally builds an SQL statement based on the value of the value of strAxisName. The SQL statement will pass the group variable and headers as records, so that the report can bind to them and display them. It then selects the regular database records, adds the sources along with joins, and finally adds an optional Where clause. Finally, it opens the report in design mode and hidden, changes the RecordSource, and then shows the report in Preview mode.

The form's load method is standard in that it populates the fields of cmbAxis from Categories. The form checks if the combo box was set to a valid value when cmbAxis is changed. If so, it populates cmbSelection and displays it.

TableExists is here as well and again is unused.

Form_PlaceDBOnAxis

This form is similar in code and function to Form_AxisPointEditor. Both forms have similar functions and rely on the subforms to do the majority of work and processing. Therefore, understanding Form_AxisPointEditor should provide a good solid understanding of this form.

Form_Switchboard

This form is generate by Microsoft Access's Switchboard Utility and should not need direct modification.

Report_templateReport

This report, upon opening sets warnings to not be displayed. Upon closing, it re-enables warnings. This is two prevent the user from being asked if they want to save the form, since the RecordSource property is modified.

MiscCode

This module has one function, ExitAccess. It calls the Quit method of the Application object, passing it a value of acQuitSaveNone to quit without saving anything open, and not prompt the user.

Recommendations for improvement

- Add user/group management to secure access
- Create a web interface
- Clean up form interface
    - Add delete buttons to the record altering forms
- Clean up code
    - Much of the code is repeated – move it into MiscCode and use the Eval function to dynamically generate parameters
    - Take instances of built SQL and design to use Parameter objects, to remove the threat of malformed SQL statements
    - Remove all instances of DAO code (for example, code that uses CurrentDb such as the TableExists utility function)
- Upsize to an Access Project
    - Access databases are not optimum for client/server access
    - Access projects work with MS SQL Server or MSDE, which is designed for client/server access.
- Verify data

Code Listing

Form_AddAxis

```
Option Compare Database
Option Explicit

Private Sub btnClose_Click()
      On Error GoTo Err_btnClose_Click
      DoCmd.Close
      Exit_btnClose_Click:
      Exit Sub
      Err_btnClose_Click:
      MsgBox Err.Description
      Resume Exit_btnClose_Click
End Sub


Private Sub btnCreate_Click()
On Error GoTo Err_btnCreate_Click

'1. Create a table
'2. Create a junction table
'3. Make a record in the Categories table

'Variables
      Dim adoCmdObject As ADODB.Command
      Dim strSQL As String
      Set adoCmdObject = New ADODB.Command

'Ensure a reasonably valid value for the Axis to delete
```

```vba
      If Nz(txtAxis.Value, "") = "" Then
            MsgBox "Please give a valid axis name"
            GoTo Exit_btnCreate_Click
      End If

'Check if the axis already exists
      If TableExists(txtAxis.Value) Then
            MsgBox "That axis already exists"
            Exit Sub
      End If

'1. A table is created with an ID, and a text field
      strSQL = "CREATE TABLE " + Me.txtAxis.Value + " ( axisid COUNTER
      PRIMARY KEY, Col1 VARCHAR(50))"

      adoCmdObject.ActiveConnection = CurrentProject.Connection
      adoCmdObject.CommandText = strSQL
      adoCmdObject.Execute

'2. A junction table has two fields, the database ID and the axis id
      strSQL = "CREATE TABLE " + Me.txtAxis.Value + "Lnk ( dbid
      INTEGER" + _
      " CONSTRAINT dbid_" + txtAxis.Value + _
      "_rf REFERENCES Databases (dbID)" + _
      "ON UPDATE CASCADE ON DELETE CASCADE" + _
      ", axisid INTEGER CONSTRAINT " + _
      txtAxis.Value + "id_rf REFERENCES " + _
      txtAxis.Value + _
      " (axisid) ON UPDATE CASCADE ON DELETE CASCADE," & _
      "CONSTRAINT " + txtAxis.Value + _
      "Lnk_pk PRIMARY KEY (dbid, axisid) )"

      adoCmdObject.CommandText = strSQL
      adoCmdObject.Execute

'3. Add a record to the Categories table
      strSQL = "INSERT INTO Categories (CatName) VALUES ('" +
      txtAxis.Value + "')"

      adoCmdObject.CommandText = strSQL
      adoCmdObject.Execute
      Set adoCmdObject = Nothing

Exit_btnCreate_Click:
      Me.txtAxis.SetFocus
      Exit Sub

Err_btnCreate_Click:
      MsgBox Err.Description
      Resume Exit_btnCreate_Click
End Sub

Function TableExists(strTabName As String) As Boolean
      Dim Table As TableDef
      TableExists = False
      For Each Table In CurrentDb.TableDefs
            If Table.Name = strTabName Then
```

```
                TableExists = True
                Exit Function
            End If
        Next Table
End Function
```

