NOAA Technical Memorandum NOS ORCA 115

Environmental Sensitivity Index Guidelines
Version 2.0

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

National Ocean Service

Office of Ocean Resources Conservation and Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

The Office of Ocean Resources Conservation and Assessment (ORCA) provides decisionmakers comprehensive, scientific information on characteristics of the oceans, coastal areas, and estuaries of the United States of America. The information ranges from strategic, national assessments of coastal and estuarine environmental quality to real-time information for navigation or hazardous materials spill response. Through its National Status and Trends (NS&T) Program, ORCA uses uniform techniques to monitor toxic chemical contamination of bottom-feeding fish, mussels and oysters, and sediments at about 300 locations throughout the United States. A related NS&T Program of directed research examines the relationships between contaminant exposure and indicators of biological responses in fish and shellfish.

Through the Hazardous Materials Response and Assessment Division (HAZMAT) Scientific Support Coordination program, ORCA provides critical scientific support for planning and responding to spills of oil or hazardous materials into coastal environments. Technical guidance includes spill trajectory predictions, chemical hazard analyses, and assessments of the sensitivity of marine and estuarine environments to spills. To fulfill the responsibilities of the Secretary of Commerce as a trustee for living marine resources, HAZMAT's Coastal Resource Coordination program provides technical support to the U.S. Environmental Protection Agency during all phases of the remedial process to protect the environment and restore natural resources at hundreds of waste sites each year. As another part of its marine trusteeship responsibilities, ORCA conducts comprehensive assessments of damages to coastal and marine resources from discharges of oil and hazardous materials.

ORCA collects, synthesizes, and distributes information on the use of the coastal and oceanic resources of the United States to identify compatibilities and conflicts and to determine research needs and priorities. It conducts comprehensive, strategic assessments of multiple resource uses in coastal, estuarine, and oceanic areas for decisionmaking by NOAA, other Federal agencies, state agencies, Congress, industry, and public interest groups. It publishes a series of thematic data atlases on major regions of the U.S. Exclusive Economic Zone and on selected characteristics of major U.S. estuaries.

ORCA implements NOAA responsibilities under Title II of the Marine Protection, Research, and Sanctuaries Act of 1972; Section 6 of the National Ocean Pollution Planning Act of 1978; the Oil Pollution Act of 1990; the National Coastal Monitoring Act of 1992; and other Federal laws. It has four major line organizations: Coastal Monitoring and Bioeffects Assessment Division, Hazardous Materials Response and Assessment Division, Strategic Environmental Assessment Division, and the Damage Assessment Center.

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1 INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been an integral component of oil-spill contingency planning and response since 1979, when the first ESI maps were prepared days in advance of the arrival of the oil slicks from the Ixtoc 1 well blowout in the Gulf of Mexico. Since that time, ESI atlases have been prepared for most of the U.S. shoreline, including Alaska and the Great Lakes (Table 1). Nearly all of the maps of the lower 48 states have been compiled at a scale of 1:24,000, using U.S. Geological Survey (USGS) 7.5-minute quadrangles as the base map. There are a few exceptions where USGS maps were available at different scales or too outdated to be of use. For work in Alaska, 15-minute USGS topographic quadrangles at a scale of 1:63,360 have been used as base maps.

Before 1989, traditional sensitivity maps were produced as color-coded paper maps, with limited distribution (because of the cost of reproduction), and without a means for ready updating. However, since 1989, ESI atlases have been generated from digital databases using Geographic Information System (GIS) techniques. As the oil-spill response community moves towards development of automated sensitivity maps, it is important to define what comprises the ESI mapping system and how this information is being developed and distributed using GIS technology.

The primary objectives of this report are to: outline the basic elements of a sensitivity mapping system; guide the collection and synthesis of data for the system; and define the data structure for developing a digital ESI application using GIS technology. There are many aspects of a fully functional application that are still under development, such as pre-set queries and integration with other spill response systems (e.g., trajectories and equipment inventories), or are specific to the type of software being used (e.g., the user interface), which are not addressed at this time. However, we recommend standard output formats and symbology for maps to be shown on the screen or printed out in hard copy. Hard copy products are as important as developing the on-screen user interface. The printed map is still a major product for spill response applications.

Table 1. Environmental Sensitivity Index (ESI) atlases published for the U.S. (Bold names indicate atlases produced in digital format.)

Name	Year Published	No. of Maps
Alabama	1981/**1996**	20/**26**
Alaska (6 atlases)	1982-1986	371
Alaska (Southeast)	**1992**	**98**
California (Central)	**1994**	**41**
California (Northern)	**1994**	**39**
California (Southern)	1980/**1995**	52/**51**
California (San Francisco Bay)	1986	23
Columbia River, Washington/Oregon	**1991**	**26**
Connecticut	1984	17
Delaware/New Jersey/Pennsylvania	1985/**1996**	59/**64**
Florida (6 atlases/**5 atlases**)	1981-1984/**1995-1996***	246/**265**
Georgia	1985/**1997**	29/**38**
Guam	1994	15
Hawaii	1986	86
Lake Erie System	1985	66
Lake Huron (Michigan)	**1994**	**69**
Lake Michigan (Eastern Shore)	1986	23
Northern Lake Michigan	**1994**	**70**
Southern Lake Michigan	**1994**	**11**
Western Lake Michigan	**1993**	**54**
Lake Ontario (New York)	**1993**	**34**
Lake Superior (3 volumes)	**1993**	**133**
Louisiana	**1989**	**98**
Maine (Downeast)	1985	42
Maine (Mid-Coast)	1985	35
Maine (Southern/New Hampshire)	1983	25
Maryland	1983	118
Massachusetts	1980/**1997**	51/**51**
Mississippi	**1995**	**29**
New York (Harbor/Hudson River)	1985	37
New York (Long Island)	1985	41

* Produced and published by the State of Florida

Table 1. *Continued.*

Name	Year Published	No. of Maps
North Carolina (2 volumes/**3 volumes**)	1983/**1996**	113/**135**
Oregon/Washington (Outer Coast)	1986	55
Puerto Rico	1984	35
Rhode Island/Massachusetts	1983	18
St. Johns River	**1997**	**31**
St. Lawrence River	1985	17
St. Marys River	1986	15
South Carolina	1982/**1996**	50/**63**
Texas (Galveston Bay)	1979	19
Texas (South)	1980	15
Texas (Upper Coast)	**1995****	**51**
U.S. Virgin Islands	1986	8
Virginia (2 volumes)	1983	104
Washington (Strait of Juan de Fuca/ Northern Puget Sound	1984	36
Washington (Central/Southern Puget Sound)	1985	44

The Need for Standardized Definitions

The spill contingency planning requirements of the Oil Pollution Act of 1990 (OPA 90) and similar legislation passed by many states requires information on the location of sensitive resources to be used as the basis for establishing protection priorities. Digital databases being developed to support oil-spill planning and response functions are a subset of those needed for a wide range of natural resource management applications. Standardization of the basic elements for a spill application speeds the development of systems and facilitate their use by national response teams and organizations, such as the U.S. Coast Guard, industry response staff, and spill cooperatives. Data sharing and updates are greatly facilitated by a uniform data structure.

** Jointly produced and published with the State of Texas

Report Outline

This report is divided into four chapters, with the following content and intended users:

Chapter 2—The basic components of sensitivity mapping, data layers and how they are defined, for the resource manager developing sensitivity data.

Chapter 3—Detailed guidelines for biologists and resource managers on how to collect and compile the resource information on hard copy maps and data tables.

Chapter 4—Guidelines on how the data are digitized, stored, and delivered as a GIS product, for all users but especially for the GIS manager.

Chapter 5—Description of the map product, for all users.

2 THE ENVIRONMENTAL SENSITIVITY INDEX MAPPING SYSTEM

ESI maps are comprised of three general types of information:

1. Shoreline Classification–ranked according to a scale relating to sensitivity, natural persistence of oil, and ease of cleanup.

2. Biological Resources–including oil-sensitive animals, habitats, and rare plants, which are used by oil-sensitive species or are themselves sensitive to oil spills, such as submersed aquatic vegetation and coral reefs.

3. Human-Use Resources–specific areas that have added sensitivity and value because of their use, such as beaches, parks and marine sanctuaries, water intakes, and archaeological sites.

Each of these elements is discussed in the following sections.

Shoreline Classification

Shoreline habitats are at risk during spills because of the high likelihood of being directly oiled when floating slicks impact the shoreline. Oil fate and effects vary significantly by shoreline type, and many cleanup methods are shoreline-specific. The concept of mapping coastal environments and ranking them on a scale of relative sensitivity was originated in 1976 for Lower Cook Inlet (Michel et al. 1978). Since that time, the ranking system has been refined and expanded to cover shoreline types for most of North America, including the Great Lakes and riverine environments (NOAA 1995). The ranking system is most developed for sub-arctic, temperate, and tropical zones. Some unique Arctic zone shore types, such as peat scarps and eroding tundra scarps, are not included in the ranking scheme. However, they could be, based on field study and characterization. The standardized ESI shoreline rankings include estuarine, lacustrine, and riverine habitats (Table 2). To facilitate data use and exchange, these shoreline types and ranks should be used on all sensitivity mapping projects.

Each ranking scheme is based on an understanding of the physical and biological character of the shoreline environment, not just the substrate type and grain size. The sensitivity ranking is controlled by the following factors:

Table 2. ESI shoreline classification.

ESI NO.	ESTUARINE	LACUSTRINE	RIVERINE
1A	Exposed rocky shores	Exposed rocky shores	Exposed rocky banks
1B	Exposed, solid man-made structures	Exposed, solid man-made structures	Exposed, solid man-made structures
2A	Exposed wave-cut platforms in bedrock, mud, or clay	Shelving bedrock shores	Rocky shoals; bedrock ledges
2B	Exposed scarps and steep slopes in clay		
3A	Fine- to medium-grained sand beaches	Eroding scarps in unconsolidated sediments	Exposed, eroding banks in unconsolidated sediments
3B	Scarps and steep slopes in sand		
4	Coarse-grained sand beaches	Sand beaches	Sandy bars and gently sloping banks
5	Mixed sand and gravel beaches	Mixed sand and gravel beaches	Mixed sand and gravel bars and gently sloping banks
6A	Gravel beaches	Gravel beaches	Gravel bars and gently sloping banks
6B	Riprap	Riprap	Riprap
7	Exposed tidal flats	Exposed tidal flats	
8A	Sheltered rocky shores and sheltered scarps in bedrock, mud, or clay	Sheltered scarps in bedrock, mud, or clay	
8B	Sheltered, solid man-made structures	Sheltered, solid man-made structures	Sheltered, solid man-made structures
8C	Sheltered riprap	Sheltered riprap	Sheltered riprap
8D	Vegetated, steeply-sloping bluffs		Vegetated, steeply-sloping bluffs
9A	Sheltered tidal flats	Sheltered sand/mud flats	
9B	Vegetated low banks	Sheltered, vegetated low banks	Vegetated low banks
10A	Salt- and brackish-water marshes		
10B	Freshwater marshes	Freshwater marshes	Freshwater marshes
10C	Swamps	Swamps	Swamps
10D	Scrub-shrub wetlands	Scrub-shrub wetlands	Scrub-shrub wetlands

1. Relative exposure to wave and tidal energy
2. Shoreline slope
3. Substrate type (grain size, mobility, penetration, and trafficability)
4. Biological productivity and sensitivity

All of these factors are used to determine the relative ESI ranking for a shoreline segment. Key to the rankings is understanding the relationships among physical processes, substrate type, and associated biota that produce specific geomorphic/ ecologic shoreline types and predictable patterns in oil behavior, sediment transport patterns, and biological impact. Each of these factors is discussed in detail below.

Relative Degree of Exposure to Wave and Tidal Energy

Biologists have long recognized that the makeup of intertidal biological communities is closely correlated with relative degree of exposure. In *Between Pacific Tide*s, Rickets et al. (1968) classified the coastal habitats of the central California coast as *exposed* and *sheltered*, differentiating between settings subject to intense pounding by the large waves on that coast and those sheltered by offshore rocks, barrier beaches, and other protective features. Early geomorphology studies at the *Metula*, *Urquiola*, and *Amoco Cadiz* oil spills showed that the level of impacts of oil spills is closely related to the relative degree of exposure of the impacted habitat (Hayes and Gundlach 1975; Gundlach and Hayes 1978; Gundlach et al. 1978; Michel et al. 1978).

Two physical factors, wave-energy flux and tidal-energy flux, primarily determine the degree of exposure, also referred to as the *hydrodynamic energy level*, at the coastline. Wave-energy flux is basically a function of the average wave height, measured over at least one year. Where waves are typically large (e.g., heights more than one meter occur frequently), the impact of oil spills on the exposed habitats is reduced because 1) offshore-directed currents generated by waves reflecting off hard surfaces push the oil away from the shore; 2) wave-generated currents mix and rework coastal sediments, which are typically coarse-grained in these settings, rapidly removing stranded oil; and 3) organisms adapted to living in such a setting are accustomed to short-term perturbations in the environment.

Tidal-energy flux is also important in determining the potential of oil-spill impacts on coastal habitats, although not as pervasive as wave-energy flux. The potential for strong tidal currents to remove stranded oil and to build and move intertidal sand and/or gravel bars that bury oil are the most important considerations. The effect of the currents on biological communities can also be pronounced. For example, highly mobile substrates set in motion by strong tidal currents typically harbor considerably fewer infauna than stable substrates. As a generalization, tidal currents increase with increasing tidal range.

Within a mapping region, the degree of energy is relative to the overall energy levels in the region. A continuum of energy levels must be divided into broad classes. High-energy shorelines are regularly exposed to large waves or strong tidal currents during all seasons. They most commonly occur along the outer coast or where waves from the dominant winds can impinge on the shoreline by wave refraction or through breaks in the shoreline. Low-energy shorelines are sheltered from wave and tidal energy, except during unusual or infrequent events. In between, medium-energy shorelines often have seasonal patterns in storm frequency and wave size.

Inherent in these energy classes are inferences as to the persistence of stranded oil. *High energy* means rapid natural removal, usually days to weeks. *Low energy* means slow, natural removal, usually years. *Medium energy* means that stranded oil will be removed when the next high-energy event occurs, which could be days or months after the spill. It is an event-driven process. More difficult to characterize are those shorelines that do not have predictable, seasonal patterns in the frequency of storms that generate waves from a particular direction or size. Along these shorelines, high-energy events usually happen more than once each year. These shorelines typically have active storm berms with one to three years of vegetation growth. The macroalgae coverage on the larger boulders in the intertidal zone is higher than on those exposed to annual storms. These kinds of features are used to identify those shorelines which have the potential for longer than usual oil persistence, and efforts should be made to differentiate them, particularly for gravel beaches.

Shoreline Slope

Shoreline slope is a measure of the steepness of the intertidal zone between maximum high and low tides. It can be characterized as steep (greater than 30 degrees), moderate (between 30 and 5 degrees), or flat (less than 5 degrees).

The primary importance of shoreline slope in exposed settings is its effect on wave reflection and breaking. Steep intertidal areas are usually subject to abrupt wave run-up and breaking, and even reflection in places, which enhances natural cleanup of the shoreline. Flat intertidal areas, on the other hand, promote dissipation of wave energy further offshore, which allows for longer residence time of oil in the intertidal zone. Also, the broad intertidal areas typically have more extensive areal development of biological communities (e.g., mussel beds, clam beds, and plant communities). In sheltered habitats, slope is a less important distinguishing factor with regard to oil-spill impacts, except that sensitive biological communities have more area to develop where the slopes are flatter.

Substrate Type

Substrate types are classified as:

- *Bedrock*, which can be further divided into impermeable and permeable, depending upon the presence of surficial deposits on top of the bedrock.
- *Sediments*, which are divided by grain size as:
  - Mud, consisting of silt and clay, less than 0.06 millimeters (mm)
  - Fine- to medium-grained sand, ranging in size from 0.06-1 mm
  - Coarse-grained sand, ranging from 1-2 mm
  - Granule, ranging from 2-4 mm
  - Pebble, ranging from 4-64 mm
  - Cobble, ranging from 64-256 mm
  - Boulder, greater than 256 mm
- *Vegetation*, such as
  - Marsh grasses
  - Wetland trees/shrubs
  - Mangroves
  - Riparian trees/shrubs (vegetated banks)
- *Man-made materials,* such as:
  - Riprap, or broken rock of various sizes, usually cobble or larger, that are permeable to oil penetration
  - Seawalls which are composed of solid material, such as concrete or steel, which are impermeable to oil penetration

Certain characteristics of the substrate type affect the degree of oil impact on coastal habitats. The most important distinction is between bedrock and unconsolidated sediments. Sediments have the potential for penetration and burial of the oil and thus, the potential for prolonged exposure of important infaunal organisms that may be susceptible to oil-spill effects. Penetration and burial in sediments increases the persistence of oil, leads to potential long-term biological impacts, and makes cleanup much more difficult and intrusive. Penetration and burial are very different. Oil stranded on the surface can penetrate permeable sediments; the depth of penetration is controlled by the grain size of the substrate, as well as the sorting (range of grain sizes in the sediments). Deepest penetration is expected for coarse sediments (gravel) that are most uniform in grain size (well sorted). On gravel beaches, oil penetration up to one meter can occur under heavy oil accumulations. If the sediments are poorly sorted, such as on mixed sand and gravel beaches, penetration is usually less than 50 centimeters (cm). Sand beaches are also differentiated into grain-size categories (fine- to medium-grained versus coarse-grained) that differ by permeability and thus potential depths of penetration. Muddy sediments have the lowest permeability and also tend to be water-saturated, so oil penetration is very limited. However, where the substrate is burrowed by infauna, burrows can provide a mechanism for oil to penetrate an otherwise impermeable substrate.

Burial occurs when clean sediments are deposited on top of oil layers. The rate of burial can vary widely and can be as short as six hours (one-half of a tidal cycle) after the initial stranding. The most rapid burial usually occurs on coarse-grained sand beaches, because they have the highest mobility under normal wave and tidal conditions. During storms, oil in gravel beaches can be buried by the building of gravel berms or bars. Along shorelines with strong seasonal storm patterns, there can be annual erosion/deposition cycles in the beach profile and sediment distribution patterns. These shorelines have the greatest potential for burial, particularly if the oil is stranded at the beginning of the depositional period.

Substrate type also affects the trafficability. Fine-grained sand beaches are typically compacted and hard, and they are the most likely substrate type to be trafficable. Using equipment on muddy substrates is not possible because of their innate softness.

Vehicle use on gravel beaches tends to cause significant disruption. Equipment should not be used on vegetated shorelines, such as marshes.

Definitions of ESI Rankings

Rank of 1: Exposed, Impermeable Vertical Substrates

The essential elements are:

- Regular exposure to high wave energy or tidal currents.
- Strong wave-reflection patterns are common.
- Substrate is impermeable (usually bedrock) with no potential for subsurface penetration.
- Slope of the intertidal zone is 30 degrees or greater, which results in a narrow intertidal zone.
- By the nature of the high-energy setting, attached organisms are hardy and accustomed to high hydraulic impacts and pressures.

Shoreline types that meet these elements include:

1A = Exposed rocky shores (estuarine, lacustrine, and riverine)

1B = Exposed, solid, man-made structures (estuarine, lacustrine, and riverine)

These shoreline types are exposed to large waves, which tend to keep oil offshore by reflecting waves. The substrate is impermeable so oil remains on the surface where natural processes will quickly remove any oil that does strand within a few weeks. Also, any stranded oil tends to form a band along the high-tide line or splash zone, above the elevation of the greatest biological value. No cleanup is generally required or recommended.

Rank of 2: Exposed, Impermeable Substrates, Non-Vertical

The essential elements are:

- Regular exposure to high wave energy or tidal currents.
- Regular strong wave-reflection patterns.
- Slope of the intertidal zone is usually less than 30 degrees, which results in a wider intertidal zone, although it can be less than five degrees and the intertidal zone can be up to hundreds of meters wide.
- Substrate is impermeable with no potential for subsurface penetration over much of the intertidal zone, although there can be a thin, mobile veneer of sediment in patches on the surface.
- Sediments can accumulate at the base of bedrock cliffs, but are regularly mobilized by storm waves.

- By the nature of the setting, attached organisms are hardy and used to high hydraulic impacts and pressures.

Shoreline types that meet these elements include:

2A = Exposed wave-cut platforms in bedrock, mud, or clay (estuarine)

2A = Shelving bedrock shores (lacustrine)

2A = Rocky shoals; bedrock ledges along rivers (riverine)

2B = Exposed scarps and steep slopes in clay (estuarine)

As with ESI = 1, these shorelines are low in rank because they are exposed to high wave energy. However, they have a flatter intertidal zone, sometimes with small accumulations of sediment at the high-tide line, where oil could persist for up to several weeks to months. When the sediments have been formed into a beach on the rocky platform that has multiple berms built by waves, it is designated as a separate shoreline type on the maps. Along coastal plain areas, the equivalent shoreline type consists of scarps in relict marsh clay. Biological impacts can be immediate and severe, particularly if fresh oil slicks cover tidal pool communities on rocky platforms. However, the oil is usually removed quickly from the platform by wave action. Cleanup is not necessary except for removal of oiled debris and oil deposits at the high-tide line in areas of high recreational use or to protect a nearshore resource, such as marine birds.