Form_AddItemSubform

```
Option Compare Database
Public Sub SetRcdSrc(strSrc As String)
      Me.RecordSource = strSrc
End Sub
```

Form_AxisPointEditor

```vba
Option Compare Database
Option Explicit

Private Sub cmbAxis_Change()
      Dim rs As ADODB.Recordset
      Set rs = New ADODB.Recordset

      rs.ActiveConnection = CurrentProject.Connection
      rs.Open "SELECT CatName FROM Categories WHERE CatName = '" + _
      cmbAxis.Value + "'", , adOpenForwardOnly, adLockReadOnly

      If rs.Fields(0) = cmbAxis.Value Then
            [Form_AddItemSubform].SetRcdSrc cmbAxis.Value
      End If

      Set rs = Nothing

      ' 'If the table typed in is valid
      ' If TableExists(cmbAxis.Value) Then
      ' If Left(cmbAxis.Value, 4) <> "MSys" Then
      ' If cmbAxis.Value <> "Databases" Then
      ' If Right(cmbAxis.Value, 3) <> "Lnk" Then
      ' If cmbAxis.Value <> "Switchboard Items" Then
      ' 'Me.RecordSource = cmbAxis.Value
      ' [Form_AddItemSubform].SetRcdSrc cmbAxis.Value
      ' End If
      ' End If
      ' End If
      ' End If
      '
      ' End If

      Me.frmContent.Requery
      Me.Requery
      Me.Refresh
End Sub


Private Sub cmdQuit_Click()
On Error GoTo Err_cmdQuit_Click
      DoCmd.Close

Exit_cmdQuit_Click:
      Exit Sub

Err_cmdQuit_Click:
      MsgBox Err.Description
      Resume Exit_cmdQuit_Click
End Sub


Private Sub Form_Load()
      ' Dim Table As TableDef
      '
```

```
      ' For Each Table In CurrentDb.TableDefs
      ' If Left(Table.Name, 4) <> "MSys" Then
      ' If Table.Name <> "Databases" Then
      ' If Right(Table.Name, 3) <> "Lnk" Then
      ' If Table.Name <> "Switchboard Items" Then
      ' Me!cmbAxis.AddItem Item:=Table.Name
      ' cmbAxis.Value = Table.Name
      ' End If
      ' End If
      ' End If
      ' End If
      ' Next Table
      Dim rs As ADODB.Recordset
      Set rs = New ADODB.Recordset

      rs.ActiveConnection = CurrentProject.Connection
      rs.Open "SELECT CatName FROM Categories", , adOpenForwardOnly,
      adLockReadOnly

      While Not rs.EOF
            cmbAxis.AddItem rs.Fields("CatName")
            cmbAxis.Value = rs.Fields("CatName")
            rs.MoveNext
      Wend

      'Cleanup
      Set rs = Nothing
      [Form_AddItemSubform].SetRcdSrc cmbAxis.Value
      Me.frmContent.Requery
End Sub

Function TableExists(strTabName As String) As Boolean
      Dim Table As TableDef
      TableExists = False

      For Each Table In CurrentDb.TableDefs
            If Table.Name = strTabName Then
                  TableExists = True
                  Exit Function
            End If
      Next Table
End Function

Private Sub Form_Unload(Cancel As Integer)
      Me.RecordSource = ""
      Me.Refresh
      [Form_AddItemSubform].SetRcdSrc ""
      Me.frmContent.Requery
End Sub
```

Form_DbAxisLinksubform

```
Option Compare Database

Public Sub SetRcdSrc(strVal As String)
      If strVal = "" Then
            Me.RecordSource = strVal
      Else
            Me.RecordSource = strVal + "Lnk"
      End If

      'SELECT a.axisid, a.Col1 FROM *axis* a;
      If Not strVal = "" Then
            Me.cmbAxisPoint.RowSource = "SELECT a.axisid, a.Col1 FROM "
            + strVal + " a"
      Else
            Me.cmbAxisPoint.RowSource = ""
      End If

      Me.Requery
      Me.Refresh
End Sub
```

Form_DropAxis

```
Option Compare Database
Option Explicit

Private Sub btnClose_Click()
On Error GoTo Err_btnClose_Click

      DoCmd.Close

Exit_btnClose_Click:
      Exit Sub

Err_btnClose_Click:
      MsgBox Err.Description
      Resume Exit_btnClose_Click
End Sub


Private Sub btnDelete_Click()
On Error GoTo Err_btnDelete_Click

'1. Delete the contents of the axis table (to ensure data continuity)
'2. Drop the junction table
'3. Drop the axis table
'4. Remove the list from the junction table

'Variables
      Dim adoCmdObject As ADODB.Command
      Dim strSQL As String
      Set adoCmdObject = New ADODB.Command

'1. Delete the contents of the axis table
      strSQL = "DELETE FROM " + Me.cmbAxisList.Value
      adoCmdObject.ActiveConnection = CurrentProject.Connection
      adoCmdObject.CommandText = strSQL
      adoCmdObject.Execute

'2. Drop the junction table
      strSQL = "DROP TABLE " + cmbAxisList.Value + "Lnk"
      adoCmdObject.CommandText = strSQL
      adoCmdObject.Execute

'3. Drop the axis table
      strSQL = "DROP TABLE " + cmbAxisList.Value
      adoCmdObject.CommandText = strSQL
      adoCmdObject.Execute

'4. Remove table from Categories
      strSQL = "DELETE FROM Categories WHERE CatName = '" +
      Me.cmbAxisList.Value + "'"
      adoCmdObject.CommandText = strSQL
      adoCmdObject.Execute

      Set adoCmdObject = Nothing
      cmbAxisList.RemoveItem cmbAxisList.Value
```

```
            cmbAxisList.Value = ""

Exit_btnDelete_Click:
        Exit Sub

Err_btnDelete_Click:
        MsgBox Err.Description
        Resume Exit_btnDelete_Click

End Sub

Function TableExists(strTabName As String) As Boolean
        Dim Table As TableDef
        TableExists = False

        For Each Table In CurrentDb.TableDefs
            If Table.Name = strTabName Then
                    TableExists = True
                    Exit Function
            End If
        Next Table
End Function

Private Sub Form_Load()
        Dim rs As ADODB.Recordset
        Set rs = New ADODB.Recordset

        rs.ActiveConnection = CurrentProject.Connection
        rs.Open "SELECT CatName FROM Categories", , adOpenForwardOnly,
        adLockReadOnly

        While Not rs.EOF
                cmbAxisList.AddItem rs.Fields("CatName")
                cmbAxisList.Value = rs.Fields("CatName")
                rs.MoveNext
        Wend

        'Cleanup
        Set rs = Nothing
End Sub
```

Form_frmAbout

```
Option Compare Database

Private Sub cmdOk_Click()
On Error GoTo Err_cmdOk_Click
      DoCmd.Close

Exit_cmdOk_Click:
      Exit Sub

Err_cmdOk_Click:
      MsgBox Err.Description
      Resume Exit_cmdOk_Click

End Sub
```