Rank of 3: Semi-Permeable Substrate, Low Potential for Oil Penetration and Burial; infauna present but not usually abundant

The essential elements are:

- The substrate is semi-permeable (fine- to medium-grained sand), with oil penetration usually less than ten cm.
- Sediments are well-sorted and compacted (hard).
- On beaches, the slope is very low, less than five degrees.
- The rate of sediment mobility is low, so the potential for rapid burial is low.
- Surface sediments are subject to regular reworking by waves.
- There are relatively low densities of infauna.

Shoreline types that meet these elements include:

3A = Fine- to medium-grained sand beaches (estuarine)

3A = Eroding scarps in unconsolidated sediments (lacustrine)

3A = Exposed, eroding river banks in unconsolidated sediments (riverine)

3B = Scarps and steep slopes in sand (estuarine)

This shoreline rank includes exposed sand beaches on outer shores, sheltered sand beaches along bays and lagoons, and sandy scarps and banks along lake and river shores. Compact, fine-grained sand substrates inhibit oil penetration, minimizing the amount of oiled sediments for removal. Furthermore, fine-grained sand beaches generally accrete slowly between storms, reducing the potential for burial of oil by clean sand. On sheltered sand beaches, burial is seldom of concern because of the low wave energy. On exposed beaches, oil may be buried deeply if the oil stranded right after an erosional storm or at the beginning of a seasonal accretionary period. Cleanup on fine-grained sand beaches is simplified by the hard substrate, which can support vehicular and foot traffic. Infaunal densities vary significantly both spatially and temporally.

Rank of 4: Medium Permeability, Moderate Potential for Oil Penetration and Burial; infauna present but not usually abundant

The essential elements are:

- The substrate is permeable (coarse-grained sand), with oil penetration up to 25 cm possible.
- The slope is intermediate, between 5 and 15 degrees.
- Rate of sediment mobility is relatively high, with accumulation of up to 20 cm of sediments within a single tidal cycle possible; there is a potential for rapid burial and erosion of oil.
- Sediments are soft, with low trafficability.
- There are relatively low densities of infauna.

Shoreline types that meet these elements include:

4 = Coarse-grained sand beaches (estuarine)

4 = Sand beaches (lacustrine)

4 = Sandy bars and gently sloping banks (riverine)

Coarse-grained sand beaches are ranked separately and higher than fine- to medium-grained sand beaches because of the potential for higher oil penetration and burial, which can be as great as one meter. These beaches can undergo very rapid erosional

and depositional cycles, with the potential for rapid burial of oil, even after only one tidal cycle. Cleanup is more difficult, as equipment tends to grind oil into the substrate because of the loosely packed sediment. Also, cleanup techniques have to deal with multiple layers of oiled and clean sediments, increasing the amount of sediments to be handled and disposed of. These more mobile sediments usually have low infaunal populations, which also vary greatly over time and space.

In some areas, there is no clear distinction between beach types because they cannot be readily differentiated by grain size. Under these conditions, such as along the Great Lakes, all sand beaches are ranked as ESI = 4.

Rank of 5: Medium-to-High Permeability, High Potential for Oil Penetration and Burial; infauna present but not usually abundant

The essential elements are:

- Medium-to-high permeability of the substrate (mixed sand and gravel) allows oil penetration up to 50 cm.
- Spatial variations in the distribution of grain sizes are significant, with finer-grained sediments (sand to pebbles) at the high-tide line and coarser sediments (cobbles to boulders) in the storm berm and at the toe of the beach.
- The gravel component should comprise at least 20 percent of the sediments.
- The slope is intermediate, between eight and 15 degrees.
- Sediment mobility is very high only during storms, thus there is a potential for rapid burial and erosion of oil during storms.
- Sediments are soft, with low trafficability.
- Infauna and epifauna populations are very low, except at the lowest intertidal levels.

Shoreline types that meet these elements include:

5 = Mixed sand and gravel beaches (estuarine and lacustrine)

5 = Mixed sand and gravel bars and gently sloping banks (riverine)

The gravel-sized component can be composed of bedrock, shell fragments, or coral rubble. Because of higher permeabilities, oil tends to penetrate deeply into sand and gravel beaches, making it difficult to remove contaminated sediment without causing erosion and sediment disposal problems. These beaches may undergo seasonal variations in wave energy and sediment reworking, so natural removal of deeply

penetrated oil may only occur during storms that occur just once or twice per year. Biological use is low, because of high sediment mobility and rapid drying during low tide.

These types of beaches are noted by a wide range in relative degree of exposure. Sediment mobility can be inferred by the extent of attached fauna and macroalgae. Indicator species or assemblage coverages can be used to reflect the potential rate of sediment reworking. For example, in southeastern Alaska, the presence of greater than 20 percent attached algae, mussels, and barnacles indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota. Where there are significant differences in the degree of exposure of sand and gravel beaches, the more exposed or mobile beaches can be designated as 5A and the less exposed or stable beaches can be designated as 5B. Pocket beaches, in particular, can have microenvironments that are more protected from wave energy (called wave shadows) where natural removal may be much slower than the adjacent beach.

Rank of 6: High Permeability, High Potential for Oil Penetration and Burial

The essential elements are:

- The substrate is highly permeable (gravel-sized sediments), with penetration up to 100 cm.
- The slope is intermediate to steep, between ten and 20 degrees.
- Rapid burial and erosion of shallow oil can occur during storms.
- There is high annual variability in degree of exposure, and thus in the frequency of mobilization by waves.
- Penetration can extend to depths below those of annual reworking.
- Sediments have lowest trafficability of all beaches.
- Natural replenishment rate of sediments is the slowest of all beaches.
- Infauna and epifauna populations are very low, except at the lowest intertidal levels.

Shoreline types that meet these elements include:

6A = Gravel beaches (estuarine and lacustrine)

6A = Gravel bars and gently sloping banks (riverine)

6B = Riprap (estuarine, lacustrine, and riverine)

Gravel beaches are ranked the highest of all beaches primarily because of the potential for very deep oil penetration and slow natural removal rates of subsurface oil. The slow replenishment rate of gravel makes removal of oiled sediment highly undesirable, and so cleanup of heavily oiled gravel beaches is particularly difficult. For many gravel beaches, significant wave action (meaning waves large enough to rework the sediments to the depth of oil penetration) occurs only every few years, leading to long-term persistence of subsurface oil. Shell fragments can be the equivalent of gravel along Gulf of Mexico and South Atlantic beaches.

Fine-grained gravel beaches are composed primarily of pebbles and cobbles (from 4 to 256 cm), with boulders as a minor fraction. No sand is evident on the surface, and there is less than 20 percent sand in the subsurface. There can be zones of pure pebbles or cobbles, with the pebbles forming berms at the high-tide line and the cobbles and boulders dominating the lower beachface. Sediment mobility limits the amount of attached algae, barnacles, and mussels to low levels. The distinction can also be made on the basis of grain size and extent of rounding of the sediments on a shoreline. The gravel is rounded or well-rounded only on those beaches regularly mobilized during storms.

Large-grained gravel beaches have boulders dominating the lower intertidal zone. The amount of attached algae and epifauna is much higher, reflecting the stability of the large sediments. A boulder-and-cobble armoring of the surface of the middle to lower intertidal zone is common on these beaches. Armor may have a very important effect on oil persistence in gravel beaches. Oil beneath an armored surface would tend to remain longer than would subsurface oil on an unarmored beach with similar grain size and wave conditions because of the higher velocities required to mobilize the armor (NOAA 1993). Sub-rounded to sub-angular gravel is a very good indicator of these less mobile beaches.

Riprap is a man-made equivalent of this ESI rank, with added problems because it is usually placed at the high-tide line where the highest oil concentrations are found and the riprap boulders are sized so that they are not reworked by storm waves. Flushing can be effective for removing mobile oil, but large amounts of residue can remain after flushing, particularly for heavy oils. Sometimes, the only way to completely clean riprap is to remove and replace it.

Rank of 7: Exposed, Flat, Permeable Substrate; infauna usually abundant

The essential elements are:

- They are flat (less than three degrees) accumulations of sediment.
- The highly permeable substrate is dominated by sand, although there may be silt and gravel components.
- Sediments are water-saturated so oil penetration is very limited.
- Exposure to wave or tidal-current energy is evidenced by ripples in sand, scour marks around gravel, or presence of sand ridges or bars.
- Width can vary from a few meters to nearly one kilometer.
- Sediments are soft, with low trafficability.
- Infaunal densities are usually very high.

Shoreline types that meet these elements include:

7 = Exposed tidal flats (estuarine and lacustrine)

Exposed tidal flats commonly occur with other shoreline types, usually marsh vegetation, on the landward edge of the flat. Oil does not readily adhere to or penetrate the compact, water-saturated sediments of exposed sand flats. Instead, the oil is pushed across the surface and accumulates at the high-tide line. Even when large slicks spread over the tidal flat at low tide, the tidal currents pick up the oil and move it alongshore. However, oil can penetrate the tops of sand bars and burrows if they dry out at low tide. Because of the high biological use, impacts can be significant to benthic invertebrates exposed to the water-accommodated fraction or smothered. Cleanup is always difficult because of the potential for mixing the oil deeper into the sediment, especially with foot traffic.

Rank of 8: Sheltered Impermeable Substrate, Hard; epibiota usually abundant

The essential elements are:

- They are sheltered from wave energy or strong tidal currents.
- Substrate is hard, composed of bedrock, man-made materials, or stiff clay.
- The type of bedrock can be highly variable, from smooth, vertical bedrock, to rubble slopes, which vary in permeability to oil.

- Slope is generally steep (greater than 15 degrees), resulting in a narrow intertidal zone.
- There is usually a very high coverage of attached algae and organisms.

Shoreline types that meet these elements include:

8A = Sheltered rocky shores and sheltered scarps in bedrock, mud, or clay (estuarine)

8A = Sheltered scarps in bedrock, mud, or clay (lacustrine)

8B = Sheltered, solid man-made structures, such as bulkheads (estuarine, lacustrine, and riverine)

8C = Sheltered riprap (estuarine, lacustrine, and riverine)

8D = Vegetated, steeply-sloping bluffs (estuarine and riverine)

Oil tends to coat rough rock surfaces in sheltered settings, and oil persists long-term because of the low-energy setting. Where appropriate, mapping should differentiate between solid rock surfaces, which are impermeable to oil, and rocky rubble slopes, which tend to trap oil beneath a veneer of coarse boulders. Both types can have large amounts of attached organisms, supporting a rich and diverse community. Cleanup is often required because natural removal rates are slow. Yet cleanup is often difficult and intrusive. Sheltered seawalls and riprap are the man-made equivalents, with similar oil behavior and persistence patterns. Usually, more intrusive cleanup is necessary for aesthetic reasons. In riverine settings, terrestrial vegetation along the river bluff indicates low energy and thus slow natural removal rates.

Rank of 9: Sheltered, Flat, Semi-Permeable Substrate, Soft; infauna usually abundant

The essential elements are:

- They are sheltered from exposure to wave energy or strong tidal currents.
- The substrate is flat (less than three degrees) and dominated by mud.
- The sediments are water-saturated, so permeability is very low, except where animal burrows are present.
- Width can vary from a few meters to nearly one kilometer.
- Sediments are soft, with low trafficability.
- Infaunal densities are usually very high.

Shoreline types which meet these elements include:

9A = Sheltered tidal flats (estuarine)

9A = Sheltered sand/mud flats (lacustrine)

9B = Vegetated low banks (estuarine and riverine)

9B = Sheltered vegetated low banks (lacustrine)

The soft substrate and limited access makes sheltered tidal flats almost impossible to clean. Usually, any cleanup efforts result in mixing oil deeper into the sediments and prolonging recovery. Once oil reaches these habitats, natural removal rates are very slow. They can be important feeding areas for birds and rearing areas for fish, making them highly sensitive to oil-spill impacts. In areas without a significant tidal range, such as the Great Lakes, sheltered flats are created by less-frequent variations in water level. These flats are unique in that low-water conditions can persist for weeks to months, providing a mechanism for sediment contamination in areas that can be subsequently flooded. Low riverine banks are often muddy, soft, and vegetated, making them extremely difficult to clean. Natural removal rates could be very slow, and a function of flooding frequency.

Rank of 10: Vegetated Emergent Wetlands

The essential elements are:

- The substrate is flat and can vary from mud to sand, though high organic, muddy soils are most common.
- Various types of wetland vegetation, including herbaceous grasses and woody vegetation, cover the substrate. Floating aquatic vegetation (FAV) and submersed aquatic vegetation (SAV) are treated separately from the ESI classification, as biological resources under the habitat/rare plant coverage.
- The break between salt- and brackish-water marshes and freshwater marshes occurs at the inland extent of 0.5 ppt salinity under average yearly low-flow conditions (Cowardin et al. 1979).
- The difference between scrub-shrub wetlands (<6 m) and swamps (≥6 m) is plant height (Cowardin et al. 1979).

Shoreline types that meet these elements include:

10A = Salt- and brackish-water marshes (estuarine)

10B = Freshwater marshes (estuarine, lacustrine, and riverine)

10C = Swamps (estuarine, lacustrine, and riverine)

10D = Scrub-shrub wetlands (estuarine, lacustrine, and riverine)

Marshes, mangroves, and other vegetated wetlands are the most sensitive habitats because of their high biological use and value, difficulty of cleanup, and potential for

long-term impacts to many organisms. Many factors influence how oil affects wetlands: oil type, extent of vegetation contamination, degree of sediment contamination, exposure to natural removal processes, time of year of the spill, and species types.

Biological Resources

There are numerous animal species and habitats that are potentially at risk from oil spills. These biological resources are segmented into seven elements based on major taxonomic and functional groupings. Each element is further divided into groups of species or sub-elements with similar taxonomy, morphology, life-history, and/or behavior relative to oil spill vulnerability and sensitivity (Table 3). For example, there are eight sub-elements for birds, with raptors including those species of eagles, hawks, falcons, kites, and osprey, which nest or migrate close to major water bodies and feed on fish or aquatic birds.

The areas and sites where the many marine, coastal, or aquatic/wetland species are located are wide-ranging; they can be present over a very large area at any time. Maps or data indicating the entire distribution of a species, for example, can cover very large areas and thus not help responders in assessing resources at risk and setting protection priorities. However, biological resources are most at risk from oil spills when:

- Large numbers of individuals are concentrated in a relatively small area;
- Marine or aquatic species come ashore during special life stages or activities, such as nesting, birthing, resting, or molting;
- Early life stages or important reproductive activities occur in somewhat restricted areas;
- There are restricted areas of importance to specific life stages or migration patterns;
- Specific areas are known to be vital sources for seed or propagation;
- The species are threatened, endangered, or rare; or
- A significant percentage of the population is likely to be exposed to oil.

In short, the goal of mapping biological resources is to emphasize identifying locations and areas of the highest concentrations, the most sensitive life-history stages

Table 3. Biological resources included on sensitivity maps.

Data Element	Sub-Element	Areas/Sites to be Mapped
Marine Mammals	Dolphins	Concentration areas
	Manatees	Concentration areas, cold weather refugia
	Pinnipeds (Seals and Sea Lions)	Haulouts, concentrations areas
	Polar Bears	Concentration areas, denning concentratons
	Sea Otters	Concentration areas
	Whales	Migratory or other concentration areas
Terrestrial Mammals	Bears	Intertidal feeding or aquatic/wetland concentrations, hazard areas for spill responders
	Canines	Threatened/endangered or rare species
	Felines	Threatened, endangered, or rare species
	Small Mammals	Aquatic fur-bearer concentrations, other special areas
	Ungulates	Migratory concentrations, other concentrations, hazard areas for spill responders
Birds	Alcids	Rookeries; wintering concentration areas
	Diving Birds	Rookeries; forage/wintering areas; roosting concentrations
	Gulls and Terns	Nesting sites; other concentration areas
	Landfowl	Nesting sites, other concentrations
	Passerine Birds	Threatened, endangered, or rare occurrences, especially nesting
	Pelagic Birds	Rookeries, roosting, and other concentrations
	Raptors	Nesting sites; migratory/feeding concentrations
	Shorebirds	Nesting sites; migratory, wintering, roosting concentrations
	Wading Birds	Rookeries; feeding and roosting concentrations
	Waterfowl	Wintering and migration concentrations, nesting sites
Reptiles and Amphibians	Alligators/Crocodiles	Concentration areas, especially nesting
	Lizards, Snakes, Amphibians, and Other Reptiles	Threatened, endangered, or rare occurrences, especially aquatic/ wetland concentrations
	Turtles	Nesting beaches; concentration areas
Fish	Diadromous Fish	Spawning runs, nursery areas, threatened, endangered, or rare occurrences
	Estuarine Nursery Fish	Spawning, nursery, and other concentration areas

Table 3. *Continued.*

Data Element	Sub-Element	Areas/Sites to be Mapped
Fish	Estuarine Resident Fish	Spawning or other concentration areas; threatened, endangered, or rare occurrences
	Freshwater Fish	Spawning and nursery areas; threatened, endangered, or rare occurrences
	Marine Benthic Fish	Spawning and nursery areas; reef, kelp bed, or other concentrations
	Marine Pelagic Fish	Spawning or other concentration areas
Invertebrates	Bivalves	Harvest areas; abundant beds; threatened, endangered, or rare occurrences
	Cephalopods	Harvest areas; high concentrations
	Crabs	Nursery areas; high concentrations
	Echinoderms	Harvest areas
	Gastropods	Harvest areas; high concentrations, threatened, endangered, or rare occurrences
	Insects	Threatened, endangered, or rare occurrences
	Lobsters and Crayfish	Nursery spawning and harvest areas; threatened, endangered, or rare occurrences
	Shrimp	Nursery areas; high concentrations
Habitats and Plants	Algae	Algal beds of flats, important species
	Coral Reefs	Living, reef-building coral areas
	FAV	Floating aquatic vegetation
	Hardbottom Reefs	Other hard substrates which provide structural habitats or cover
	Kelp	Beds or forests of kelp
	SAV	Submersed aquatic vegetation; seagrass beds
	Upland Plants	Special upland (terrestrial) plants, habitats, or communities
	Wetlands	Special wetland plants, habitats, or communities
	Worm Beds	Intertidal or subtidal beds of structure-building worm species

or activities, and the most vulnerable and sensitive species. The vulnerability and sensitivity to oil spills and disturbance-related response activities, the conservation status (threatened, endangered, or rare), and the commercial/recreational importance of species and habitats are all considered (Table 3). In general, coastal, marine, aquatic, wetland, and riparian species and habitats are emphasized. In some cases, the sensitivity

of a habitat type may be low, but the sensitivity of species that use or rely on the habitat may be high.

In addition to the geographic or spatial data depicted for biological resources, important attribute data are also included. Attribute data include: species names (common and scientific); the legal status of each species (state and/or Federal threatened or endangered listings); concentration; seasonal presence and/or abundance by month; and special life-history time-periods. In addition to federal and state legal status, the global conservation status ranks for certain species, as defined by The Nature Conservancy and the Natural Heritage Programs, are included in atlases published from 1997 on.

The concentration of a species in a given location may include qualitatively or quantitatively defined descriptions of species abundance (usually High, Medium, or Low), or numbers indicating the number of individuals, nesting or breeding pairs, or nests which occur at a site or within a polygon. The data collection tables, atlas introductory pages, and metadata identify the types of numbers included in the concentration field. Other descriptions of concentration may include "Very High" for exceptionally large concentrations, or "Dense," "Sparse," and "Patchy," which are often used to describe submersed aquatic vegetation cover. When concentration is not known, or abundance is listed monthly in the seasonality columns, the concentration field is left blank.

The monthly seasonality data contain "Xs" or abundance values in months when the species are present in the site or polygon location. The "Xs" indicate presence, while the numbers correspond to abundance categories. Monthly abundance is typically used for fish and invertebrates data based on NOAA's Estuarine Living Marine Resources (ELMR) databases. The numbers listed for each month in which the species is present correspond to: 1 = no information; 2 = rare; 3 = common; 4 = abundant; and 5 = highly abundant. In cases where ELMR fisheries data are used, the months in which high salinity (low rainfall, stream flow, or runoff), transitional, and low-salinity time-periods occur are indicated directly under the listing of the fish and invertebrates seasonalities, as: H = high, T = transitional, and L = low.

Associated with each species location and monthly presence are the time-periods when various life-history stages or activities occur. The life-history time periods are different for each biological element. The life-history time periods listed are those that have resulted in the concentration of the species at the particular location (e.g., a nesting colony, spawning site, or nursery area has been mapped) and often are related

to sensitive time-periods associated with reproductive activities or early life-history stages.