Form_GenReport

```
Option Compare Database
Option Explicit

Private Sub cmdViewRpt_Click()
      'Shows the report
      'Generate the SQL source string
      '(group1) is the Axis to view
      'if (No Axis) is selected, just view all databases,
      'set group1 to NULL, and hide txtGrp1 (better to do inside the
      report)

'Open the report hidden
'Set the report source
'Show the report
'Create a list of the possible values for the axis
      'Select into a temporary table, and then join?

      'First, need to be able to add columns to the table
      'Build the SQL
      'SELECT *group1 field* AS group1, *Desired database fields*
      'FROM Databases AS db INNER JOIN (*Axis* AS a INNER JOIN
      *Axis*Lnk AS al ON a.axisid = al.axisid)
      'ON Databases.dbid = al.dbid;

      Dim strSQL As String
      Dim strAxisName As String
      strAxisName = Nz(cmbAxis.Value, "(No Category)")

      'Select clause
      strSQL = "SELECT "

      'group1
      If strAxisName = "(No Category)" Then
            strSQL = strSQL + "'' as group1, 'Databases' AS RptHdr, ''
            AS GrpHdr, "
      Else
            strSQL = strSQL + "a.Col1 as group1, 'Databases by " +
            strAxisName + _
            "' AS RptHdr, "
            strSQL = strSQL + "'" + strAxisName + "' AS GrpHdr, "
      End If

'Other database fields
      strSQL = strSQL + "db.DBAcronym, db.DBName, db.DBSponsor,
      db.ContactName, db.ContactEmail, db.DBur
      l "

'From clause, with inner joins
      strSQL = strSQL + "FROM Databases AS db"

'If axis selected, use inner joins
      If Not strAxisName = "(No Category)" Then
            strSQL = strSQL + " INNER JOIN (" + strAxisName + " AS a
            INNER JOIN " + _
```

```
                strAxisName + "Lnk AS al ON a.axisid = al.axisid)" + _
                " ON db.dbid = al.dbid"
        End If

'Add a where clause based on the value of cmbSelection.Value
        If Not cmbSelection.Value = "(no subcategory)" Then
                strSQL = strSQL + _
                " WHERE a.Col1 = '" + cmbSelection.Value + "'"
        End If

        cmbSelection.Value = "(no subcategory)"

'Open the report hidden
        DoCmd.OpenReport "templateReport", acViewDesign, , , acHidden

'Set the report source
        Reports("templateReport").RecordSource = strSQL

'Show the report
        DoCmd.OpenReport "templateReport", acViewPreview, , ,
        acWindowNormal
End Sub


Private Sub Form_Load()
        ' Dim Table As TableDef
        '
        ' For Each Table In CurrentDb.TableDefs
        ' If Left(Table.Name, 4) <> "MSys" Then
        ' If Table.Name <> "Databases" Then
        ' If Right(Table.Name, 3) <> "Lnk" Then
        ' If Table.Name <> "Switchboard Items" Then
        ' Me!cmbAxis.AddItem Item:=Table.Name
        ' End If
        ' End If
        ' End If
        ' End If
        ' Next Table

        Dim rs As ADODB.Recordset
        Set rs = New ADODB.Recordset

        rs.ActiveConnection = CurrentProject.Connection
        rs.Open "SELECT CatName FROM Categories", , adOpenForwardOnly,
        adLockReadOnly

        While Not rs.EOF
                cmbAxis.AddItem rs.Fields("CatName")
                cmbAxis.Value = rs.Fields("CatName")
                rs.MoveNext
        Wend

        cmbAxis.AddItem "(No Category)", 0
        cmbAxis.Value = "(No Category)"
        cmbSelection.Visible = False

        'Cleanup
```

```
        Set rs = Nothing
End Sub


Private Sub cmdClose_Click()
On Error GoTo Err_cmdClose_Click
        DoCmd.Close

Exit_cmdClose_Click:
        Exit Sub

Err_cmdClose_Click:
        MsgBox Err.Description
        Resume Exit_cmdClose_Click

End Sub


Private Sub cmbAxis_Change()
        On Error GoTo Err_cmbAxis_Change

        Dim rs As ADODB.Recordset
        Dim strSQL As String
        Dim i As Integer

        'This is the giant else
        'Hide the second combo box and clear it

        cmbSelection.Visible = False

        For i = 1 To cmbSelection.ListCount
              cmbSelection.RemoveItem 0
        Next i

        ' 'If the table typed in is valid
        ' If TableExists(cmbAxis.Value) Then
        ' If Left(cmbAxis.Value, 4) <> "MSys" Then
        ' If cmbAxis.Value <> "Databases" Then
        ' If Right(cmbAxis.Value, 3) <> "Lnk" Then
        ' If cmbAxis.Value <> "Switchboard Items" Then

        Dim rs2 As ADODB.Recordset
        Set rs2 = New ADODB.Recordset

        rs2.ActiveConnection = CurrentProject.Connection
        rs2.Open "SELECT CatName FROM Categories WHERE CatName = '" + _
        cmbAxis.Value + "'", , adOpenForwardOnly, adLockReadOnly

        If Not rs2.EOF Then
              'Alter the second combo box to show a list of possible
              values
              cmbSelection.AddItem ("(no subcategory)")
              Set rs = New ADODB.Recordset

              'SELECT Col1 FROM *cmbAxis.Value*
              strSQL = "SELECT Col1 FROM " + cmbAxis.Value
              rs.ActiveConnection = CurrentProject.Connection
```

```
                rs.Open strSQL, , adOpenForwardOnly, adLockReadOnly
                While Not rs.EOF
                        cmbSelection.AddItem (rs.Fields("Col1"))
                        rs.MoveNext
                Wend

                Set rs = Nothing
                cmbSelection.Value = "(no subcategory)"
                cmbSelection.Visible = True

                GoTo Exit_cmbAxis_Change
                ' End If
                ' End If
                ' End If
                ' End If
        End If

Exit_cmbAxis_Change:
        Set rs2 = Nothing
        Set rs = Nothing
        Exit Sub

Err_cmbAxis_Change:
        MsgBox Err.Description
        Resume Exit_cmbAxis_Change
End Sub

Function TableExists(strTabName As String) As Boolean
        Dim Table As TableDef
        TableExists = False

        For Each Table In CurrentDb.TableDefs
            If Table.Name = strTabName Then
                    TableExists = True
                    Exit Function
            End If
        Next Table
End Function
```