Finally, the databases include source documentation at the feature/species level. That is, for every species associated with each feature (a site or location indicated by a point, line, polygon, etc.) there can be a unique source or sources. Two source fields are used for biological resources, a geographic and a seasonality source. Typically, one source will provide the geographic location, species name or list, concentration, and type of resource occurrence (nesting site, migratory stop-over), while another source will be used to determine seasonality and life-history information. The same source may provide all of the information and would be listed as both the geographic and seasonality source.

Human-Use Resources

Human-use resources can be divided into four major components (Table 4):

- High-use recreational and shoreline access locations;
- Management areas;
- Resource extraction locations; and
- Archaeological and historical cultural resource locations.

Each of these components is discussed below.

Recreational Areas/Access Locations

Recreational areas shown on sensitivity maps include high-use recreational beaches, sport-fishing, and diving areas. Boat ramps and marinas are shown, both as recreational sites and access points for response activities.

Management Areas

Officially designated management areas include national parks, state and regional parks, Indian reservations, marine sanctuaries, national wildlife refuges, and preserves and reserves set aside by various agencies and organizations. Other ecological sites that

Table 4. Human-use resources included on sensitivity maps.

Data Element	Sub-Element	Comments
Recreation Areas/ Access Locations	Access	Vehicular access to the shoreline
	Beaches	High-use beaches
	Boat Ramps	
	Diving Sites	High-use areas
	Marinas	
Management Areas	Indian Reservations	
	Marine Sanctuaries	
	National Parks	
	Parks	State and regional parks
	Special Management Areas	Usually water-associated
	Wildlife Refuges, Preserves, Reserves	
Resource Extraction Sites	Aquaculture Sites	Hatcheries, ponds, pens, etc.
	Commercial Fisheries	
	Log Storage Areas	
	Mining	Intertidal/subtidal mining leases
	Subsistence	Designated harvest sites
	Recreational Fishing	High-use areas
	Water Intakes	Industrial; drinking water; cooling water, aquaculture
Cultural Resources	Archaeological Sites	Water-, coastal-, or wetland-associated
	Historical Sites	Water-, coastal-, or wetland-associated

have special resource management status can be included as "Special Management Areas."

Resource Extraction Sites

Resource extraction locations include aquaculture, commercial and subsistence fisheries, log-storage areas, mining-lease sites, and water intakes. We include log-storage sites and intertidal/subtidal mining leases so that appropriate protection and cleanup strategies can be developed. Each has a unique problem or issue that can significantly complicate oil removal strategies. Log-storage sites can contain large numbers of valuable wood products that, when oiled, must be cleaned at great expense before sale. Owners of intertidal mining leases must be contacted before removal of oiled sediment. For aquaculture, water intakes, and other economic resources, an owner and emergency contact name and telephone number is also listed.

High-value commercial fishing areas are also a critical component to ESI mapping, particularly leased shellfish beds and nearshore, shallow-water fisheries such as crabbing, shrimp harvest, lobster harvest, and estuarine fisheries. Often, the concern is to minimize impacts to the catch and fishing equipment as gear is pulled from the water through surface slicks. Non-commercial seafood harvest areas, including subsistence use areas, identify sites where monitoring of seafood quality may be needed to protect local populations in the event of a spill.

Cultural Resources

Cultural resources include archaeological and historical sites, as well as other sites which may be important to Native Americans. The most sensitive types of cultural resources are sites that are actually located in the intertidal zone, such as parts of Alaska where subsidence exposes important archaeological sites to coastal erosion. Also, sites located very close to the shoreline where they may be crossed by response or cleanup crews are included. If there are multiple sites in close proximity, then the general area should be indicated. However, many archaeological, historical, and cultural sites are location-sensitive, so the exact location of the site often cannot be disclosed. In such cases, the actual location is used to generate a symbol on the ESI map that is then moved to a cartographically pleasing location within one-half mile of the actual site. It is important to note that users of ESI products must go the original source to obtain location-sensitive digital data.

3 COMPILING BIOLOGY AND HUMAN-USE RESOURCE INFORMATION

Introduction

Developing an ESI atlas involves gathering digital and non-digital data, meeting with resource experts, compiling information onto maps, digitizing the data into a Geographic Information System (GIS), reviewing the data, making ESI maps, and producing GIS data. Before compiling information, a complete inventory of all digital and non-digital sources must be performed to assess data availability. All digital data sources should be gathered, integrated into the GIS, and assessed for ESI validity before performing hard-copy data collection. Chapter 4 describes digitizing the ESI data, including using existing digital databases. This chapter describes the methodology for compiling biological and human-use (socio-economic) resources onto maps and data tables for data entry. These guidelines are for biologists or resources managers who compile and edit ESI data.

The general sequence of data compilation entails making contacts with scientists and resource managers who can provide expert knowledge and suggest relevant source materials; reviewing existing hard-copy data sources; meeting with individuals or groups of experts to delineate the locations of resources for which hard-copy or digital data are not available; drawing resource distributions onto the compilation maps based on hard-copy data and expert opinion; and recording non-spatial or attribute data, and associating it with the resource locations delineated on the maps.

General Guidelines

Review hard-copy data sources first. Next, meet with scientists and resource managers who are providing expert opinions on resource locations. During or after this meeting, compile biological and human-use resource distributions by hand onto USGS 7.5-minute topographic maps or NOAA nautical charts for areas without topographical map coverage. Points, lines, and polygons are drawn on the compilation maps to represent the locations of biological and human-use resources. Use a pencil to draw on the maps, as changes and edits are often necessary. When drawing polygons,

lines already present on the topographic maps can be used as part of the polygon. For example, a polygon for a species restricted to the water can include the shoreline as the landward extent of the polygon. Following this convention reduces clutter and ambiguity, especially along the shoreline. Roads, contour lines, and bathymetry lines can also be used in this manner.

Biological polygons and human-use features (points, lines, and polygons) are uniquely numbered on the topographic maps and in corresponding data tables for easy identification and editing. The numbering system, listed as the wildhab# (biology) or socval# (human-use) in corresponding data tables, includes the topographic map number, a dash, and the feature number. For example, wildhab# = 001-01 is map number one, polygon number one. Human-use features are preceded with a "H" (e.g., 001-H01). Biology and human-use resources are treated separately. For example, biological polygons might consist of 1 to 25 on map #001 (001-01 to 001-25), while human-use features might consist of H01 to H011 (001-H01 to 001-H11). During the initial compilation and editing, each polygon or feature usually receives a separate site number. However, if a set of polygons or points on one map contains the same species, concentrations, seasonalities, and source, all the polygons can be given the same wildhab#. The same convention applies to human-use data. In the digital data, the biological and human-use data are all numeric.

When polygons or lines extend to the edge of a map, they must be edge-matched with the corresponding polygons or lines on adjacent maps. The biological or human-use attributes of the polygons or lines must also be edge-matched, so that the resources listed for the polygons correspond (including species, concentrations, seasonality, and life-history information, and source). As an example, if polygon #05 (sawfish and sailfish) extends to the right-hand edge of map #001 but does not end there, and the left-hand edge of map #002 is continuous with the right-hand edge of map #001, there must be a corresponding polygon containing sawfish and sailfish on map #002. During compilation, polygon and line edges do not have to match exactly, but they should be close. Where edge-matching is intended, a note should be written in the map margin indicating which polygon or feature should be edge-matched on adjacent maps. Continuing with the above example, "edge-match 001-05 to 002-01" should be written in the margin of map #001 near the unclosed edges of the polygon #05. On map #002, "edge-match 002-01 to 001-05" should be written in the margin near the unclosed edges of polygon #01. This convention greatly improves data quality and

communication between the data compiler and the GIS technicians. When a polygon extends to the edge of a map, but not beyond, the polygon should be closed to indicate that it does not continue onto the next map.

Biological Resources

The biological resources to be mapped are arranged hierarchically into elements, sub-elements, and species (see Table 3; Chapter 2). During the biology compilation and editing, colors are used to distinguish among elements:

marine mammals	—	yellow
terrestrial mammals	—	yellow
birds	—	green
reptiles/amphibians	—	red
fish	—	blue
invertebrates	—	orange
habitats	—	purple

These colors resemble the final map product. To efficiently digitize the biological data, each wildhab# is underlined with the appropriate color. This allows the digitizing technician to separate information into the proper element or data layer.

Generalized rules can be followed for placing biological information related to each element or sub-element on the maps, unless otherwise specified by resource specialists or other data sources (Table 5). For offshore and onshore restrictions, approximate distances when hand-drawing polygons. While digitizing the information, the features are automatically entered using the specified distances.

Overlapping Distributions of Biological Polygons

In most instances, several species will display similar or partially overlapping distributions. If different polygons were displayed for each species, ESI maps would become much too busy, and many features would become wholly or partially obscured. For this reason, individual polygons can contain any number of species, even if they are

Table 5. *General guidelines for mapping biological resources.*

ELEMENT	SUB-ELEMENT	DESCRIPTION
Marine Mammals	Dolphins and Whales	Restricted to water. There are no restrictions to offshore or inshore extent, although in many cases, whales do not occur very far into estuarine waters.
	Manatees	Restricted to water. Manatees are generally shown in estuarine waters and are often associated with cold-weather refuge areas such as springs, river mouths, and power plant cooling water outfalls. They may also concentrate in inlet mouths.
	Pinnipeds (Seals and Sea Lions)	Can be displayed on water and land. There are no restrictions to offshore extent. On land, seal and sea lion haulouts may be shown as polygons occurring on beaches and across small islands.
	Polar Bears	Can be displayed on land or water. They are often associated with pack ice, but do not occur far inland. They are described as marine mammals because they are classified as such in the Marine Mammal Protection Act.
	Sea Otters	May be restricted to waters within 30 m depth. They may also be associated with kelp beds and invertebrate concentration areas.
Terrestrial Mammals	Bears	In Alaska, they are shown along streams with salmon runs or where they present a hazard to spill responders. Threatened and endangered species and other special aquatic or wetland concentrations may be shown also.
	Small Mammals	Can be shown throughout wetlands and streams, and are generally shown at the shorelines of sheltered waters such as estuaries and bays. They are generally restricted to 75 m offshore.
	Other Mammals (Canines, Felines, and Ungulates)	Mostly threatened, endangered, or other important species are mapped on a case-by-case basis.
Birds	Alcids	Occur in offshore waters and on islands or cliffs where they nest. There is no restriction on their offshore extent.
	Diving Birds	Typically restricted to 1,500 m offshore and 75 m onshore along open coasts. Diving birds can also extend across small islands and sheltered waters.
	Gulls and Terns	Usually restricted to 500 m offshore and 250 m onshore along open coasts. Gulls and terns can occur along any shoreline type. Gulls and terns can also be shown throughout sheltered waters (bays, estuaries, etc.).

Table 5. *Continued.*

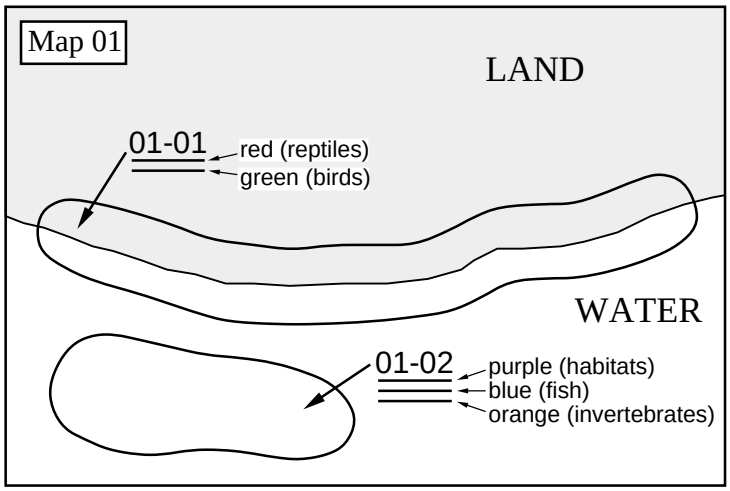
ELEMENT	SUB-ELEMENT	DESCRIPTION
	Landfowl	Usually occur on land, but may occur in or around some wetland areas.
	Passerine Birds	Endangered, threatened, or rare, passerines who rely on coastal or wetland habitats are included when appropriate, especially if they nest in the area.
	Pelagic Birds	Occur in offshore waters and on islands or cliffs where they nest. There is no restriction on their offshore extent.
	Raptors	Can be mapped along coastal shorelines, in wetlands, and across sheltered waters and islands.
	Shorebirds	Typically restricted to 75 m on either side (offshore and onshore) of the shoreline along open coasts. Shorebirds are often associated with sand beaches, gravel beaches, tidal flats, and wetland habitats. In the case of tidal flats and wetlands, shorebirds could extend across the entire area.
	Wading Birds	Usually restricted to wetlands, tidal flats, small tidal creeks, and the margins of sheltered waters (bays, estuaries, lagoons, sloughs). If water depths in sheltered areas are shallow then wading birds can be shown throughout the water body.
	Waterfowl	Usually restricted to 1,500 m offshore and 75 m onshore along open coasts. Waterfowl are also commonly shown extending throughout wetlands, tidal flats, and sheltered waters (bays, estuaries, lagoons, sloughs). Waterfowl can also be shown in isolated fresh or backwater areas. Duck species are often classified into four distinct groups: diving ducks, dabbling ducks, sea ducks, and mergansers. Dabbling ducks generally do not occur offshore. Sea ducks generally do not occur in inland waters or wetlands. In contrast, diving ducks and mergansers can occur across the habitat spectrum considered during ESI mapping.
Reptiles and Amphibians	Alligators and Crocodiles	Often restricted to sheltered waters (estuaries, bays, etc.), streams, wetlands, and nesting along sand or vegetated shorelines.
	Turtles	Sea turtle nesting areas are usually restricted to 75 m offshore and 75 m onshore, and generally occur along sand beaches. Important foraging or nursery areas can be shown where specifically indicated by resource experts.
	Lizards, Snakes, Amphibians, and Other Reptiles	In some cases, other threatened, endangered, or rare species may be included, such as salt marsh snakes.

Table 5. *Continued.*

ELEMENT	SUB-ELEMENT	DESCRIPTION
Fish		Almost always restricted to water. General distributions are usually defined by bathymetric contours, distance from the shreline, habitat type (such as reefs), or salinity zone.
Invertebrates	Bivalves, Cephalopods, Crabs, Crayfish, Echinoderms, Gastropods, Lobsters, and Shrimp	Almost always restricted to water and tidal flats. General distributions are usually defined by bathymetric contours or distance from the shore. There may also be special concentration areas defined by habitat type or fishing concentrations.
	Insects	Typically only depicted if they are threatened, endangered, or rare and associated with coastal, wetland, or aquatic habitats.
Habitats and Plants	Algae, Coral Reefs, FAV, Hard-bottom reefs, kelp, SAV, Worm Beds	Generally restricted to water and tidal flats.
	Upland Plants	Upland (terrestrial) plants, habitats, or communities.
	Wetlands	Wetland plants, habitats, or communities.

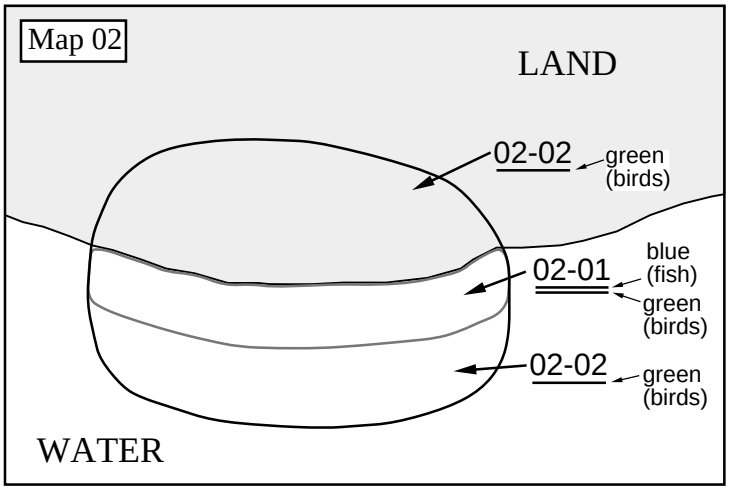
different sub-elements or elements. Where groups of species have the same or very similar distributions, a single polygon can represent all the species (Figure 1). This multi-resource polygon would be identified by a single wildhab# on the topographic map and in the data tables. The color code for each element would be indicated with colored pencils near the site number on the topographic map.

In cases where single or multiple species distributions overlap, but are not similar, overlapping portions of the distributions can also be listed as multi-resource polygons (Figure 2). As an example, suppose the distribution of a species of fish extended from the 3-m depth contour to the shoreline. The distribution of a group of diving birds overlaps the fish distribution, extending offshore to the 20-m depth contour and onshore to Beach Road. Both the diving birds and the fish extend along the same length of shoreline. In this case, three polygons could be drawn during the biology data compilation. One polygon would be assigned to the group of diving birds, extending from Beach Road (onshore) to the shoreline. Another polygon would be assigned to



Polygon 01-01 = sea turtles and diving birds
Polygon 01-02 = seagrass, fish, and invertebrates

Figure 1. *Biological polygons with multiple elements.*



Polygon 02-01 = fish and diving birds
Polygon 02-02 = diving birds

Figure 2. *Overlapping biological polygons.*

the fish and birds, extending from the shoreline to the 3-m depth contour. The third polygon would be assigned to the birds, from the 3-m depth contour to the 20-m contour. Here, the polygons containing only the birds would have one number with the polygons containing birds and fish having another. The species in both sets of polygons would be listed separately in the data tables. The multi-polygon convention

for overlapping polygons is used more often when three or more resource types (elements) overlap.

Digitizing Directions

During the biology data compilation, short digitizing directions can be written on the maps (instead of polygons) when a species or group of species covers large areas, specific habitat types, or major geographical features. During the GIS phases of ESI production, these directions on the compilation maps are converted to polygons that completely fill the areas or habitats specified by the data compiler.

To indicate digitizing directions, a small box is drawn on the map within the area or major geographic feature identified, and a wildhab# is assigned to the box as if it were a polygon. The specific directions are then written inside the box. For example, several species of waterfowl, fish, and invertebrates may occur throughout Fish Bay. A box would be drawn within the bay and "All Fish Bay Waters" would be written in the box along with the wildhab#, for instance "001-34," and the color code for each biological element. During digitizing of the biology, a multi-resource polygon would be created that included all of Fish Bay. In cases where drawn polygons become confusing, written digitizing directions could also be included, and should be located directly under the wildhab#.

Tabular Data Guidelines for Biological Data

As the biological features (polygons, lines, and points) are drawn on the maps, attribute data (species, concentration, seasonality, and source information) are recorded in associated data forms. Attribute data are collected and recorded at the feature (i.e., for each biological polygon, line, or point) and species levels. These forms, combined with the maps, allow for complete and accurate data compilation, entry, and processing.

The Biological Resources form (Table 6) identifies the various species associated with the biology polygons on the ESI maps and their individual concentrations. The form also includes fields or columns for seasonality and source numbers which link to other tables (Table 7).

Table 6. Biological resources form.

Site #[1] (Map#-Poly#)	Species Name[2]	Concentration[3] (High, Medium, Low, #)	Season ID#[4]	Geog Source[5]	Seasonality[6] Source
001-01	Brown pelican	High	1	1	3
001-02	Brown pelican	High	2	1	3
001-02	Loggerhead turtle	Med	1	2	2

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1 = unique id indicating the location of the biological resource
2 = species common name
3 = descriptive concentration or # individuals per polygon
4 = number code to differentiate polygons in which the same species has different seasonal distributions
5 = unique id identifying the source that provided locational information
6 = unique id identifying the source that provided seasonality information

The Seasonality/Life-history forms (Table 8) list seasonal presence information and special life-history stage or activity time periods for each species (Table 9). Separate forms are completed for each biological element included in the ESI atlas. The life-history categories are listed in Table 10.

Table 7. *Column descriptions of the Biological Resources form.*

COLUMN	DESCRIPTION
Site# (Map#-Poly #)	Identifies each polygon by map number and polygon number. The map number is entered in the bottom right corner of the map. Multiple polygons with the same combination of species, concentration, seasonality, and source can be assigned the same wildhab#.
Species Name	Refers to the common name of a species found within a polygon. When a polygon contains an assemblage of species, each species associated with the wildhab# should be listed separately. Species name, combined with Season ID#, is linked to the Seasonality/Life-history data tables. Species name is also linked to the Atlas Species List.
Concentration	Refers to the concentration of a species within a polygon. Concentration can be given as "high," "medium," or "low," or as the number of individuals or nests within the polygon. The definition or range of values represented by each descriptive category or numerical value must be described in the introductory pages of the atlas and in the metadata report. If numerical concentrations are used, it should be indicated whether these numbers represent individuals, nests, breeding pairs, etc. for each element or sub-element. If abundance categories are listed by month in the seasonality tables (e.g., for ELMR data), the concentration field is blank (Table 8).
Season ID#	Refers to a code number (e.g., 1, 2, 3, etc.) representing the seasonal distribution of a species within a polygon or group of polygons. The code number, combined with species name, is linked to the seasonal information given in the Seasonality/Life-history data tables. When the same species is present in different seasons, different season ID#s are used. For instance, least terns may be present in several different polygons at two different times of the year. They may be listed for wildhab# 01-05 (and other maps and polygons) as being present in spring only, while least terns listed for wildhab# 01-12 are present year-round. In this case, the first group of listings for least terns would have Season ID# "1", and the second listing would have Season ID# "2." This convention is followed throughout the set of maps and data tables.
Geographic Source	Corresponds to the source of the locational and concentration information on a species included in a polygon, line, or point feature.
Seasonality Source	Corresponds to the source of the seasonality information on a species included in a polygon, line, or point feature. The seasonality source may be the same as the geographic source.

Table 8. Seasonality/life-history data form.

element = **BIRD**

SEASON[1] ID#	SPECIES NAME[2]	Seasonal Presence[3]												Life-history Stage and Reproductive Timespans			
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NESTING[4]	LAYING[5]	HATCHING[6]	FLEDGING[7]
1	Brown pelican	X	X	X	X	X	X	X	X	X	X	X	X	–	–	–	–
2	Brown pelican	–	–	–	–	–	X	X	X	X	–	–	–	JUN-SEP	JUN-JUL	JUL-AUG	AUG-SEP

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1 = number code which differentiates polygons in which the same species has different seasonal distributions (see Table 1)
2 = species common name
3 = check the months in which the species/season ID# combination is present
4 = the entire timespan in which eggs/young are present (includes laying, hatching, and fledging)
5 = time period when eggs are being laid and incubated
6 = time period when young are hatching
7 = time period when young are being reared (until they leave the nest)

Table 9. Column descriptions of the Seasonality/Life-history form.

COLUMN	DESCRIPTION
Season ID#	Refers to a code number (e.g., 1, 2, 3) representing the seasonal distribution of a species within a polygon or group of polygons. The code number, combined with species name, is linked to the seasonal information given in the Seasonality/Life-history Data forms. When the same species is present in different seasons, different season ID#s are used. For instance, least terns may be present in several different polygons at two different times of the year. They may be listed for wildhab# 01-05 (and other maps and polygons) as being present in spring only, while least terns listed for wildhab# 01-12 are present year round. In this case, the first group of listings for least terns would have season ID# "1," and the second listing would have Season ID# "2." This convention is followed throughout the set of maps and data tables.
Species Name	Refers to the common name of a species found within a polygon.
Seasonal Presence	Indicated by checking off the months (JAN, FEB, MAR, etc.) when a species is present. If relative abundances are known for the monthly presence, the following number codes may be used: 1 = No Information 2 = Rare 3 = Common 4 = Abundant 5 = Highly Abundant To date, monthly abundance categories have only been used for ELMR fisheries data. If such categories are used, they should be clearly defined for each element or sub-element in the atlas introductory text and metadata reports.
Life-history Stage and Reproductive Timespans	Indicated for certain special or sensitive life-history stages or activities. Sensitive life-history stages and activities differ by element and sub-element. Life-history time-periods are listed as a range in months (e.g., APR-JUL). Five fields are available for listing sensitive time periods.

Table 10. Life-history time periods for each biological element.

COLUMN	DESCRIPTION
Marine Mammals	The special life-history time periods are calving, pupping, and molting. Calving (dolphins, whales, and manatees) and pupping (seals, sea lions, and sea otters) refer to times when females give birth to young. Molting refers to the time when seals and sea lions haul out to shed fur and skin.
Terrestrial Mammals	Special life-history categories are not typically listed for terrestrial mammals and habitats/rare plants. In certain instances (e.g., coral spawning periods), they could be indicated, but must be defined in the atlas introductory text and metadata report.
Birds	The life-history time periods are nesting, laying, hatching, and fledging. Nesting refers to the entire period when birds are laying eggs, hatching eggs, and fledging young. Laying, hatching, and fledging are subsets of nesting.
Reptiles	The life-history time periods are nesting, hatching, and internesting. Nesting refers to the deposition of eggs by turtles and the time period when turtle eggs are present. Nesting also refers to the laying and tending of eggs and nests by crocodilians. Hatching refers to the time period when young are hatching and emerging from the nests. Internesting is a special category for sea turtles, defined as the time before and during nesting when adult males and females are highly concentrated in nearshore waters. Mating often takes place during this time.
Fish	The special life-history time periods are spawning, outmigration, larvae, juvenile, and adult. Spawning includes the actual spawning act and any spawning-related migration or concentration periods, especially those associated with diadromous or estuarine fishes. Outmigration refers to the time period when late juveniles or young adults are leaving spawning streams (anadromous fishes) or estuarine areas (estuarine nursery fishes). Larvae refers to the time period when eggs and larval stages are present. Juvenile refers to the time when juveniles are present, and is especially emphasized in nursery areas. Adult indicates the seasons when adult (mature) fish are present. If spawning is indicated, adult fish must also be indicated.
Invertebrates	The special life-history time periods are spawning, larvae, mating, juveniles, and adults. The descriptions of these activities and life stages are generally the same as for fish (see above). Mating refers to reproductive activities performed by species with internal fertilization (e.g., blue crab), and can include migratory or other concentrations associated with mating. Spawning typically refers to the release of gametes to the water column, but in species that mate, it can also refer to the mass release of fertilized eggs or larvae to the water column.

Species List

The Atlas Species List (Table 11) is linked to the Biological Resources Table using the Species Name field. The atlas species list provides additional information to the species common name, such as scientific name (genus/species), state and Federal T/E listings, element and subelement classifications, and Natural Heritage Program (NHP) global conservation status ranking compiled by The Nature Conservancy and the state NHPs. NHP global conservation rankings include G1 (critically imperiled), G2 (imperiled), G3 (vulnerable), G4 (apparently secure), and G5 (secure). Definitions of each category are given in Masters (1991).

The Atlas Species List for compiling data contains all data regarding the Federal, state, and global NHP rankings; however, in the relational GIS database, the Federal and state status is stored in a separate table (STATUS), which maintains database normality, reduces redundancy, and minimizes the number of records with blank values.

This list is particularly useful where there are several common names used for the same or different species, when species have different state or Federal T/E listings in different geographic locations, and when a new species needs to be added to the nationwide species list (Table 12).

Human-Use Resources

Each human-use resource is assigned to a feature type and feature code (Table 13). Color codes are not used. A leader line is attached to each feature so that the map and feature number (socval#) are clearly indicated. Where a resource, such as an archaeological site or fishing area, is large enough to require several point symbols to delineate the extent of the resource, the same site number can be given to each point symbol, unless the resource extends across multiple topographic maps.

The Human-Use Resources form (Table 14) lists the mapped human-use features; the headings are described in Table 15.

Table 11. Atlas species list for data compilation.

SPECIES ID#[1]	SPECIES NAME[2]	SCIENTIFIC NAME[3]	STATE[4]	F/S[5]	T/E[6]	DATE_PUB[7]	ELEMENT[8]	SUBELEMENT[9]	NHP[10]
118	Brown pelican	*Pelecanus occidentalis*	DE	S	E	51994	BIRD	DIVING	G4
118	Brown pelican	*Pelecanus occidentalis*	NJ	—	—	21994	BIRD	DIVING	G4

1 = species identification code from the ESI Species ID# Master List
2 = common name
3 = scientific genus and species (Latin name)
4 = indicate state for T/E species using the two-letter abbreviation code
5 = protection status for Federal and/or state
6 = threatened and/or endangered listing
7 = date of list used to determine listing and NHP status
8 = biological element
9 = biological subelement (see Chapter 2, Table 3)
10 = Natural Heritage Program (NHP) global conservation status ranking

Table 12. Column descriptions for the atlas species list for data compilation.

COLUMN	DESCRIPTION
Species ID#	A number code used to identify and track species during GIS data processing. An ESI Species ID# Master List contains number codes for all species that have been included in previous ESI atlases. The person compiling biological data for an ESI map must have the most recent copy of the ESI Species ID# Master List (Appendix A) to enter the species code. New species can be added to the ESI Species ID# Master List upon request to NOAA.
Species Name	The common name of the species listed in the biology tables. The common name can vary geographically and a new species ID# can be added when the common name does not match the existing master species list.
Scientific Name	The Latin genus and species name of the species. This field is extremely important when there are several common names used for the same species.
State	The two-letter state abbreviation code. For a single-state atlas, this code is entered only once for all threatened or endangered species. If an atlas spans more than one state, each state in which the species is threatened or endangered is listed on a separate line.
F/S	Federal and/or State protection status. Indicate both using F_S or just one using either "F" or "S".

Table 12., cont.

COLUMN	DESCRIPTION
T/E	Threatened/endangered status. Indicate both using T_E in the same order as the jurisdictional designation.
Date_Pub	Date of reference used to determine listing or status.
Element	Biological element.
Subelement	Biological subelement.
Natural Heritage Program	Natural Heritage Program global conservation status rankings (e.g., G1, G2, etc.) compiled by The Nature Conservancy and the state Natural Heritage Programs. Contact the appropriate state NHP office for a list of rankings by species. If a species is not tracked by the NHP, place a "–" in this field.

Source (Metadata) Documentation

Two forms are used to document source information. The Source Master List (Table 16) provides detailed information on the sources used to compile biological and human-use data. The source information is needed for metadata documentation of the ESI atlas (Table 17). The human-use data require listing all sources that provided spatial and attribute features. Sources for spatial, concentration, seasonality, and life-history information are documented for the biological data.

The Source Data Dictionary form (Table 18) documents the study methods used by a particular source (sampling method, spatial referencing and accuracy, study area boundaries, and sampling dates and frequency). This information is necessary so that geographic completeness and temporal consistency can be monitored while merging data sets from various sources. Complete a separate form for each source. For some data sources, such as expert knowledge, you will need to estimate entries for the different headings. To maintain data quality, fill in this form as completely and as accurately as possible just as soon as the information is obtained (see example in Table 19).

Table 13. Human-use feature types and codes.

Feature Type	Code
Airport	A
Access Location	A2
Aquaculture Facility	AQ
Archaeological Site	AS
Artificial Reef	AR
Beach	B
Boat Ramp	BR
Coast Guard Facility	CG
Commercial Fishing	CF
Diving Site	DV
Equipment	EQ
Factory	F2
Ferry	F
Helipad	HP
Historical Site	HS
Hoist	H
Indian Reservation	IR
International Boundary	IB
Lock and Dam	LD
Marina	M
Mining	MZ
National Park	NP
Oil Facility	OF
Park (State or Regional)	P
Pipeline	PL
Platform	PF
Process Facility	P2
Recreational Fishing	RF
Road	R
Shipwreck	SW
Staging Site	ST
State Border	SB
Subsistence	S
Waste Disposal Site	WD
Water Intake	WI
Well	W
Wildlife Refuge	WR

Table 14. Human-use resources form.

Site #[1] (Map#-Feat.#)	Resource Type[2]	Resource Name[3]	Geog[4] Source	Attribute[5] Source
001-H01	WR	Wild Goose Chase National Wildlife Refuge	4	4

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1 = location of the socio-economic resource
2 = type of human-use resource (access, recreational beach, water intake, etc.)
3 = name of the facility
4 = unique id identifying the source that provided locational information
5 = unique id identifying the source that provided attribute information

Table 15. Column descriptions for the human-use resources form.

COLUMN	DESCRIPTION
Site# (map#–feat#)	Refers to the location of each human-use resource by map number and feature number. The feature number is always preceded by the letter "H" to denote human-use resources.
Resource Type	Refers to the type of human-use resource (e.g., wildlife refuge; Table 13).
Resource Name	Refers to the name of the resource (e.g., Sabine Pass National Wildlife Refuge). Some resource types may not have names.
Geographic Source	A number that corresponds to the source that provided the locational and concentration information on a species included in a polygon, line, or point feature. This number references the sources in the Source Master List.
Attribute Source	A number that corresponds to the source that provided attribute information such as feature names. This number references the sources in the Source Master List.

Table 16. Source master list.

SOURCE_ID[1]	ORIGINATOR[2]	DATE[3]	TITLE[4]	RESOURCE[5] ELEMENTS	DATA[6] FORMAT	PUBLICATION[7] INFORMATION	SCALE[8]	TIME[9] PERIOD	DISTRIBUTE	SENSITIVI
1	Audubon, Chuck E. The Byrd Society Wingtown, ST	None	None	Birds (brown pelicans)	Personal knowledge	None	N/A	1995	NO	YES
2	State Natural Resources Agency	1994	Turtle Nesting Locations*	Turtles	X,Y Coordinates	None	Unknown	1965-1993	YES	NO
3	Murre, John and David Thorough	1993	ACME Atlas of Breeding Birds	Birds	text and data tables	ACME University Press, Campus City, ST, 1002 pp.	65000	1990-1992	NO	YES
4	Geographer, Jessica USFWS GIS Director	None	NWR Boundaries*	Wildlife refuges	Digital maps (ARC/ INFO)	Unpublished GIS coverages, USFWS, Office of Map Resources, Washington, D.C.	24000	1994	NO	YES
5	State Office of Control State Capital	1993	Infrastructure and Protected Areas*	Human-use	Digital	None	24000	1990-1992	YES	YES, wit disclaim

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1 = unique id for each source in the database
2 = the author, editor, database manager, expert, etc. who produced the original information
3 = date of publication
4 = title of the source document, map, or database
5 = the biological or human-use elements for which the source provided information
6 = format type (allowable descriptions are digital maps, digital tables, hard-copy maps, hard-copy tables, text descriptions, personal communication, or personal knowledge)
7 = information that would be needed for a reference citation
8 = original scale at which data were mapped
9 = dates over which the original data were collected, or date to which the information is current

Table 17. Column descriptions for the source master list.

COLUMN	DESCRIPTION
Source ID	The unique ID for each source in the database, which is assigned sequentially and is referenced by Geographic Source, Attribute Source, and Seasonality Source.
Originator	The author, editor, database manager, or expert who produced the original information used in ESI maps. Originator does not necessarily refer to the person who provided a document or information, an agency or group that published or funded a study or document, or a person who interpreted an original source during the ESI production. For instance, if John Smith of State DNR used the "Atlas of Colonial Breeding Water Buffalo" sent to him by Jane Doe of the USFWS (the project officer for the study), the originator would be none of the above. The originator would be the person(s) who conducted the study, produced the maps, and wrote the report. For persons providing expert knowledge, the agency or affiliation of the originator should be included.
Date	The date of publication or data collection if expert knowledge is the source. If there are multiple dates, use "varies."
Title	The title of the source document, map, or database. If the source does not have a title, briefly describe the source.
Resource Elements	The specific biological elements (e.g., terrestrial mammal, reptile, habitat) or human-use elements. Many sources cover a variety of resources. However, only those resources for which information was gathered from the source should be listed. For example, the title of a source book could be "ACME Coastal Resource Guide." This publication might cover birds, fish, invertebrates, marine mammals, commercial fisheries, recreation areas, and archaeological resources. If only fish and invertebrate distributions were derived using this source, "fish and invertebrates" should be the only resource elements listed.
Data Format	The type of source used. Hard-copy maps, text, hard-copy tables, and personal knowledge are the analog data formats. Digital data formats include polygon, point, and GT polygon, which comply with the Spatial Data Transfer Standard.
Publication Information	All information that would be needed for a reference or bibliographic citation, except for the author, date, and title which are listed in other fields. Information for this field usually includes the publisher or agency name, city, and state; the journal name, volume, and pages; the report or map number; and the total number of pages. If the source is unpublished, enough information should be provided so that readers can locate the document or database. Agency affiliations for persons contributing expert knowledge (listed under originator) should provide information needed by those interested in contacting expert sources.

Table 17. *Continued.*

COLUMN	DESCRIPTION
Scale	Applies to digital maps, hard-copy maps, and some digital databases. For instance, one common map scale is "1:24,000." Only the scale denominator without commas is entered in this field. If scale does not apply, enter "N/A" in this field, and if the scale is not known, use "Unknown."
Time Period	The dates over which data were collected by a source. This will usually be a year or range of years (e.g., "1979-1982") that precedes the publication date. This information may be contained in the "introduction" or "methods" section of a book or paper. For extensive data compilations or literature reviews, time period can sometimes be estimated by examining the references or literature-cited sections of the source. For expert knowledge, the year the source was contacted is usually given as the source time period, indicating the date to which the information was current.

Table 18. *Source data dictionary form.*

Source ID#: _____

Originator: _____

_____

Title: _____

I. **Source Sampling Method**. *Describe how the data were collected, i.e., overflights, visual surveys, photography, physical collection methods (nets, traps, etc.), radio-tracking, etc. Also describe the sampling method (point, quadrat, transect, etc.) and any statistical design (random, stratified, etc.):*

_____

_____

II. **Spatial Referencing Method**. *Describe how sampling sites or areas were defined and how geographic locations were determined (i.e., landmarks, compass triangulation, aerial photography, traditional surveying and mapping, township-range-section, LORAN C, GPS, etc.):*

_____

_____

III. **Study Area**. *Define the boundaries of the study; these should also be indicated on the quad maps (boundaries for land and water areas should be included as appropriate):*

_____

_____

_____

IV. **Sampling Period and Interval**. *Give the starting and ending date of the study. Also check the sampling frequency. Include at least the months when data were collected. If yearly or quarterly sampling was conducted, but at different months in different years, list the month(s) when sampling occurred for each year under "Other:"*

Start-End Dates (month/year): _____

❑ Yearly/Annually, month(s) when sampling occurred_____

❑ Quarterly/Seasonally, months when sampling occurred_____

❑ Monthly ❑ Weekly

❑ Other (describe in detail):_____

V. **Sensitivity and Distribution**. *Identify the data set as either sensitive or not sensitive, and whether there are any restrictions on distributing the data:*

❑ Not Sensitive

❑ Sensitive

Distribution Restrictions:

_____

_____

Table 19. Example source data dictionary form.

Source ID#: 3

Originator: John Murre and David Thorough, U.S. Fish and Wildlife Service

Title: ACME Atlas of Breeding Birds

I. **Source Sampling Method**. Describe how the data were collected, i.e., overflights, visual surveys, photography, physical collection methods (nets, traps, etc.), radio-tracking, etc. Also describe the sampling method (point, quadrat, transect, etc.) and any statistical design (random, stratified, etc.):

survey of coastal bird rookeries by aerial overflights along multiple overlapping transects oriented parallel to the shoreline

II. **Spatial Referencing Method**. Describe how sampling sites or areas were defined and how geographic locations were determined (i.e., landmarks, compass triangulation, aerial photography, traditional surveying and mapping, township-range-section, LORAN C, GPS, etc.):

flight path and the location of bird rookeries were recorded using a GPS, with 15-meter accuracy

III. **Study Area**. Define the boundaries of the study; these should also be indicated on the quad maps (boundaries for land and water areas should be included as appropriate):

entire state coastline was surveyed except for the Big Bend Region from Crystal River north to Horseshoe Beach; surveys were conducted from the shoreline to roughly 35 km inland along mainland coastlines; all the barrier islands were completely surveyed

IV. **Sampling Period and Interval**. Give the starting and ending date of the study. Also check the sampling frequency. Include at least the months when data were collected. If yearly or quarterly sampling was conducted, but if different months in different years, list the month(s) when sampling occurred for each year under "Other":

Start-End Dates (month/year): 3/90-11/92

❑ Yearly/Annually, month(s) when sampling occurred_____

❑ Quarterly/Seasonally, months when sampling occurred_____

✔ Monthly ❑ Weekly

❑ Other (describe in detail):_____

V. **Sensitivity and Distribution**. Identify the data set as either sensitive or not sensitive, and whether or not there are any restrictions to distribute the data:

✔ Not Sensitive Distribution Restrictions:

❑ Sensitive Yes, but include disclaimer from source

4 ESI DATABASE ORGANIZATION

The ESI data structure has evolved to its current structure since the first atlas using GIS was produced for Louisiana in 1989. As with many GIS projects, the ESI mapping effort has changed to take advantage of rapidly evolving technology. However, these changes have not dramatically altered the data structure or data content, but instead have increased spatial accuracy and attribute consistency. The ESI data structure was designed to be a GIS capable of complex relational links between spatial and aspatial data (Figure 3). The data in ESI atlases are grouped into three general categories: basemap, biology, and human-use. The basemap group contains the classified shoreline and habitats (ESI), hydrography (HYDRO), and map boundary polygons (INDEX). The shoreline classification contains the arcs delineating the water/land interface, environmental sensitivity ranking codes, and wetlands polygons. The biology group contains birds (BIRDS), fish (FISH), habitats and rare plants (HABITATS), invertebrates (INVERT), marine mammals (M_MAMMAL), birds nesting sites (NESTS), reptiles and amphibians (REPTILES), and terrestrial mammals (T_MAMMAL). The biological data contain points and polygons for all elements, subelements, and species. These data layers link to lookup tables which in turn link to the BIORES data table that contains the species id, concentration, and seasonality links as well as links to source information. The species table (SPECIES) contains a list of each species in the atlas, with the Natural Heritage Program ranking; the species status table (STATUS) contains the state and Federal threatened and endangered status; the seasonality table (SEASONAL) contains the monthly presence of each species, which may vary throughout the atlas; the life stage table (BREED) identifies the breeding activity or life stage for each species; and the source table (SOURCES) identifies all sources used in the atlas. The human-use group contains managed lands (MGT) and other recreational and economic features (SOCECON). The human-use data are point features such as water intakes, marinas, and boat ramps; line features such as international boundaries; and polygonal features such as wildlife refuges and national parks. These data layers link to a lookup table (SOC_LUT) that links to a data table (SOC_DAT) containing feature names, contact information, and links to the source table.