Form_PlaceDBOnAxis

```
Option Compare Database
Option Explicit

Private Sub cmbAxis_Change()
' 'If the table typed in is valid
' If TableExists(cmbAxis.Value) Then
' If Left(cmbAxis.Value, 4) <> "MSys" Then
' If cmbAxis.Value <> "Databases" Then
' If cmbAxis.Value <> "Switchboard Items" Then
' If Right(cmbAxis.Value, 3) <> "Lnk" Then
' 'Me.RecordSource = cmbAxis.Value
' [Form_DbAxisLinksubform].SetRcdSrc cmbAxis.Value
' End If
' End If
' End If
' End If
' End If
        Dim rs As ADODB.Recordset
        Set rs = New ADODB.Recordset

        rs.ActiveConnection = CurrentProject.Connection
        rs.Open "SELECT CatName FROM Categories WHERE CatName = '" + _
        cmbAxis.Value + "'", , adOpenForwardOnly, adLockReadOnly

        If rs.Fields(0) = cmbAxis.Value Then
              [Form_DbAxisLinksubform].SetRcdSrc cmbAxis.Value
        End If

        Set rs = Nothing

        Me.DbAxisLinksubform.Requery
        Me.Requery
        Me.Refresh
End Sub


Private Sub cmdQuit_Click()
On Error GoTo Err_cmdQuit_Click

        DoCmd.Close

Exit_cmdQuit_Click:
        Exit Sub

Err_cmdQuit_Click:
        MsgBox Err.Description
        Resume Exit_cmdQuit_Click

End Sub


Private Sub Form_Load()
        ' Dim Table As TableDef
        '
```

```
        ' For Each Table In CurrentDb.TableDefs
        ' If Left(Table.Name, 4) <> "MSys" Then
        ' If Table.Name <> "Databases" Then
        ' If Right(Table.Name, 3) <> "Lnk" Then
        ' If Table.Name <> "Switchboard Items" Then
        ' Me!cmbAxis.AddItem Item:=Table.Name
        ' cmbAxis.Value = Table.Name
        ' End If
        ' End If
        ' End If
        ' End If
        ' Next Table

        Dim rs As ADODB.Recordset
        Set rs = New ADODB.Recordset

        rs.ActiveConnection = CurrentProject.Connection
        rs.Open "SELECT CatName FROM Categories", , adOpenForwardOnly,
        adLockReadOnly

        While Not rs.EOF
                cmbAxis.AddItem rs.Fields("CatName")
                cmbAxis.Value = rs.Fields("CatName")
                rs.MoveNext
        Wend

        'Cleanup
        Set rs = Nothing
        'Me.RecordSource = cmbAxis.Value
        [Form_DbAxisLinksubform].SetRcdSrc cmbAxis.Value
        Me.DbAxisLinksubform.Requery
        [Form_DbAxisLinksubform].DataEntry = Me.DataEntry
End Sub

Function TableExists(strTabName As String) As Boolean
        Dim Table As TableDef
        TableExists = False

        For Each Table In CurrentDb.TableDefs
                If Table.Name = strTabName Then
                        TableExists = True
                        Exit Function
                End If
        Next Table
End Function

Private Sub Form_Unload(Cancel As Integer)
        Me.RecordSource = ""
        Me.Refresh
        [Form_DbAxisLinksubform].SetRcdSrc ""
        Me.DbAxisLinksubform.Requery
End Sub
```