The ESI-GIS data are produced using a standard data automation methodology. However, due to numerous data sources and rapidly changing technology, the data structure and mapping methods have progressed over the years (Table 20). The original objective of using GIS technology was to produce the ESI atlas; now the

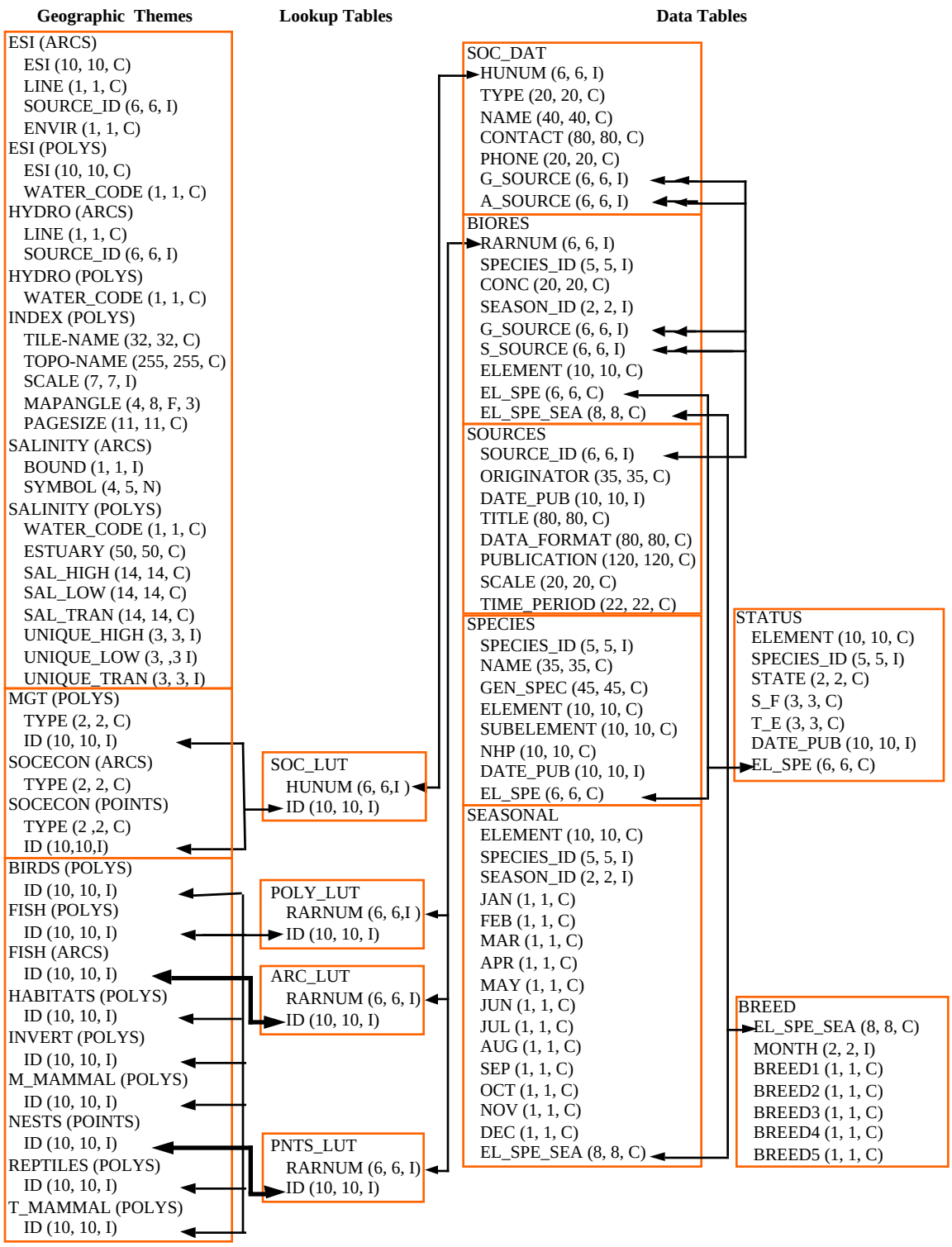

Figure 3. *The ESI-GIS data structure.*

primary objectives are to produce the atlases and robust spatial databases for distribution and application development.

Table 20. The automation of ESI atlases, divided into nine distinct tasks.

TASK	DESCRIPTION
1. Project Setup	• The Project Manager determines the scope of work, deliverables, study area, map projection, major data providers, and begins the Project Log Book that documents decisions and processing steps. • The map numbering scheme is decided. • The map index is created, including map numbers and names. • Base maps (usually USGS 7.5-minute quadrangles) are ordered.
2. Scan Base Maps	• Each quad is scanned at 400 dots per inch (dpi) using a gray-scale from 0 to 256. • Images are cleaned to adjust brightness. • Images are registered to the projected map index using an RMS error of not greater than 30 feet or ten meters. • Images are backed up on tape and quads are given to the geomorphologist for ESI classification.
3. Classify ESI	• National Wetlands Inventory (NWI) wetlands (or other comparable data) and shorelines are obtained, converted, projected, and processed for integration into the ESI data structure. • 1:24,000 maps are plotted for use in performing field work. • Geomorphologist visits aerial photography repository, interprets and classifies shoreline, annotates USGS quadrangles using photography and wetlands maps, and performs overflight for difficult areas. • Geomorphologist checks all maps for completeness and gives to GIS for digitizing. • ESI shoreline pictures are chosen for introductory pages.
4. Digitize ESI	• Each field map is scanned and registered to the map index. • Shoreline attributes are digitized, water and land polygons are checked for correctness, water-based annotation is digitized, ESI polygons are checked using the NWI classification scheme and field notes, and digitizing is checked for proper digitizing rules and GIS completeness. • 1:24,000 maps are plotted showing ESI classification, water/land polygons, and annotation. • Geomorphologist checks and edits each map. • GIS enters edits, performs complete check of every quad, merges all quads to perform edge-matching, and dissolves water/land to generate final shoreline. The final ESI shoreline is used in subsequent biology and human-use data layers.

Table 20. *Continued.*

TASK	DESCRIPTION
5. Collect Biology and Human-Use Data	• Biologist and GIS identify all digital and non-digital data sources. • GIS converts and processes data into ESI data structure and plots at 1:24,000 using standard map production style. • Biologist gathers and compiles all hard-copy information onto USGS quadrangles, using the existing data plots as a reference. • Biologist meets with experts to gather additional spatial and non-spatial information. • All maps are checked and completed before data automation. • Biologist and GIS discuss the data automation and integration methods for merging digital and non-digital data.
6. Digitize Biology and Human-Use Data	• GIS scans each biology map and digitizes each feature into the appropriate data layer and database table(s). • After all quads are completed they are joined to form a complete study area and checked for edge-matching, completeness, and correctness. • 1:24,000 plots and data tables are produced and checked by the biologist and edits are made if necessary. • 1:24,000 or 1:100,000 plots, data tables, and atlas text are produced for expert review.
7. Edit Review Comments	• Biologist compiles review edits and GIS enters them. • GIS performs final quality control checks and runs in-house final map comps on 11 x 17 paper. • Biologist makes final data check and identifies polygon data for "Common Throughout."
8. Produce Atlas	• Final map compositions are created, edited, and plotted. • Copies are made, tables are printed on the backs of the maps, final atlas text is produced, and the entire set of atlases is laminated and organized into binders.
9. Deliver Digital and Metadata	• Each quad data layer is merged into study area layers. • Final data structure conversions are performed. • Final metadata document is prepared. • Data tapes are created for data layers, legend, map compositions, and image map compositions. • Diskettes are created for title page, atlas text, data tables, and metadata report.

The following sections detail the data structure, data contents, and rules for coding each of the data sets. Accompanying each ESI atlas is a metadata report that documents particular characteristics specific to each atlas and must be read by users of these data. Appendix B contains a detailed data dictionary of the geographic layers, data tables, and lookup tables with accompanying values for each type of feature. Figure 3 and Appendix B are comparable and may be used together to visualize the ESI-GIS.

Basemap Data

Three coverages establish basemap, or baseline, information in the ESI-GIS: ESI, HYDRO, and INDEX. ESI and HYDRO contain polygonal water and land features as well as linear features for rivers and streams. In both coverages, all polygons are designated as either water or land. However, the ESI coverage contains only those features with ESI classifications and the HYDRO coverage contains all hydrographic features used in the atlas as well as all annotation. The INDEX data layer contains the map boundary polygons (usually USGS 1:24,000-quadrangles) and associated map attributes.

The ESI Data Layer

The ESI shoreline classification contains water and land features (polygons), rivers and streams (arcs), source codes (arcs), and ESI sensitivity classification (arcs) (Table 21).

The arc item ESI contains the values for the shoreline sensitivity and generally ranges from 1 through 10 (see Table 2). The values can have multiple (two and even three) combinations of sensitivity to designate the landward, shore, and seaward classifications. The metadata report details each value in the ESI item. There are also specific coding rules for how the shorelines are attributed:

1. When ESI classified shorelines form polygons and the polygons are unclassified (i.e., land), the ESI value for the polygon is "U" for unranked.

2. Arcs whose left or right polygon is a flat (ESI = "7" or "9") or marsh (ESI = "10A", "10B", or "10C") is designated as "F" or "M" respectively.

Table 21. Features of the ESI data layer.

DESCRIPTION	ITEM	VALUE
ESI classification	ESI (10, 10, C)	Multiple combination of 1 through 10 (see Table 2)
Type of linear feature	LINE (1, 1, C)	B (breakwater) F (flat) H (hydrography) I (index) S (shoreline) M (marsh) P (pier)
Source code	SOURCE_ID (1, 1, I)	0 (original digital information) 1 (low-altitude overflight) 2 (aerial photograph) 3 (digitized from 1:24,000-USGS topographic quadrangle) 4 (digitized from scanned 1:24,000-USGS topographic quadrangle) 5 (National Wetlands Inventory)
Environment	ENVIR (1, 1, C)	E (estuarine) L (lacustrine) R (riverine)
Water and land polygons	WATER_CODE (1, 1, C)	W (water) L (land)

3. In most environments, polygons classified as flats (ESI = "7" or "9") are water (WATER_CODE = "W") and have ESI arc attributes on the inland side of the polygon.

4. In most environments, polygons classified as wetlands (ESI = "10A", "10B", "10C", or "10D") are land (WATER_CODE = "L") and have ESI arc attributes in the water side of the polygons (Figure 4).

The WATER_CODE item stores this information as "L" for land and "W" for water. The arc attribute item LINE contains a code which corresponds to the type of geographic feature. The following rules apply:

1. Arcs that form the boundary between open water and land are shoreline ("S").
2. Arcs where land is on both the right and left must be hydrography ("H").
3. Arcs that form an inland water polygon are classified as hydrography ("H").
4. Quad/map boundaries are classified as Index ("I").
5. Polygons or arcs that are on the water side of the shoreline are breakwaters ("B") or piers ("P") (Figure 5).

All polygons are designated as water or land.

The arc item SOURCE_ID contains the source code for the shoreline. The values of SOURCE_ID are commonly: 0 (digital, with sources listed in the metadata report); 1 (low-altitude overflight); 2 (aerial photograph); 3 (digitized off paper quad); 4 (digitized off scanned quad); and 5 (National Wetlands Inventory digital data). However, the companion metadata document to each atlas details the values of the SOURCE_ID item.

In many ESI atlases, NWI data help develop ESI polygon data. NWI data are recorded, dissolved, and merged with the shorelines before ESI habitat classification. This ensures that all shoreline (arc) attributes and polygon attributes will be maintained. The following rules are used to recode, or reclassify, NWI data to ESI polygons:

ESI	NWI DEFINITION	NWI CODE
10A	Estuarine, intertidal, emergent wetland	E2EM
10B	Riverine, tidal, emergent wetland	R1EM
	Riverine, lower perennial, emergent wetland	R2EM
	Lacustrine, littoral, emergent wetland	L2EM
	Palustrine, emergent wetland	PEM
10C	Estuarine, intertidal, forested wetland	E2FO
	Palustrine, forested wetland	PFO
10D	Estuarine, intertidal, scrub-shrub	E2SS
	Palustrine, scrub-shrub	PSS

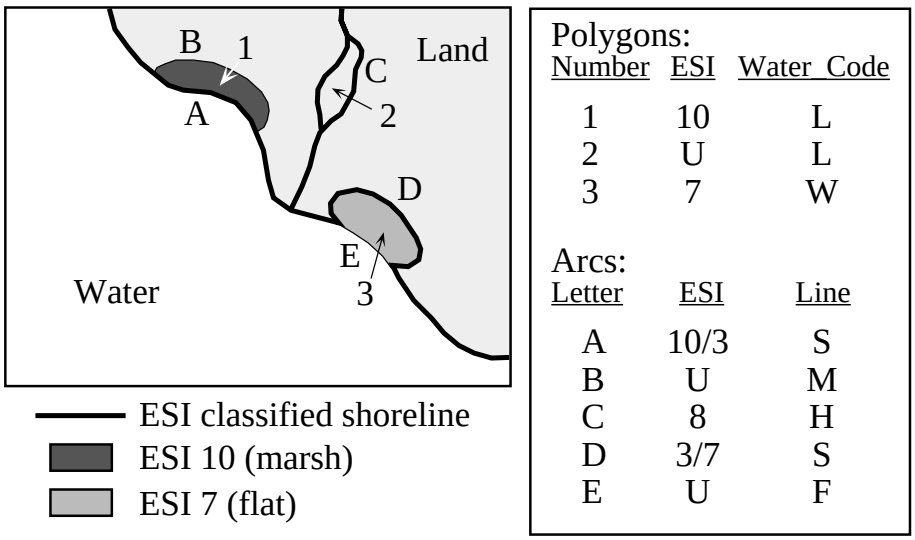

Figure 4. ESI shoreline with wetland (10) and flat (7) polygons.

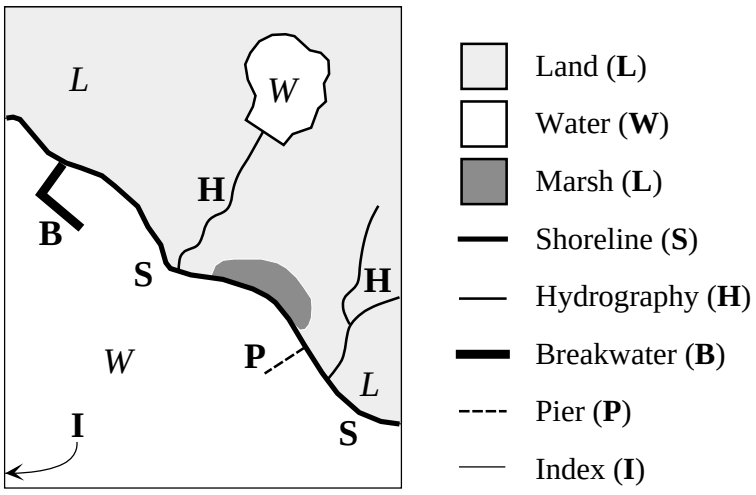

Figure 5. Polygon WATER_CODE and arc LINE coding rules.

The ENVIR item stores the type of regional environment. The possible values are "E" for estuarine, "L" for lacustrine, and "R" for riverine. This item is used to standardize the ESI classification as well as allow the user to select areas of a particular region.

To ensure that the shoreline is consistent between layers, the ESI coverage is copied to the HYDRO coverage. The ESI coverage is then edited so that only the arcs and

polygons which are required for the user to examine the sensitivity of the shoreline remain. The LINE, SOURCE_ID, and WATER_CODE attributes are the same in both the ESI and HYDRO coverages.

The HYDRO Data Layer

The HYDRO data layer contains all linear features (streams, creeks, etc.) and polygonal features (oceans, lakes, etc.). Depending upon the source information available, the hydrography may extend to all areas of the USGS quads/maps used in the atlas, or the features may stop where the ESI shoreline classification ends. The HYDRO coverage also contains all annotation used in producing the atlas. The annotation is usually digitized from the USGS quadrangles and consists of text located in the water and is cartographically important for producing the map product. The annotation features are grouped into three subclasses: hydro (water body names), geog (geographic places of interest), and soc (parks, city and town names, etc.). The annotation is created using fonts and sizes mimicking those used on the USGS quadrangles. The items LINE and SOURCE_ID are copied to the HYDRO layer from the ESI layer.

The INDEX Data Layer

The data layer INDEX contains the map boundary polygons for each map (usually USGS 1:24,000-quadrangles) in the atlas. The attributes assigned to each polygon are TILE-NAME (map number according to the layout of the atlas), TOPO-NAME (the USGS map name and latest published date), SCALE (value of the denominator of the scale), MAPANGLE (value to rotate the final map product so that it is situated straight up and down), and PAGESIZE (value of the width and height of the map in the final map product).

Biological Data

The biological data contain the most complex information in the ESI atlas due to the numerous relationships between data layers and data tables. The data layers are based on element or biological category, and an atlas usually has BIRDS, FISH, HABITATS,

INVERT, M_MAMMAL, NESTS, REPTILES, and T_MAMMAL layers. Occasionally, special, unique data layers are documented in the atlas metadata report.

Biology Data Layers

Biological data layers contain numerous overlapping polygons. To identify the contents of these polygons the item ID is used, which contains a unique combination of the atlas number, the element number, and the feature number. By including the atlas number, the data and associated lookup tables may be merged from multiple atlases which allows for the creation of new study area boundaries. The ID item has the syntax:

OOO	OO	OOOOO
atlas	element	Poly ID

where the atlas numbers range from 1 to 101. These are listed in Appendix C. The elements are numbered:

1	BIRD	7	INVERT
2	FISH	8	SPECIAL
3	HABITAT	9	T_MAMMAL
4	M_MAMMAL	10	SOCECON
5	NEST	11	MGT
6	REPTILE		

The element "SPECIAL" (8) is used when there are special data layers. These are documented in the metadata. The ID items link to the biology lookup tables (Figure 6).

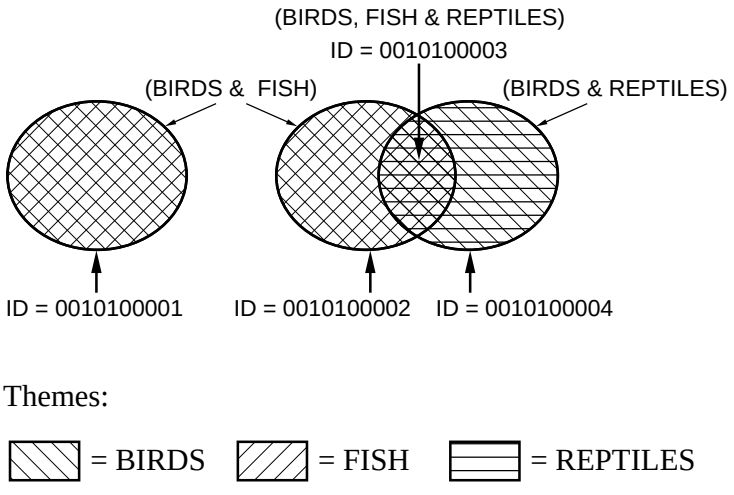

Figure 6. Biology data layers and identification codes for the BIRDS data layer.

A polygon duplicated in the BIRD and FISH coverages will have a different ID in each of these coverages. Besides the differences in the element number (01 and 02), the polygon number is determined internally based upon the sequence in which the polygons are created.

Biology Lookup Tables

The lookup tables are POLY_LUT, ARC_LUT, and PNTS_LUT. These link the unique IDs in the data layers to the relational data tables containing (unique) attributes. The item RARNUM provides the link from the lookup tables to the Biological Resources Table (BIORES).

The value of the RARNUM item constitutes a unique combination of species, concentration, and seasonality. The RARNUM may contain multiple species across elements. From the GIS perspective, this means that polygons are shared between themes. Methodologically, all shared polygons are copied from one theme to another, never digitized more than once. Polygons copied from one data layer to another will have different IDs but the same RARNUM.

Biology Data Tables

Each biological data layer is linked to the Biological Resources data table (BIORES) using the lookup tables. From BIORES, the user can investigate the species data (SPECIES and STATUS), the seasonality data (SEASONAL), the life stages data (BREED), and the feature-level metadata (SOURCES; Figure 7).

The items in BIORES are RARNUM, SPECIES_ID (nationwide species identification code linked to the SPECIES table), CONC (concentration), SEASON_ID (seasonality code linked to the SEASONAL table), G_SOURCE (geographic source linked to the SOURCES data table), S_SOURCE (seasonality source linked to the SOURCES data table), and ELEMENT (biology group). The values for ELEMENT are:

BIRD
FISH
HABITAT
INVERT
M_MAMMAL
REPTILE
T_MAMMAL

BIRDS.PAT:

ID
0010100001
0010100002
0010100003
0010100004

FISH.PAT:

ID
0010200009
0010200010
0010200011

POLY_LUT:

RARNUM	ID
1	0010100001
1	0010100002
2	0010100003
3	0010100004
1	0010100009
1	0010100010
2	0020100009
2	0020100010

BIORES:

RARNUM	SPECIES_ID	CONC	SEASON_ID	G_SOURCE	S_SOURCE	ELEMENT
1	118	20	1	7	6	BIRD
1	118	HIGH	2	5	5	FISH
2	10	MED	1	5	6	FISH
2	12	LOW	1	8	6	REPTILE

SPECIES:

SPECIES_ID	NAME	GEN_SPEC	ELEMENT	SUBELEMENT	NHP	DATE_PUB
118	Brown pelican	*Pelecanus occidentalis*	BIRD	DIVING	G4	11996
118	Yellowfin mojarra	*Gerres cinereus*	FISH	RESIDENT		0
143	Tarpon	*Megatops atlanticus*	FISH	RESIDENT		0
6	Atlantic loggerhead sea turtle	*Caretta caretta*	REPTILE	TURTLE	G3	11996

STATUS:

ELEMENT	SPECIES_ID	STATE	S_F	T_E	DATE_PUB
REPTILE	6	SC	S_F	T_T	061995

SEASONAL:

ELEMENT	SPECIES_ID	SEASON_ID	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	EL_SPE_SEA
BIRD	118	1			X	X	X	X	X	X	X	-	-	-	B0011801
FISH	118	1	X	X	X	X	X	X	X	X	X	X	X	X	F0011801
FISH	143	2	-	-	-	-	-	-	-	X	X	X	X	X	F0014302
REPTILE	6	1	-	-	-	-	X	X	X	X	X	-	-	-	R0000601

BREED:

EL_SPE_SEA	MONTH	BREED1	BREED2	BREED3	BREED4	BREED5
B0011801	3	Y	Y	N	N	-
B0011801	4	Y	Y	N	N	-
B0011801	5	Y	Y	Y	N	-
B0011801	6	Y	N	Y	Y	-
B0011801	7	Y	N	Y	Y	-
B0011801	8	Y	N	N	Y	-
B0011801	9	Y	N	N	Y	-
F0011801	1	N	N	N	Y	N
F0011801	2	N	N	N	Y	N
F0011801	3	N	N	N	Y	N
F0011801	4	N	N	N	Y	N
F0011801	5	N	N	N	Y	N
F0011801	6	N	N	N	Y	N
F0011801	7	N	N	N	Y	N
F0011801	8	N	Y	N	Y	Y
F0011801	9	N	Y	N	Y	Y
F0011801	10	N	N	N	Y	N
F0011801	11	N	N	N	Y	N
F0011801	12	N	N	N	Y	N

Figure 7. Example biology data for the data layers, lookup tables, and data tables.

SOURCES:

SOURCE_ ID	ORIGINATOR	DATE_ PUB	TITLE	DATA_ FORMAT	PUBLICATION	SCALE	TIME_PERIOD
5	Dept. of Fish and Game	1995	Dist. of wildlife	Hard-copy Map	None	24000	Unknown
6	Univ. of South Carolina	1995	Breeding Characteristics of S.C. Wildlife	Book	USC Press	None	1995
7	National Biological Survey	1994	Field Survey of Endangered Species	ASCII coord.	Unknown	100000	Sept 1992-Sept 1993
8	State Wildlife Dept.	1991	Dist. of Sea Turtles	dBase file	None	Unknown	1975-1985

Figure 7. *cont.*

The SPECIES table is linked to BIORES by the item SPECIES_ID, a nationwide species identification code. Items included in this table are NAME, giving species common name; GEN_SPEC, listing the genus and species; ELEMENT; and SUBELEMENT. The items NHP and DATE_PUB are also part of the SPECIES table. NHP lists the global conservation status ranking as compiled by the Nature Conservancy and the state National Heritage Programs. NHP global conservation rankings include G1 (critically imperiled), G2 (imperiled), G3 (vulnerable), G4 (apparently secure), and G5 (secure). The DATE_PUB item in this table contains the date when the list was published.

The SEASONAL data table stores the monthly presence of each species. The BIORES data table is linked to the SEASONAL data table using the SPECIES_ID, ELEMENT, and SEASON_ID items. The SEASONAL data table is linked to the BREED data table using the item EL_SPE_SEA, which incorporates the initial letters of ELEMENT, the five-digit SPECIES_ID, and the two-digit SEASON_ID. For example, for an ELEMENT BIRD with a species_ID of 00001 and SEASON_ID of 01, a unique lookup item of B0000101 would be used. The life activity represented by BREED1 - BREED5 varies from element to element. Not all elements have five different activities defined. In these cases, the additional breed columns are populated by "_", indicating non-applicable. The activities are listed below. There are up to 12 records for each combination/concatenation of ELEMENT, SPECIES_ID, and SEASON_ID, depending upon whether any of the special life stages are present that month. The item MONTH contains the monthly integer, which ranges from 1 through 12.

	BREED1	BREED2	BREED3	BREED4	BREED5
BIRD	NESTING	LAYING	HATCHING	FLEDGING	-
FISH	SPAWNING	OUTMIGRATION	LARVAE	JUVENILES	ADULTS
HABITAT	-	-	-	-	-

INVERT	SPAWNING	LARVAE	MATING	JUVENILES	ADULTS
M_MAMMAL	MATING	CALVING	PUPPING	MOLTING	-
REPTILE	NESTING	HATCHING	INTERNESTING	-	-
T_MAMMAL	-	-	-	-	-

The STATUS data table contains only those species which are listed as threatened or endangered by either state or Federal authorities. The STATUS table contains the biological ELEMENT (ELEMENT), the species number (SPECIES_ID), the two-character state abbreviation (STATE), the state and/or Federal status (S_F), the threatened or endangered status (T_E), and the two-digit month and four-digit year in which the list was published (DATE_PUB). If the species is both state and Federal listed, the S_F item will contain "S_F" and the T_E item will contain either "T_E," "E_T", "E_E," or "T_T." The two-digit state abbreviation code is given for all threatened or endangered species. If the atlas covers more than one state, then the threatened or endangered species will be listed in the STATUS table for each state in which they are mapped. Therefore, an atlas which covers three states may have some species listed three times in the STATUS table. The STATE variable may be used for merging tables from several ESI atlases and determining the presence of endangered species without the need of a GIS.

The SOURCES data table contains a list of sources who contributed to the creation of the atlas. The items and contents of the SOURCES data table meet the requirements of the U.S. Federal Geographic Data Committee's Content Standards for Digital Geospatial Metadata (June 8, 1994). All data, both biology and human-use, reference the SOURCES table. The following items are in the SOURCES table: SOURCE_ID (a unique identifier for each source that provided information); ORIGINATOR (person or organization who provided the data); DATE_PUB (production or publication date); TITLE (name of the original data set or body of work); DATA_FORMAT (media); PUBLICATION (citation); SCALE (denominator); and TIME_PERIOD (range of time when data were collected). The DATA_FORMAT item can contain "DIGITAL POLY" (geospatial polygons), "DIGITAL ARC" (geospatial polygons), "DIGITAL POINT: (geospatial points), "DIGITAL TABLE" (digital database such as dBase), "HARD MAP" (hard-copy map), "HARD TABLE" (hard-copy table), "BOOK" (published book), "HARD TEXT" (published or unpublished hard-copy text, not book), or "EXPERT" (expert knowledge from verbal communication). The information in this table is

downloaded and published in the Metadata Report for the atlas. The G_SOURCE and S_SOURCE items from the BIORES table link to the SOURCE_ID item. This structure allows for sources to be documented once in the SOURCES table, even if used for multiple polygons or different types of sources.

The following relationships summarize the characteristics of the biology data layers and data tables:

- There is a one-to-one relationship between biology polygons (ID) and the polygon lookup table.
- There is a many-to-many relationship between the lookup tables (RARNUM) and records in the BIORES table (RARNUM).
- For each unique occurrence of ELEMENT, SPECIES_ID, CONC, and SEASON_ID, there are one or more records in BIORES (RARNUM).
- The SPECIES table is linked to BIORES using ELEMENT and SPECIES_ID.
- The SEASONAL table is linked to BIORES using ELEMENT, SPECIES_ID, and SEASON_ID.
- The BREED table is linked to SEASONAL using EL_SPE_SEA.

For users who have Arc/INFO®, it may be beneficial to use the biological data layers in "region" topology rather than polygonal data and associated lookup tables. Refer to Appendix D for a description of the region to polygon and the reverse process.

Recently, ESI atlases have incorporated NOAA's Estuarine Living Marine Resources (ELMR) databases to model fish and invertebrates into salinity zones throughout estuaries. This incorporation of ELMR into ESI encompasses all of the attribute data into the current ESI data structure. However, many users may find the original salinity geospatial data interesting and applicable in their GIS and desktop mapping applications. Therefore, the data layer SALINITY is added to those atlases that have used ELMR data. The SALINITY polygon data includes WATER_CODE (specifies a polygon as either water or land and is the same as the HYDRO data layer), ESTUARY (the name of the estuary and bathymetry zone for ocean areas, SAL_HIGH (salinity level during the high-salinity time period), SAL_LOW (salinity level during the low-salinity time period), SAL_TRAN (salinity level during the transitional salinity time period), UNIQUE_HIGH (identification number that links to the original ELMR database and links to those records associated with the high-salinity time period), UNIQUE_LOW

(same as UNIQUE_HIGH except the linked records are for the low-salinity time period), and UNIQUE_TRAN (same as UNIQUE_HIGH except the linked records are for the transitional salinity time period). The SALINITY arc data includes BOUND (identifies the arc as a boundary for the salinity time period) and SYMBOL (the number of the map symbol used to color-shade the arc for either high [red] or low [blue] salinity and increasing or decreasing on either side of the line). The SALINITY data layer is generated by NOAA's ELMR program (the Strategic and Environmental Assessments Division) using the HYDRO as a base and then adding all of the attributes except the SYMBOL attribute, which is added for producing ESI maps. A more detailed description of the ELMR data is located in Appendix E.

Human-Use Data

Several human-use features are included in ESI atlases. Points and arcs are digitized into the SOCECON data layer and managed lands (polygons) are stored in the MGT data layer. The SOCECON arcs contain features such as international and state boundaries and transportation features such as bridges. These features are minimal and the general rule is that arcs are only digitized when they cannot be either polygons or points and are used for creating map products. They do not contain any links to the associated data tables because they are cartographic features and there are other databases (such as TIGER or DLG) that should be used when performing GIS analyses. Both the SOCECON points and the MGT polygon data layers have the item ID that links to SOC_LUT, which has the item's ID and HUNUM. HUNUM links to SOC_DAT table, which contains HUNUM, SOC_TYPE (feature type), NAME (facility name), CONTACT, PHONE, G_SOURCE (source for the geographic information), and A_SOURCE (source for the attribute information). The source codes are unique and are linked to the SOURCES data table. The SOURCES table is described in the previous section (Biological Resources). The SOCECON arc coverage doesn't link to any other data tables.

Figure 8 is an example of the MGT and SOCECON themes. The relationships between the SOCECON and MGT themes and the tables SOCECON and SOURCES are illustrated in Figure 9.

There is a one-to-one relationship between SOCECON points (ID) and the SOC_LUT table. There is a many-to-one relationship between the lookup table (HUNUM) and records in the SOC_DAT table. This means that there may be two

aquaculture sites (1) with one record in the database (Joe's Shrimp Farm). There is a many-to-one relationship between the SOC_DAT data table and the SOURCES data table. Each feature (aquaculture site) has one geographic source of information (The Planning Dept.), and one attribute source of information (the State Authority), but many features may have the same source information and therefore the same SOURCE_ID.

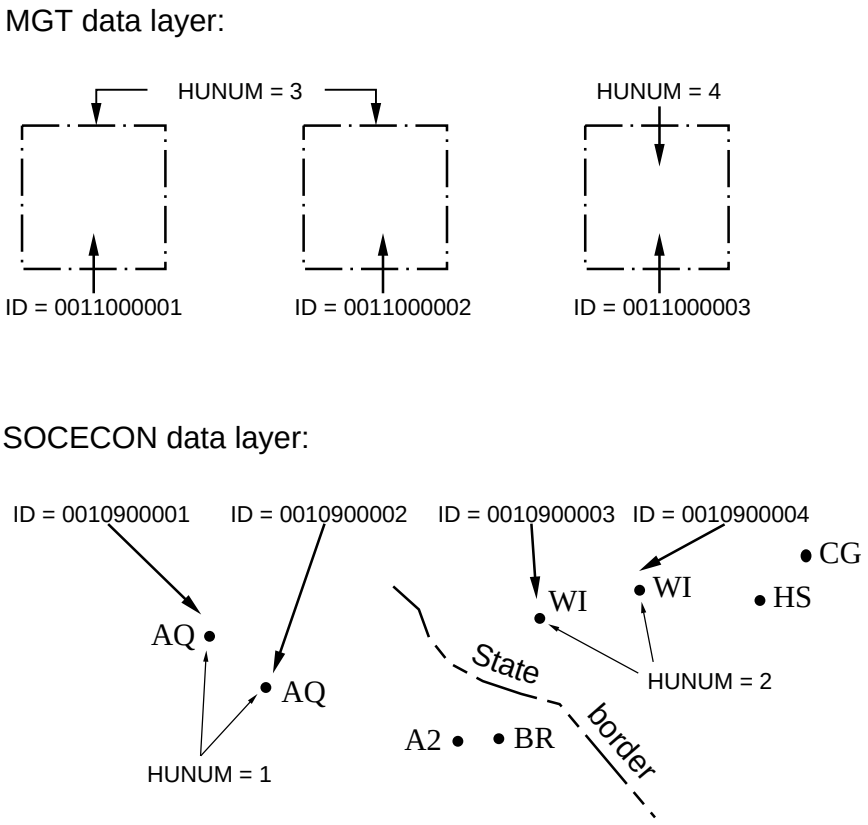

Figure 8. Example MGT (polygons) and SOCECON (points and arcs) data layers.

Quality Control Standards

To maintain a quality-controlled GIS database, all geographic data must have attributes. No features are uncoded (blank) and strict rules are enforced during the coding process. Digitizing basemap data, human-use resources, and biological resources is a complex and highly quality-controlled process. In order to facilitate digitizing, the entire study area is split into individual quadrangles using the INDEX coverage. The

SOCECON.PAT:

SOCECON	ID
AQ	0010900001
AQ	0010900002
WI	0010900003
WI	0010900004

MGT.PAT:

SOCECON	ID
IR	0011000001
IR	0011000002
WR	0011000003

SOC_LUT:

ID	HUNUM
0010900001	1
0010900002	1
0010900003	2
0010900004	2
0011000001	3
0011000002	3
0011000003	4

SOC_DAT:

HUNUM	SOC_TYPE	NAME	G_SOURCE	A_SOURCE
1	AQUACULTURE	Joe's Shrimp Farm	5	5
2	WATER INTAKE	City Power Plant	5	5
3	INDIAN RESERVATION		5	5
4	WILDLIFE REFUGE	Olympic Coast	4	4

SOURCES:

SOURCE_ ID	ORIGINATOR	DATE	TITLE	DATA_ FORMAT	PUBLICATION	SCALE	TIME_ PERIOD
4	Jessica Geographer USFWS GIS Director	None	NWR Boundaries	Digital complex polygons	Unpublished GIS coverages, USFWS, Office of Map Resources, Washington, D.C.	24000	1994
5	State Office of Control, State Capital	1993	Infrastructure and Protected Areas	Digital	None	24000	1990-1992

Figure 9. Example illustrating the relationships between the SOCECON and MGT data layers, the lookup table SOC_LUT, and the data tables SOC_DAT and SOURCES.

first layer of information digitized is the ESI shoreline. After digitization is completed, the data are checked for completeness and topological and logical consistency and then plotted and checked by the mapping geologists. Any errors in the shoreline classification are updated before digitizing the biological and human-use layers. All layers use the shoreline as the geographic reference to avoid slivers between polygons. The hard-copy biological information is compiled onto 1:24,000-USGS topographic quadrangles by a biological expert using data from regional specialists in the form of maps, tables, charts, and written descriptions of resource distributions. The data are digitized, then checked using both digital and on-screen procedures, plotted, and sent for review by the regional specialists. The edited maps are updated, rechecked, and the final product plotted (at approximately 1:50,000 scale). A team of specialists reviews the entire series of maps, checks all data, and makes final edits. The data are then

merged to form the study-wide layers. The data merging includes a final quality-control check where labels, chains, and polygons are checked for attribute accuracy.

To finalize the data-checking process, each coverage is checked for topological consistencies using a standardized form by two GIS personnel (a technician and the GIS manager; Figure F-1), and each attribute database is checked using several programs that test the files for missing or duplicate data, rules for proper coding, and geographic-to-tabular consistencies. The GIS manager does a final review and runs programs to generate the unique IDs and associated lookup tables (Figure F-2). Appendix F outlines the quality control checks performed on the data layers and associated data tables.

5 STANDARDS FOR ESI MAP SYMBOLIZATION

On ESI maps, the distribution of oil-sensitive fish and wildlife is shown by patterns, symbols, and colors representing ecological groupings. There are descriptive data on the back of each map and a key that identifies the colors and patterns used in the atlas.

The back of the map summarizes the GIS data tables discussed in Chapter 4. For example, the back of the map lists only the species' common names, but the scientific names are included in the digital database. For endangered or threatened species, a red box surrounds the icons on the maps. The specific state and/or Federal (S/F) threatened and/or endangered (T/E) status is shown on the back of the map. The conservation status information may be listed in the atlas tables, and is included in the databases. See Figure 10 for an example of the back of the map.

Shoreline Sensitivity Ranking Index

Over time, the color schemes for representation of the shoreline habitats have varied somewhat, but have followed a general trend with least sensitive always dark and most sensitive always red. To standardize the maps, we have modified the color scheme to range in a gradient from cool to hot colors. The numeric ESI values and ESI types associated with each color have varied from atlas to atlas in the past, depending upon the number of subclasses used. The new standardized color scheme, from least sensitive to most sensitive, is:

ESI RANK	COLOR	CMYK	RGB
1A/1B	Dark Purple	56/94/0/13	119/38/105
2A/2B	Light Purple	38/44/0/0	174/153/191
3A/3B	Blue	88/19/0/0	0/151/212
4	Light Blue	50/0/0/0	146/209/241
5	Light Blue Green	50/0/25/0	152/206/201
6A	Green	100/0/100/0	0/149/32
6B	Light Green	22/0/100/0	221/214/0
7	Olive	0/0/100/25	214/186/0
8A	Yellow	0/0/100/0	255/232/0
8B/8C/8D	Peach	0/34/28/0	254/189/170

ESI RANK	COLOR	CMYK	RGB
9A/9B	Orange	1/42/99/0	248/163/0
10A	Red	0/100/100/0	214/0/24
10B	Light Magenta	0/50/0/0	245/162/188
10C	Dark Red	0/81/56/13	209/77/80
10D	Brown	0/56/69/25	197/114/70

These colors have been tested and optimized to provide the best contrast and color reproduction using color photocopiers when used as a narrow band of color along the shoreline. These colors are standard on all current NOAA sensitivity maps. If more than fifteen shoreline types are mapped, you may need to use the same color for subclasses on the maps.

In some areas, the shoreline segment will be composed of two or three different ESI types (riprap behind a sand beach). In this situation, the shoreline color must reflect both of these features. Each shoreline combination has a unique line pattern that includes the appropriate colors. That is, when the shoreline is coded as a 6/3, for riprap behind a sand beach, the line pattern is defined as green on the landward half and blue on the seaward half of the shoreline. Some of the ESI features, such as marshes and tidal flats, are polygons. These polygons have either a solid fill pattern of the appropriate color or USGS symbology using the associated color. Only the shoreline-bounding edges of the land polygons have an ESI line type and are color-coded for that particular ESI.