Form_Switchboard

```
Option Compare Database

Private Sub Form_Open(Cancel As Integer)
      ' Minimize the database window and initialize the form.
      ' Move to the switchboard page that is marked as the default.
      Me.Filter = "[ItemNumber] = 0 AND [Argument] = 'Default' "
      Me.FilterOn = True
End Sub


Private Sub Form_Current()
      ' Update the caption and fill in the list of options.
      Me.Caption = Nz(Me![ItemText], "")
      FillOptions
End Sub


Private Sub FillOptions()
      ' Fill in the options for this switchboard page.
      ' The number of buttons on the form.
      Const conNumButtons = 8
      Dim con As Object
      Dim rs As Object
      Dim stSql As String
      Dim intOption As Integer

      ' Set the focus to the first button on the form,
      ' and then hide all of the buttons on the form
      ' but the first. You can't hide the field with the focus.
      Me![Option1].SetFocus

      For intOption = 2 To conNumButtons
            Me("Option" & intOption).Visible = False
            Me("OptionLabel" & intOption).Visible = False
      Next intOption

      ' Open the table of Switchboard Items, and find
      ' the first item for this Switchboard Page.
      Set con = Application.CurrentProject.Connection
      stSql = "SELECT * FROM [Switchboard Items]"
      stSql = stSql & " WHERE [ItemNumber] > 0 AND [SwitchboardID]=" &
      Me![SwitchboardID]
      stSql = stSql & " ORDER BY [ItemNumber];"
      Set rs = CreateObject("ADODB.Recordset")
      rs.Open stSql, con, 1 ' 1 = adOpenKeyset
      ' If there are no options for this Switchboard Page,
      ' display a message. Otherwise, fill the page with the items.

      If (rs.EOF) Then
            Me![OptionLabel1].Caption = "There are no items for this
            switchboard page"
      Else
            While (Not (rs.EOF))
                  Me("Option" & rs![ItemNumber]).Visible = True
```

```
                    Me("OptionLabel" & rs![ItemNumber]).Visible = True
                    Me("OptionLabel" & rs![ItemNumber]).Caption =
                    rs![ItemText]
                    rs.MoveNext
            Wend
        End If

        ' Close the recordset and the database.
        rs.Close
        Set rs = Nothing
        Set con = Nothing
End Sub

Private Function HandleButtonClick(intBtn As Integer)
        ' This function is called when a button is clicked.
        ' intBtn indicates which button was clicked.
        ' Constants for the commands that can be executed.
        Const conCmdGotoSwitchboard = 1
        Const conCmdOpenFormAdd = 2
        Const conCmdOpenFormBrowse = 3
        Const conCmdOpenReport = 4
        Const conCmdCustomizeSwitchboard = 5
        Const conCmdExitApplication = 6
        Const conCmdRunMacro = 7
        Const conCmdRunCode = 8
        Const conCmdOpenPage = 9
        ' An error that is special cased.
        Const conErrDoCmdCancelled = 2501

        Dim con As Object
        Dim rs As Object
        Dim stSql As String
        On Error GoTo HandleButtonClick_Err

        ' Find the item in the Switchboard Items table
        ' that corresponds to the button that was clicked.
        Set con = Application.CurrentProject.Connection
        Set rs = CreateObject("ADODB.Recordset")
        stSql = "SELECT * FROM [Switchboard Items] "
        stSql = stSql & "WHERE [SwitchboardID]=" & Me![SwitchboardID] & "
        AND [ItemNumber]=" & intBtn
        rs.Open stSql, con, 1 ' 1 = adOpenKeyset
        ' If no item matches, report the error and exit the function.

        If (rs.EOF) Then
              MsgBox "There was an error reading the Switchboard Items
              table."
              rs.Close

              Set rs = Nothing
              Set con = Nothing
              Exit Function
        End If

        Select Case rs![Command]
              ' Go to another switchboard.
              Case conCmdGotoSwitchboard
```

```
                    Me.Filter = "[ItemNumber] = 0 AND [SwitchboardID]=" &
                    rs![Argument]

            ' Open a form in Add mode.
            Case conCmdOpenFormAdd
                    DoCmd.OpenForm rs![Argument], , , , acAdd

            ' Open a form.
            Case conCmdOpenFormBrowse
                    DoCmd.OpenForm rs![Argument]

            ' Open a report.
            Case conCmdOpenReport
                    DoCmd.OpenReport rs![Argument], acPreview

            ' Customize the Switchboard.
            Case conCmdCustomizeSwitchboard
                    ' Handle the case where the Switchboard Manager
                    ' is not installed (e.g. Minimal Install).
                    On Error Resume Next

                    Application.Run "ACWZMAIN.sbm_Entry"
                    If (Err <> 0) Then MsgBox "Command not available."
                    On Error GoTo 0
                    ' Update the form.
                    Me.Filter = "[ItemNumber] = 0 AND [Argument] =
                    'Default' "
                    Me.Caption = Nz(Me![ItemText], "")
                    FillOptions

            ' Exit the application.
            Case conCmdExitApplication
                    CloseCurrentDatabase

            ' Run a macro.
            Case conCmdRunMacro
                    DoCmd.RunMacro rs![Argument]

            ' Run code.
            Case conCmdRunCode
                    Application.Run rs![Argument]

            ' Open a Data Access Page
            Case conCmdOpenPage
                    DoCmd.OpenDataAccessPage rs![Argument]

            ' Any other command is unrecognized.
            Case Else
                    MsgBox "Unknown option."

        End Select

        ' Close the recordset and the database.
        rs.Close

HandleButtonClick_Exit:
        On Error Resume Next
```

```
        Set rs = Nothing
        Set con = Nothing
        Exit Function

HandleButtonClick_Err:
        ' If the action was cancelled by the user for
        ' some reason, don't display an error message.
        ' Instead, resume on the next line.
        If (Err = conErrDoCmdCancelled) Then
                Resume Next
        Else
                MsgBox "There was an error executing the command.",
                vbCritical
                Resume HandleButtonClick_Exit
        End If
End Function
```