Biological Features Symbolization

The points and polygons representing the animal groups use the same colors as the traditional ESI maps, except for mammals (changed from yellow to brown to be more visible in color copies). The polygons for each element use the following colors and hatch patterns:

NORTH CAROLINA ESIMAP 71

BIOLOGICAL RESOURCES:

BIRD:

RAR#	Species	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Nesting	Laying	Hatching	Fledging
3	Common loon			MED	X	X	X	X	X						X	X	–	–	–	–
	Northern gannet			MED	X	X	X	x	x	x			X	X	x	x	–	–	–	–
	Red-throated loon			MED	X	X	X	X							X	X	–	–	–	–
	Scoter			MED	X	X	X	X						X	X	X	–	–	–	–
166	American oystercatcher			LOW	X	X	X	X	X	X	X	X	X	X	X	X	–	–	–	–
	Black skimmer						X	X	X	X	X	X	X	X	X	X	–	–	–	–
	Black-bellied plover			LOW	X	X	X	X	X	X	X	X	X	X	X	X	–	–	–	–
	Bonaparte's gull				X	X							X	X	X	X	–	–	–	–
	Caspian tern											X	X	X	X		–	–	–	–
	Least tern			LOW			X	X	X	X	X	X	X				APR-AUG	–	–	–
	Peregrine falcon	S/F	E/E		X	X	X	X					X	X	X	X	–	–	–	–

FISH:

RAR#	Species	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Spawning	Outmig.	Larvae	Juveniles	Adults
290	Alewife				2	2	2	2	3	3	3	3	3	3	3	2	–	OCT-NOV	–	JAN-DEC	JAN-SEP
	Bay anchovy				5	5	5	5	5	5	5	5	5	5	5	5	APR-SEP	–	APR-OCT	JAN-DEC	JAN-DEC
	Gray snapper										3	3	3	3	3		–	–	–	JUL-NOV	–
290	Striped bass				2	2	2	2	2	2	2	2	2	2	2	2	–	–	–	JAN-DEC	JAN-DEC
	Striped mullet				3	3	3	3	4	4	4	4	4	4	3	3	–	NOV-DEC	DEC-APR	JAN-DEC	JAN-DEC
	Summer flounder				4	4	4	4	4	4	4	4	4	4	4	4	–	JAN-FEB	DEC-APR	JAN-DEC	JAN-DEC
SALINITY TIME PERIOD					T	L	L	L	T	T	T	T	H	H	H	T					

HABITAT:

RAR#	Species	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D
4	Carolina grasswort	S	T		X	X	X	X	X	X	X	X	X	X	X	X
6	Seabeach amaranth	S/F	T/T		X	X	X	X	X	X	X	X	X	X	X	X

INVERTEBRATE:

RAR#	Species	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Spawning	Larvae	Mating	Juveniles	Adults
290	American oystercatcher (eastern)				3	3	3	3	3	3	3	3	3	3	3	3	MAY-NOV	MAY-NOV	–	JAN-DEC	JAN-DEC
	Atlantic bay scallop				4	4	4	4	4	4	4	4	4	4	4	4	–	AUG-DEC	–	JAN-DEC	JAN-DEC
	Blue crab				4	4	5	5	5	5	4	4	4	4	4	4	–	APR-SEP	MAR-OCT	JAN-DEC	JAN-DEC
	Brackishwater clam				4	4	4	4	4	4	4	4	4	4	4	4	MAY-MAY AUG-NOV	MAR-JUN AUG-DEC	–	JAN-DEC	JAN-DEC
SALINITY TIME PERIOD					T	L	L	L	T	T	T	T	H	H	H	T					

M_MAMMAL:

RAR#	Species	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Mating	Calving	Pupping
20	Harbor seal			HIGH	X	X	X	X	X	X	X	X	X	X	X	X	–	–	MAR-JUN
198	Dall's porpoise				X	X			X	X	X			X			–	–	–
	Gray whale			HIGH	X	X	X		X	X					X	X	–	–	–
	Harbor porpoise				X	X	X	X	X	X	X	X	X	X	X	X	–	–	–
199	California sea lion			HIGH	X	X	X	X	X	X	X	X	X	X	X	X	–	–	MAY-AUG
	Northern (Stellar) sea lion	F	T	MED						X	X	X	X				–	–	MAY-AUG
	Northern elephant seal			LOW	X	X	X			X	X			X			–	–	DEC-MAR

REPTILE:

RAR#	Species	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Nesting	Hatching	Internesting
166	Green sea turtle	S/F	T/T	LOW					X	X	X	X	X	X	X	X	MAY-AUG	JUL-NOV	–
	Loggerhead sea turtle	S/F	T/T	LOW					X	X	X	X	X	X	X	X	MAY-AUG	JUL-NOV	–
210	Green sea turtle	S/F	T/T	HIGH					X	X	X	X	X	X	X	X	MAY-AUG	JUL-NOV	–
	Loggerhead sea turtle	S/F	T/T	HIGH					X	X	X	X	X	X	X	X	MAY-AUG	JUL-NOV	–

HUMAN USE RESOURCES:

WATER_INTAKE:

RAR #	Name	Owner	Contact	Phone
H704	PEA ISLAND NWR IMPOUNDMENTS	USFWS		(919)987-2394

Figure 10. Example of the data associated with the biological resources on the ESI maps.

ELEMENT	COLOR	HATCH PATTERN ANGLE	SYMBOL	CMYK	RGB
Birds	Green	45		56/0/100/0	136/185/0
Habitats	Violet	90		31/100/0/0	168/0/102
Fish	Cyan	135		100/0/0/0	0/159/230
Invertebrates	Light Orange	45		0/31/100/0	255/184/0
Marine Mammals	Light Brown	0		19/44/88/0	215/153/52
Reptiles and Amphibians	Red	135		0/100/56/0	216/0/67
Terrestrial Mammals	Light Brown	90		19/44/88/0	215/153/52

Polygons representing the distribution of biological resources are filled with a hatched pattern using the appropriate color, and icons are placed in or connected to the boundary of the polygon. When more than one biological element (e.g., fish and birds) is included in the same polygon, a black-hatch polygon is used. A symbol set for ESI mapping applications has been developed and is included in Figure 11.

Resources that have widespread distribution are indicated by listing them in a box labeled "common throughout." Otherwise, the maps will be too cluttered. This same convention was used extensively and successfully on the traditional maps.

Human-Use Features

Nearly all human-use features are represented as points on the map. The only exceptions are managed lands (e.g., parks, preserves, reserves, and refuges), which are shown as polygons, and bridges, international boundaries, and other unclosed polygons which are shown as lines. The symbol for the human-use feature is offset from the feature with a leader line drawn from the symbol to the feature. For polygon and line features, the boundary of the feature is drawn using a dashed line, and the symbol for

the feature is placed somewhere inside the boundary. For sensitive resources where revealing the exact location may endanger the resources (such as historical and archaeological sites), the maps have icons that typically obscure the location. If there are many points clustered in the same area, either only a few icons are placed on the map products or they are moved in order to display all of the features. In the GIS database, the disclosure of sensitive resources is at the discretion of the data provider. In some instances, the data may be displayed on the map products only, with the resources removed from the digital database. Users should consult the ESI atlas introductory pages and GIS metadata to determine the availability of human-use resource information.

SENSITIVE BIOLOGICAL RESOURCES

BIRD

- Alcid / Pelagic Bird
- Diving Bird
- Gull / Tern
- Passerine Bird
- Raptor
- Shorebird
- Wading Bird
- Waterfowl

TERRESTRIAL MAMMAL

- Bear
- Deer
- Small Mammal

MARINE MAMMAL

- Dolphin
- Manatee
- Polar Bear
- Sea Otter
- Seal / Sea Lion
- Whale

REPTILE / AMPHIBIAN

- Alligator / Crocodile
- Turtle
- Other Reptiles / Amphibians

FISH

- Fish
- Nursery Area

SHELLFISH AND INSECT

- Bivalve
- Crab
- Echinoderm
- Gastropod
- Lobster/ Crayfish
- Shrimp
- Squid/ Octopus
- Insect

HABITAT

- Coral/ Hardbottom Reef
- Floating Aquatic Vegetation
- Rare Plant
- Submerged Aquatic Vegetation

HUMAN-USE FEATURES

- Access
- Airport
- Aquaculture
- Archaeological Site
- Beach
- Boat Ramp
- Camping
- Coast Guard
- Commercial Fishing
- Diving
- Factory
- Ferry
- Historical Site
- Hoist
- Indian Reservation / Tribal Land
- Logging
- Marina
- Marine Sanctuary
- Mining
- National Park
- Park
- Recreational Fishing
- Special Management Area
- Subsistance Fishing
- Water Intake
- Wildlife Refuge, Reserve, Preserve
- National or State Boundary
- Park or Refuge Boundary

Figure 11. ESI symbols for representing the biological and human-use resources.

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Appendix A

Master Species List

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
BIRD	alcid	46	Common murre	*Uria aalge*
		47	Pigeon guillemot	*Cepphus columba*
		48	Marbled murrelet	*Brachyramphus marmoratus*
		49	Cassin's auklet	*Ptychoramphus aleuticus*
		50	Rhinoceros auklet	*Cerorhinca monocerata*
		51	Tufted puffin	*Lunda cirrhata*
		75	Razorbill	*Alca torda*
		78	Atlantic puffin	*Fratercula arctica*
		81	Horned puffin	*Fratercula corniculata*
		84	Parakeet auklet	*Cyclorrhynchus psittacula*
		104	Murre	*Uria sp.*
		105	Thick-billed murre	*Uria lomvia*
		106	Ancient murrelet	*Synthliboramphus antiquus*
		108	Kittlitz's murrelet	*Brachyramphus brevirostris*
		109	Crested auklet	*Aethia cristatella*
		110	Dovekie	*Alle alle*
		111	Least auklet	*Aethia pusilla*
		112	Black guillemot	*Cepphus grylle*
		143	Xantus' murrelet	*Endomychura hypoleuca*
	bird	1000		
	diving	1	Common loon	*Gavia immer*
		2	Arctic loon	*Gavia arctica*
		3	Red-throated loon	*Gavia stellata*
		4	Red-necked grebe	*Podiceps grisegena*
		5	Horned grebe	*Podiceps auritus*
		6	Eared grebe	*Podiceps nigricollis*
		7	Western grebe	*Aechmophorus occidentalis*
		8	Double-crested cormorant	*Phalacrocorax auritus*
		9	Brandt's cormorant	*Phalacrocorax penicillatus*
		10	Pelagic cormorant	*Phalacrocorax pelagicus*
		31	Pacific loon	*Gavia pacifica*
		79	Cormorant	*Phalacrocorax sp.*
		99	Red-faced cormorant	*Phalacrocorax urile*
		118	Brown pelican	*Pelecanus occidentalis*
		121	Anhinga	*Anhinga anhinga*
		168	Olivaceous cormorant	*Phalacrocorax olivaceus*
		173	American white pelican	*Pelecanus erythrorhynchos*
		179	Pied-billed grebe	*Podilymbus podiceps*
		216	Belted kingfisher	*Megaceryle alcyon*
		269	Least grebe	*Podiceps dominicus*
		275	Great cormorant	*Phalacrocorax carbo*
		321	Ringed kingfisher	*Ceryle torquata*
		322	American pygmy kingfisher	*Chloroceryle aenea*
		323	Amazon kingfisher	*Chloroceryle amazona*
		324	Green kingfisher	*Chloroceryle americana*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	diving	325	Neotropic cormorant	*Phalacrocorax brasilianus*
		408	Yellow-billed loon	*Gavia adamsii*
		1006	Diving birds	
	gull_tern	36	Glaucous-winged gull	*Larus glaucescens*
		37	Western gull	*Larus occidentalis*
		38	Herring gull	*Larus argentatus*
		39	California gull	*Larus californicus*
		40	Ring-billed gull	*Larus delawarensis*
		41	Mew gull	*Larus canus*
		42	Bonaparte's gull	*Larus philadelphia*
		43	Heermann's gull	*Larus heermanni*
		44	Thayer's gull	*Larus thayeri*
		45	Common tern	*Sterna hirundo*
		80	Arctic tern	*Sterna paradisaea*
		82	Glaucous gull	*Larus hyperboreus*
		85	California least tern	*Sterna antillarum browni*
		86	Least tern	*Sterna albifrons*
		92	Great black-backed gull	*Larus marinus*
		95	Roseate tern	*Sterna dougallii*
		98	Laughing gull	*Larus atricilla*
		101	Aleutian tern	*Sterna aleutica*
		114	Sabine's gull	*Xema sabini*
		127	Sooty tern	*Sterna fuscata*
		133	Black skimmer	*Rynchops niger*
		134	Gull-billed tern	*Sterna nilotica*
		135	Sandwich tern	*Sterna sandvicensis*
		136	Caspian tern	*Sterna caspia*
		137	Royal tern	*Sterna maxima*
		138	Forster's tern	*Sterna fosteri*
		145	Elegant tern	*Sterna elegans*
		193	Black tern	*Chilidonias niger*
		241	Franklin's gull	*Larus pipixcan*
		264	White tern	*Gygis alba*
		283	Bridled tern	*Sterna anaethetus*
		317	Rare tern	
		318	Threatened tern	
		409	Ross' gull	*Rhodostethia rosea*
		410	Ivory gull	*Pagophila eburnea*
		1001	Gulls	
		1008	Terns	
	landfowl	276	Attwater's greater prairie chicken	*Tympanuchus cupido attwateri*
		416	Spruce grouse	*Falcipennis canadensis*
		417	Blue grouse	*Dendro gapus obscurus*
		418	Willow ptarmigan	*Lagopus lagopus*
		419	Rock ptarmigan	*Lagopus mutus*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	passerine	224	Sedge wren	*Cistothorus platensis*
		225	Marsh wren	*Cistothorus palustris*
		226	Red-winged blackbird	*Agelaius phoeniceus*
		228	Brewer's blackbird	*Euphagus cyanocephalus*
		229	Swamp sparrow	*Melospiza georgiana*
		235	Long-billed marsh wren	*Cistothorus palustris*
		236	Short-billed marsh wren	*Cistothorus platensis*
		274	Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
		277	Seaside sparrow	*Ammospiza maritima*
		278	Sharp-tailed sparrow	*Ammospiza caudacuta*
		279	Swainson's warbler	*Limnothlypis swainsonii*
		281	Yellow-bellied sapsucker	*Sphyrapicus varius*
		294	Cape Sable seaside sparrow	*Ammodramus maritimus mirabilis*
		295	Florida scrub jay	*Aphelocoma coerulescens coerulescens*
		297	White-crowned pigeon	*Columba leucocephala*
		305	Red-cockaded woodpecker	*Picoides borealis*
		310	Rare passerine bird	
		311	Endangered passerine bird	
		327	White-fronted parrot	*Amazona albifrons*
		328	Yellow-naped parrot	*Amazona auropalliata*
		329	Scarlet macaw	*Ara macao*
		330	Orange-fronted parakeet	*Aratinga canicularis*
		331	Green (red-throated) parakeet	*Aratinga horochlora*
		332	Pacific parakeet	*Aratinga strenua*
		333	Orange-chinned parakeet	*Brotogeris jugularis*
		334	Yellow warbler	*Dendroica petechia*
		335	Tropical mockingbird	*Mimus gilvus*
		336	Mangrove swallow	*Tachycineta albilinea*
		337	Mangrove vireo	*Vireo pallens*
		411	McKay's bunting	*Plextrophenax hyperboreus*
		1011	Migratory songbirds	
		1012	Neotropical migrants	
	pelagic	35	Parasitic jaeger	*Stercorarius parasiticus*
		83	Kittiwake	*Rissa sp.*
		96	Leach's storm-petrel	*Oceanodroma leucorhoa*
		100	Black-legged kittiwake	*Rissa tridactyla*
		102	Fork-tailed storm-petrel	*Oceanodroma furcata*
		119	Magnificent frigatebird	*Fregata magnificens*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	pelagic	126	Brown noddy	*Anous stolidus*
		128	Masked (blue-faced) booby	*Sula dactylatra*
		129	Northern fulmar	*Fulmarus glacialis*
		130	Red-legged kittiwake	*Rissa brevirostris*
		144	Ashy storm-petrel	*Oceanodroma homochroa*
		146	Black storm-petrel	*Oceanodroma melania*
		167	Northern gannet	*Morus bassanus*
		199	Pomarine jaegar	*Stercorarius pomarinus*
		200	Sooty shearwater	*Puffinus griseus*
		201	Short-tailed shearwater	*Puffinus tenuirostris*
		202	Pink-footed shearwater	*Puffinus creatopus*
		203	Flesh-footed shearwater	*Puffinus carneipes*
		247	Wedge-tailed shearwater	*Puffinus pacificus*
		248	Bulwer's petrel	*Bulweria bulwerii*
		249	Black noddy	*Anous minuta*
		250	Red-tailed tropicbird	*Phaethon rubridauda*
		251	Great frigatebird	*Fregata minor*
		252	White-tailed tropicbird	*Pheathon lepturus*
		253	Manx shearwater	*Puffinus puffinus*
		254	Laysan albatross	*Diomedia immutabilis*
		255	Black-footed albatross	*Diomedia nigriped*
		256	Bonin petrel	*Pterodroma hypoleuca*
		257	Tristram's storm petrel	*Oceanodroma tristrami*
		258	Christmas shearwater	*Puffinus nativitatis*
		260	Red-footed booby	*Sula sula*
		261	Brown booby	*Sula leucogaster*
		262	Gray-backed tern	*Sterna lunata*
		263	Blue-gray noddy	*Procelsterna serulea*
		312	Endangered pelagic bird	
		326	Jaegers	*Stercorarius spp.*
		338	South polar skua	*Catharacta maccormicki*
		339	Band-rumped storm-petrel	*Oceanodroma castro*
		340	Markham's storm-petrel	*Oceanodroma markhami*
		341	Wedge-rumped storm-petrel	*Oceanodroma tethys*
		342	Red-billed tropicbird	*Phaethon aethereus*
		343	Long-tailed jaeger	*Stercorarius longicaudus*
		344	Blue-footed booby	*Sula nebouxii*
		345	Storm petrels	*Oceanodroma spp.*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	pelagic	346	Boobys	*Sula spp.*
		412	Short-tailed albatross	*Phoebastria albatrus*
		1009	Shearwaters	
		1010	Pelagic birds	
	raptor	76	Bald eagle	*Haliaeetus leucocephalus*
		77	Osprey	*Pandion haliaetus*
		107	Peregrine falcon	*Falco peregrinus*
		113	Gyrfalcon	*Falco rusticolus*
		131	White-tailed kite	*Elanus leucuras*
		181	Northern harrier	*Circus cyaneus*
		182	American kestrel	*Falco sparverius*
		183	Snowy owl	*Nyctea scandiaca*
		218	Red-shouldered hawk	*Buteo lineatus*
		219	Sharp-shinned hawk	*Accipiter striatus*
		220	Merlin	*Falco columbarius*
		221	Cooper's hawk	*Accipiter cooperii*
		222	Barred owl	*Strix varia*
		230	Red-tailed hawk	*Buteo jamaicensis*
		231	Broad-winged hawk	*Buteo platypterus*
		232	Rough-legged hawk	*Buteo lagopus*
		233	Northern goshawk	*Accipiter gentilis*
		240	Goshawk	*Accipiter gentilis*
		280	Swallow-tailed kite	*Elanoides forficatus*
		296	Snail kite	*Rostrhamus sociabilis*
		313	Rare raptor	
		314	Endangered raptor	
		347	Bicolored hawk	*Accipiter bicolor*
		348	Striped owl	*Pseudoscops clamator*
		349	Burrowing owl	*Athene cunicularia*
		350	Great horned owl	*Bubo virginianus*
		351	Black-collared hawk	*Busarellus nigricollis*
		352	White-tailed hawk	*Buteo albicaudatus*
		353	Zone-tailed hawk	*Buteo albonotatus*
		354	Short-tailed hawk	*Buteo brachyurus*
		355	Roadside hawk	*Buteo magnirostris*
		356	Gray hawk	*Buteo nitidus*
		357	Swainson's hawk	*Buteo swainsoni*
		358	Mangrove black-hawk	*Buteogallus subtilis*
		359	Great black-hawk	*Buteogallus urubitinga*
		360	Turkey vulture	*Cathartes aura*
		361	Lesser yellow-headed vulture	*Cathartes burrovianus*
		362	Hook-billed kite	*Chondrohierax uncinatus*
		363	Black-and-white owl	*Ciccaba nigrolineata*
		364	Mottled owl	*Ciccaba virgata*
		365	Black vulture	*Coragyps atratus*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	raptor	366	Red-throated caracara	*Daptrius americanus*
		368	Orange-breasted falcon	*Falco deiroleucus*
		369	Aplomado falcon	*Falco femoralis*
		370	Bat falcon	*Falco rufigularis*
		371	Crane hawk	*Geranospiza caerulescens*
		372	Ferruginous pygmy-owl	*Glaucidium brasilianum*
		373	Double-toothed kite	*Harpagus bidentatus*
		374	Laughing falcon	*Herpetotheres cachinnans*
		375	Mississippi kite	*Ictinia mississippiensis*
		376	Plumbeous kite	*Ictinia plumbea*
		377	Gray-headed kite	*Leptodon cayanensis*
		378	Collared forest-falcon	*Micrastur semitorquatus*
		379	Pacific screech owl	*Otus cooperi*
		380	Harris' (bay-winged) hawk	*Parabuteo unicinctus*
		381	Crested caracara	*Caracara plancus*
		382	Spectacled owl	*Pulsatrix parspicillata*
		383	King vulture	*Sarcoramphus papa*
		384	Ornate hawk-eagle	*Spizaetus ornatus*
		385	Barn owl	*Tyto alba*
		386	Accipiter hawks	*Accipiter spp.*
		387	Buteo hawks	*Buteo spp.*
		388	Falcons	*Falco spp.*
		389	Owls	*Strigidae spp.*
		1005	Raptors	
	shorebird	52	Wilson's phalarope	*Steganopus tricolor*
		53	Red-necked (Northern) phalarope	*Phalaropus lobatus*
		55	Whimbrel	*Numenius phaeopus*
		56	Spotted sandpiper	*Actitis macularia*
		57	Wandering tattler	*Heteroscelus incanus*
		58	Greater yellowlegs	*Tringa melanaleuca*
		59	Lesser yellowlegs	*Tringa flavipes*
		60	Red knot	*Calidris canutus*
		61	Pectoral sandpiper	*Calidris melanotos*
		62	Least sandpiper	*Calidris minutilla*
		63	Dunlin	*Calidris alpina*
		64	Short-billed dowitcher	*Limnodromus griseus*
		65	Long-billed dowitcher	*Limnodromus scolopaceus*
		66	Western sandpiper	*Calidris mauri*
		67	Sanderling	*Calidris alba*
		68	Black oystercatcher	*Haematopus bachmani*
		69	Semipalmated plover	*Charadrius semipalmatus*
		70	Killdeer	*Charadrius vociferus*
		71	Black-bellied plover	*Pluvialis squatarola*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	shorebird	72	Surfbird	*Aphriza virgata*
		73	Ruddy turnstone	*Arenaria interpres*
		74	Black turnstone	*Arenaria melancephala*
		139	Snowy plover	*Charadrius alexandrinus*
		152	American oystercatcher	*Haematopus palliatus*
		153	Piping plover	*Charadrius melodus*
		154	Wilson's plover	*Charadrius wilsonia*
		155	Willet	*Catoptrophorus semipalmatus*
		156	Semipalmated sandpiper	*Calidris pusilla*
		160	Red phalarope	*Phalaropus fulicarius*
		161	Rock sandpiper	*Calidris ptilocnemis*
		164	American golden-plover	*Pluvialis dominica*
		165	Bar-tailed godwit	*Limosa lapponica*
		196	Common snipe	*Gallinago gallinago*
		209	Long-billed curlew	*Numenius americanus*
		210	Marbled godwit	*Limosa fedoa*
		213	Stilt sandpiper	*Calidris himantopus*
		214	Solitary sandpiper	*Tringa solitaria*
		223	Upland sandpiper	*Bartramia longicauda*
		234	Purple sandpiper	*Calidris maritima*
		237	Baird's sandpiper	*Calidris bairdii*
		238	White-rumped sandpiper	*Calidris fusciollis*
		270	Western snowy plover	*Charadrius alexandrinus nivosus*
		284	Buff-breasted sandpiper	*Tryngites subruficollis*
		286	Dowitchers	*Limnodromus spp.*
		289	Hudsonian godwit	*Limosa haemastica*
		290	Peep	*Calidris spp.*
		292	Sharp-tailed sandpiper	*Calidris acuminata*
		293	Yellowlegs	*Tringa spp.*
		303	Curlew sandpiper	*Calidris ferruginea*
		315	Rare shorebird	
		316	Endangered shorebird	
		390	Double-striped thick-knee	*Burhinus bistriatus*
		391	Collared plover	*Charadrius collaris*
		392	Northern jacana	*Jacana spinosa*
		394	Plovers	*Charadrius spp.*
		396	Phalaropes	*Phalaropus spp.*
		413	Bristle-thighed curlew	*Numenius tahitiensis*
		414	Eskimo curlew	*Numenius borealis*
		1002	Shorebirds	