Report_templateReport

```
Option Compare Database
Option Explicit

Private Sub Report_Close()
      DoCmd.SetWarnings True
End Sub


Private Sub Report_Open(Cancel As Integer)
      ' Dim rs As ADODB.Recordset
      ' Dim Field As ADODB.Field
      '
      ' Set rs = New ADODB.Recordset
      ' rs.CursorLocation = adUseClient
      ' rs.Open Me.RecordSource, CurrentProject.Connection,
      adOpenKeyset, adLockOptimistic
      '
      ' While Not rs.EOF
      ' MsgBox rs.Fields(0) + ", " + rs.Fields(1) + ", " + rs.Fields(2)
      + ", " + rs.Fields(3) + ", "
      + _
      ' rs.Fields(4) + ", " + rs.Fields(5) + ", " + rs.Fields(6) + ""
      ' rs.MoveNext
      ' Wend

      DoCmd.SetWarnings False
End Sub
```

MiscCode

```
Option Compare Database
Option Explicit

Public Function ExitAccess() As Boolean
      Application.Quit acQuitSaveNone
End Function
```

Appendix F: Feature Analysis Outline

Basic Features

- Main/Home page
    - o Introduction to site
    - o Introduction to invasive species

- External Links pages
    - o Links to databases
    - o Links to agencies
    - o Links to other organizations or programs
    - o Links to general invasive species sites

- Search
    - o Included on main page
    - o Separate search page

- About Us page
    - o Identify who runs the site
    - o Identify sources of data
    - o Contact Information

- Additional Information
    - o Background of agencies and organizations
    - o NISC background, Executive Order 13112

- Laws and Regulations page
    - o Descriptive information hosted internally
    - o Links to external legal sites

- Feedback page
    - o Survey page
    - o Comment form

- Help page
    - o FAQ page
    - o Email question form

Advanced Options

- Search engine
  - External
    - NISbase
    - Google
    - Other external search engine
    - Combination
    - None of the options above
  - Internal
    - Links to database search pages
    - New search engine to search all databases
    - Search the 'database of databases'
    - Search keywords from summaries of databases
    - Combination
    - None
  - Combination

- Advanced search options (for internal search engine)
  - Search customized by type of user
  - Search by database
  - Search by data type
  - Search by geographic location
  - Search by species type
  - Search by keyword
  - Combination
  - None

- Menu categorization
  - Type of user (General public, Researcher, Educator, Resource, Manager, Federal Agent or custom user settings)
  - Type of data (Species, Bibliographic information, Maps, Projects)
  - Geographic location (North Atlantic, Mid Atlantic, Gulf and South Atlantic, Great Lakes, Mid-West, Pacific, International)
  - Type of database (federal, education, non-profit organization, Private business, international, or case-by-case basis)
  - A combination of options above

- Amount of database information to store internally
  - Title and links only
  - Basic information (URL, title, brief description)
  - Basic information plus an index of entries
  - Case-by-case basis

- Amount of entry information to store internally
    - Copy data entries to internal site
    - Copy summaries information to internal site
    - Distributed database system
    - None, only link

- Databases to include in search/browse features
    - Federal
    - College
    - Non-Profit
    - Private
    - International government
    - International, non-government
    - Case-by-case basis

- Complexity of layout
    - Minimalist (e.g. Google)
    - Moderate
    - Maximum options on each page
    - Customizable (by user)

- Link navigation
    - Within same window
    - New window or tab
    - Frames
    - Combination

- Menu format
    - Static (plain text or static graphics)
    - Dynamic, rollover graphics or animated buttons
    - Dynamic, drop-down or sliding menus
    - Other

- Color scheme
    - Green, brighter
    - Red & orange
    - Other

- Site Map page format
    - Text-based
    - Graphic
    - None

Optional Features

- **Merged fact sheets:** the ability for pages to pull information together from separate sources into one location for the user

- **Species distribution maps:** maps displaying where particular invasive species have been found

- **Forecasting maps:** maps displaying trends and predictions in invasive species migration

- **Multimedia:** invasive species pictures (or videos or sound) to be included on the main site

- **Multi-lingual support:** translated pages for users who do not speak English

- **Identification by picture or characteristics page:** the user is presented with sets of species pictures, or lists of species characteristics, or a combination of the two, and clicks through each set to find the invasive species they are looking for

- **Identification by experts page:** questions or images submitted by users and species can be answered or identified by researchers

- **Early warning system:** predictions of how pollution, weather changes, etc. may affect an area

- **Children's section:** special page geared toward younger audiences

- **Directory database:** the categorized list of databases developed as part of this project

Appendix G: List of Contacts

Name	Agency/Organization/Company	Email
Primary Contacts		
Andreozzi, Phil	NISC	phillip_andreozzi@ios.doi.gov
Archer, Angela	IISG: Illinois-Indiana Sea Grant	amcbride@purdue.edu
Burrows, Mark	IJC: International Joint Commission	burrowsm@windsor.ijc.org
Carlson, Dorn	NOAA Sea Grant Office	dorn.carlson@noaa.gov
Dalton, Shawn	USGS	shawn_dalton@usgs.gov
Eason, Karen	NOAA National Ocean Service	karen.eason@noaa.gov
Einstein, Mark	IISG: Illinois-Indiana Sea Grant	meinstei@purdue.edu
Fuller, Pam	USGS FWS	pam_fuller@usgs.gov
Harmon, Michelle	NOAA National Ocean Service	michelle.harmon@noaa.gov
McCarthy, Susan	USDA National Agriculture Library	smccarth@nal.usda.gov
O'Neill, Chuck	New York Sea Grant	cro4@cornell.edu
Sturtevant, Rochelle	NOAA	rochelle.sturtevant@noaa.gov
Pearson, Melissa	NOAA Sea Grant Office	melissa.pearson@noaa.gov
Raikow, David	NOAA	david.raikow@noaa.gov
Ruiz, Greg	SERC	ruiz@serc.si.edu
Steves, Brian	SERC	stevesb@si.edu
Tontodonati, Marco	IJC: International Joint Commission	tontodonatim@windsor.ijc.org
Wilkinson, Dean	NOAA	dean_wilkinson@ios.usdoi.gov
Secondary Contacts		
Bartley, Devin	Food and Agriculture Organization of the UN	devin.bartley@fao.org
Graham, Jim	National Institute of Invasive Species Science	jim@nrel.colostate.edu
Jarnevich, Catherine	USGS, National Institute of Invasive Species Science	catherine_jarnevich@usgs.gov
Kolar, Cynthia	USGS	ckolar@usgs.gov
Leland, Marilyn	Prince William Sound Regional Citizens' Advisory Council	leland@pwsrcac.org
Lukens, Ron	GSMFC: Gulf State Marine Fisheries Commission	rlukens@gsmfc.org
Rassoulzadegan, Kaveh	CIESM: The Mediterranean Science Commission	kvr@ciesm.org
Slimak, Michael	EPA	slimak.michael@epamail.epa.gov
Suedmeyer, Beth	Massachusetts Office of Coastal Zone Management	beth.suedmeyer@state.ma.us
Thomas, Dan	Great Lakes Sport Fishing Council	dan@great-lakes.org

Glossary of Acronyms

AIRD — Aquatic Invasions Research Directory

AIS — Aquatic Invasive Species

ANSTF — Aquatic Nuisance Species Task Force

APIRS — Aquatic, Wetland and Invasive Plant Information Retrieval System

EPA — U.S. Environmental Protection Agency

FWS — U.S. Fish and Wildlife Service

FIGIS — Fisheries Global Information System

GLANSIS — Great Lakes Aquatic Non-indigenous Species Information System

GLERL — Great Lakes Environmental Research Laboratory

GLSLRI – Great Lakes St. Lawrence Research Inventory

IJC — International Joint Commission

IQP — Interactive Qualifying Project

NAL — National Agricultural Library

NAS — Non-indigenous Aquatic Species

NBIC — National Ballast Information Clearinghouse

NCCOS — National Centers for Coastal Ocean Science

NCRAIS — National Center for Research on Aquatic Invasive Species

NEMESIS — National Exotic Marine & Estuarine Species Information System

NESDIS — National Environmental Satellite, Data, and Information Service

NIASDWG — Non-Indigenous Aquatic Species Database Working Group

NIISS — National Institute for Invasive Species Science

NIMS — National Information Management System

NISC — National Invasive Species Council

NMFS — National Marine Fisheries Service

NOAA — National Oceanographic and Atmospheric Administration

NOS — National Ocean Service

NSGO — National Sea Grant Office

NWS — National Weather Service

OAR — Oceanic and Atmospheric Research

PI — Principal Investigator

PPI — Program Planning and Integration

SERC — Smithsonian Environmental Research Center

SGNIS — Sea Grant Non-indigenous Invasive Species

USDA — U.S. Department of Agriculture

USGS — U.S. Geological Survey

WPI — Worcester Polytechnic Institute

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