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	wading	54	Great blue heron	*Ardea herodias*
		87	Little blue heron	*Egretta caerulea*
		88	Great egret	*Casmerodius albus*
		89	Snowy egret	*Egretta thula*
		90	Black-crowned night-heron	*Nycticorax nycticorax*
		91	Glossy ibis	*Plegadis falcinellus*
		93	Cattle egret	*Bubulcus ibis*
		94	Tricolored heron	*Egretta tricolor*
		97	Green heron	*Butorides virescens*
		115	White ibis	*Eudocimus albus*
		116	Roseate spoonbill	*Ajaia ajaja*
		117	Great white heron	*Ardea occidentalis*
		120	Yellow-crowned night-heron	*Nyctanassa violacea*
		122	Scarlet ibis	*Eudocimus ruber*
		125	Clapper rail	*Rallus longirostris*
		132	Wood stork	*Mycteria americana*
		141	American avocet	*Recurvirostra americana*
		142	Black-necked stilt	*Himantopus mexicanus*
		149	White-faced ibis	*Plegadis chihi*
		150	Black rail	*Laterallus jamaicensis*
		163	Reddish egret	*Egretta rufescens*
		172	Sandhill crane	*Grus canadensis*
		178	Least bittern	*Ixobrychus exilis*
		184	King rail	*Rallus elegans*
		185	American bittern	*Botaurus lentiginosus*
		187	Virginia rail	*Rallus limicola*
		188	Sora rail	*Porzana carolina*
		189	Yellow rail	*Coturnicops noveboracensis*
		195	American woodcock	*Philohela minor*
		204	California clapper rail	*Rallus longirostris obsoletus*
		205	Light-footed clapper rail	*Rallus longirostris levipes*
		206	California black rail	*Laterallus jamaicensis coturniculus*
		242	Hawaiian stilt	*Himantopus mexicanus knudseni*
		265	Whooping crane	*Grus americana*
		271	Rails	
		298	Mississippi sandhill crane	*Grus canadensis pulla*
		304	Mangrove clapper rail	*Rallus longirostris insularum*
		306	Limpkin	*Aramus guarauna*
		309	Florida sandhill crane	*Grus canadensis pratensis*
		319	Rare wading bird	
		320	Endangered wading bird	

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	wading	397	Rufous-necked wood-rail	*Aramides axillaris*
		398	Gray-necked wood-rail	*Aramides cajanea*
		399	Pinnated bittern	*Botaurus pinnatus*
		400	Boat-billed heron	*Cochlearius cochlearius*
		401	Jabiru	*Jabiru mycteria*
		402	Ruddy crake	*Laterallus ruber*
		403	Spotted rail	*Pardirallus maculatus*
		404	Yellow-breasted crake	*Porzana flaviventer*
		405	Bare-throated tiger-heron	*Tigrisoma mexicanum*
		1004	Wading birds	
	waterfowl	11	Tundra (whistling) swan	*Cygnus columbianus*
		12	Canada goose	*Branta canadensis*
		13	Brant	*Branta bernicla*
		14	Greater white-fronted goose	*Anser albifrons*
		15	Snow goose	*Chen caerulescens*
		16	Mallard	*Anas platyrhynchos*
		17	Northern pintail	*Anas acuta*
		18	Green-winged teal	*Anas crecca*
		19	Rock dove	*Columba livia*
		20	Northern shoveler	*Anas clypeata*
		21	Canvasback	*Aythya valisineria*
		22	Greater scaup	*Aythya marila*
		23	Lesser scaup	*Aythya affinis*
		24	Common goldeneye	*Bucephala clangula*
		25	Barrow's goldeneye	*Bucephala islandica*
		26	Bufflehead	*Bucephala albeola*
		27	Oldsquaw	*Clangula hyemalis*
		28	Harlequin duck	*Histrionicus histrionicus*
		29	White-winged scoter	*Melanitta deglandi*
		30	Surf scoter	*Melanitta perspicillata*
		32	Common merganser	*Mergus merganser*
		33	Red-breasted merganser	*Mergus serrator*
		34	American coot	*Fulica americana*
		103	Common eider	*Somateria mollissima*
		124	Redhead	*Aythya americana*
		148	Ruddy duck	*Oxyura jamaicensis*
		157	Emperor goose	*Philacte canagica*
		158	King eider	*Somateria spectabilis*
		159	Steller's eider	*Polysticta stelleri*
		162	Gadwall	*Anas strepera*
		169	American wigeon	*Anas americana*
		170	Trumpeter swan	*Olor buccinator*
		171	Dusky Canada goose	*Branta canadensis occidentalis*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	waterfowl	180	Ring-necked duck	*Aythya collaris*
		186	American black duck	*Anas rubripes*
		190	Blue-winged teal	*Anas discors*
		191	Wood duck	*Aix sponsa*
		192	Common moorhen	*Gallinula chloropus*
		197	Black (common) scoter	*Melanitta nigra*
		198	Hooded merganser	*Lophodytes cucullatus*
		211	Mottled duck	*Anas fulrigula*
		212	Purple gallinule	*Porphyrula martinica*
		215	Aleutian Canada goose	*Branta canadensis leucopareia*
		217	Mute swan	*Lygnus olor*
		243	Hawaiian coot	*Fulica americana alia*
		244	Hawaiian duck	*Anas wyvilliana*
		245	Hawaiian common moorhen	*Gallinula chloropus sandvicensis*
		246	Laysan duck	*Anas laysanensis*
		266	Black-bellied whistling-duck	*Dendrocygna autumnalis*
		267	Fulvous whistling-duck	*Dendrocygna bicolor*
		268	Masked duck	*Oxyura dominica*
		272	Teals	*Anas spp.*
		273	*Geese*	
		299	Scaup	*Aythya spp.*
		300	Goldeneye	*Bucephala spp.*
		301	Mergansers	*Mergus spp.*
		302	Scoters	*Melanitta spp.*
		406	Cinnamon teal	*Anas cyanoptera*
		407	Muscovy duck	*Cairina moschata*
		415	Spectacled eider	*Somateria fischeri*
		1003	Waterfowl	
		1013	Dabbling ducks	
		1014	Diving ducks	
		1020	Eiders	*Somateria spp.*
		1021	Ducks	

ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
FISH	1	Sablefish (blackcod)	*Anoplopoma fimbria*
	2	Lingcod	*Ophiodon elongatus*
	3	Pacific sanddab	*Citharichthys sordidus*
	4	Arrowtooth flounder	*Atheresthes stomias*
	5	Petrale sole	*Eopsetta jordani*
	6	Rex sole	*Glyptocephalus zachirus*
	7	Pacific halibut	*Hippoglossus stenolepis*
	8	Butter sole	*Isopsetta isolepis*
	9	Rock sole	*Lepidopsetta bilineata*
	10	Dover sole	*Microstomus pacificus*

ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
FISH	11	English sole	*Parophrys vetulus*
	12	Starry flounder	*Platichthys stellatus*
	13	C-O sole	*Pleuronichthys coenosus*
	14	Curlfin sole	*Pleuronichthys decurrens*
	15	Sand sole	*Psettichthys melanostictus*
	16	Flathead sole	*Hippoglossoides elassodon*
	17	Slender sole	*Lyopsetta exilis*
	18	Plainfin midshipman	*Porichthys notatus*
	19	Pacific cod	*Gadus macrocephalus*
	20	Pacific hake	*Merluccius productus*
	21	Pacific tomcod	*Microgadus proximus*
	22	Walleye pollock	*Theragra chalcogramma*
	23	Wolf-eel	*Anarrhichthys ocellatus*
	24	Pacific ocean perch	*Sebastes alutus*
	25	Silvergray rockfish (short spine)	*Sebastes brevispinis*
	26	Copper rockfish	*Sebastes caurinus*
	27	Puget Sound rockfish	*Sebastes emphaeus*
	28	Yellowtail rockfish	*Sebastes flavidus*
	29	Black rockfish	*Sebastes melanops*
	30	Bocaccio	*Sebastes paucispinis*
	31	Yelloweye rockfish	*Sebastes ruberrimus*
	32	Canary rockfish (orange)	*Sebastes pinniger*
	33	Chilipepper	*Sebastes goodei*
	34	Redbanded rockfish (flag)	*Sebastes babcocki*
	35	Rougheye rockfish	*Sebastes aleutianus*
	36	Splitnose rockfish	*Sebastes diploproa*
	37	Greenstriped rockfish	*Sebastes elongatus*
	38	Brown rockfish	*Sebastes auriculatus*
	39	Redstripe rockfish	*Sebastes proriger*
	40	Big skate	*Raja binoculata*
	41	Longnose skate	*Raja rhina*
	42	Spotted ratfish	*Hydrolagus colliei*
	43	White sturgeon	*Acipenser transmontanus*
	44	Green sturgeon	*Acipenser medirostris*
	45	Cutthroat trout	*Salmo clarki*
	46	Kelp greenling	*Hexagrammos decagrammus*
	47	Rock greenling	*Hexagrammos lagocephalus*
	48	Whitespotted greenling	*Hexagrammos stelleri*
	49	Buffalo sculpin	*Enophrys bison*
	50	Red Irish lord	*Hemilepidotus hemilepidotus*
	51	Pacific staghorn sculpin	*Leptocottus armatus*
	52	Tidepool sculpin	*Oligocottus maculosus*
	53	Cabezon	*Scorpaenichthys marmoratus*
	54	Redtail surfperch	*Amphistichus rhodoterus*
	55	Kelp perch	*Brachyistius frenatus*
	56	Shiner perch	*Cymatogaster aggregata*
	57	Striped seaperch	*Embiotoca lateralis*

ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
FISH	58	Walleye surfperch	*Hyperprosopon argenteum*
	59	Pile perch	*Rhacochilus vacca*
	60	White seaperch	*Phanerodon furcatus*
	61	Penpoint gunnel	*Apodichthys flavidus*
	62	Saddleback gunnel	*Pholis ornata*
	63	Crescent gunnel	*Pholis laeta*
	64	Quillback rockfish	*Sebastes maliger*
	65	Bluefish	*Pomatomus saltatrix*
	66	Pacific herring	*Clupea harengus pallasi*
	67	Northern anchovy	*Engraulis mordax*
	68	Chinook salmon (king)	*Oncorhynchus tshawytscha*
	69	Coho salmon (silver)	*Oncorhynchus kisutch*
	70	Pink salmon (humpy)	*Oncorhynchus gorbuscha*
	71	Sockeye salmon (red)	*Oncorhynchus nerka*
	72	Chum salmon (dog)	*Oncorhynchus keta*
	73	Cherry salmon	*Oncorhynchus masu*
	74	Rainbow trout (steelhead)	*Oncorhynchus mykiss*
	75	Surf smelt	*Hypomesus pretiosus*
	77	Eulachon	*Thaleichthys pacificus*
	78	Capelin	*Mallotus villosus*
	79	White seabass	*Atractoscion nobilis*
	80	Pacific sand lance	*Ammodytes hexapterus*
	81	Spiny dogfish	*Squalus acanthias*
	83	Salmon	
	84	Rainbow smelt	*Osmerus mordax*
	85	Alewife	*Alosa pseudoharengus*
	86	Blueback herring	*Alosa aestivalis*
	87	American shad	*Alosa sapidissima*
	88	Winter flounder	*Pseudopleuronectes americanus*
	89	Cunner	*Tautogolabrus adspersus*
	90	White hake	*Urophycis tenuis*
	91	Threespine stickleback	*Gasterosteus aculeatus*
	92	Fourspine stickleback	*Apeltes quadracus*
	93	Striped killifish	*Fundulus majalis*
	94	Atlantic silverside	*Menidia menidia*
	95	Mummichog	*Fundulus heteroclitus*
	96	Sanddab	*Citharichthys sp.*
	97	Tautog	*Tautoga onitis*
	98	American eel	*Anguilla rostrata*
	99	Atlantic tomcod	*Microgadus tomcod*
	100	Brown trout	*Salmo trutta*
	101	Shortnose sturgeon	*Acipenser brevirostrum*
	102	Atlantic sturgeon	*Acipenser oxyrhynchus*
	103	Threadfin shad	*Dorosoma petenense*
	104	Striped bass	*Morone saxatilis*
	105	Hickory shad	*Alosa mediocris*
	106	California grunion	*Leuresthes tenuis*

ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
FISH	107	Spotted seatrout	*Cynoscion nebulosus*
	108	Summer flounder	*Paralichthys dentatus*
	109	Red drum	*Sciaenops ocellatus*
	110	Black seabass	*Centropristis striata*
	111	Southern flounder	*Paralichthys lethostigma*
	112	Gulf flounder	*Paralichthys albigutta*
	113	Bay anchovy	*Anchoa mitchilli*
	114	Florida pompano	*Trachinotus carolinus*
	115	Atlantic menhaden	*Brevoortia tyrannus*
	116	Striped mullet	*Mugil cephalus*
	117	Pinfish	*Lagodon rhomboides*
	118	Yellowfin mojarra	*Gerres cinereus*
	119	Silver perch	*Bairdiella chrysoura*
	120	Pigfish	*Orthopristis chrysoptera*
	121	Spot	*Leiostomus xanthurus*
	122	Black drum	*Pogonias cromis*
	123	Atlantic croaker	*Micropogonias undulatus*
	124	Southern kingfish (whiting)	*Menticirrhus americanus*
	126	King mackerel	*Scomberomorus cavalla*
	127	Spanish mackerel	*Scomberomorus maculatus*
	128	Blue runner	*Caranx crysos*
	129	Atlantic thread herring	*Opisthonema oglinum*
	130	Scaled sardine	*Harengula jaguana*
	131	Great barracuda	*Sphyraena barracuda*
	132	Grouper	*Epinephalus spp.*
	133	Snapper	*Lutjanus spp.*
	134	Cobia	*Rachycentron canadum*
	135	Dolly varden	*Salvelinus malma*
	136	Dolphin	*Coryphaena hippurus*
	137	Sheepshead	*Archosargus probatocephalus*
	138	Seatrout (weakfish)	*Cynoscion regalis*
	139	Spanish sardine	*Sardinella aurita*
	140	Ladyfish	*Elops saurus*
	141	Snook	*Centropomus undecimalis*
	142	Crevalle jack	*Caranx hippos*
	143	Tarpon	*Megalops atlanticus*
	144	Atlantic salmon	*Salmo salar*
	145	White perch	*Morone americana*
	146	Atlantic herring	*Clupea harengus harengus*
	147	Atlantic mackerel	*Scomber scombrus*
	148	Silver hake	*Merluccius bilinearis*
	149	Atlantic cod	*Gadus morhua*
	150	Porgy (scup)	*Stenotomus chrysops*
	151	Northern puffer	*Sphoeroides maculatus*
	152	Yellow perch	*Perca flavescens*
	153	Northern kingfish	*Menticirrhus saxatilis*
	154	Pollock	*Pollachius virens*

ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
FISH	155	Squirrel (red) hake (ling)	*Urophycis chuss*
	156	American sand lance	*Ammodytes americanus*
	157	Goosefish	*Lophius americanus*
	158	Butterfish	*Peprilus triacanthus*
	159	Banded killifish	*Fundulus diaphanus*
	160	Windowpane (flounder)	*Scophthalmus aquosus*
	161	Lake sturgeon	*Acipenser fulvescens*
	162	Carp	*Cyprinus carpio*
	163	Gizzard shad	*Dorosoma cepedianum*
	164	Cisco	*Coregonus spp.*
	165	Lake whitefish	*Coregonus clupeaformis*
	166	Brook trout	*Salvelinus fontinalis*
	167	Lake trout	*Salvelinus namaycush*
	168	Spottail shiner	*Notropis hudsonius*
	169	Blackchin shiner	*Notropis heterodon*
	170	Blacknose shiner	*Notropis heterolepis*
	171	Fathead minnow	*Pimephales promelas*
	172	Longfin smelt	*Spirinchus thaleichthys*
	173	White mullet	*Mugil curema*
	174	Longnose sucker	*Catostomus catostomus*
	175	White sucker	*Catostomus commersoni*
	176	Yellow bullhead	*Ictalurus natalis*
	178	Rock bass	*Ambloplites rupestris*
	179	Largemouth bass	*Micropterus salmoides*
	180	Smallmouth bass	*Micropterus dolomieui*
	181	Black crappie	*Pomoxis nigromaculatus*
	182	Bluegill	*Lepomis macrochirus*
	183	Green sunfish	*Lepomis cyanellus*
	184	Grass pickerel	*Esox americanus*
	185	Northern pike	*Esox lucius*
	186	Muskellunge	*Esox masquinongy*
	187	Sauger	*Stizostedion canadense*
	188	Walleye	*Stizostedion vitreum vitreum*
	189	Arctic char	*Salvelinus alpinus*
	190	White bass	*Morone chrysops*
	191	Shorthead redhorse	*Moxostoma macrolepidotum*
	192	Topsmelt	*Atherinops affinis*
	193	Jacksmelt	*Atherinopsis californiensis*
	194	White baitsmelt	*Allosmerus elongatus*
	195	Silver surfperch	*Hyperprosopon ellipticum*
	196	Blue rockfish	*Sebastes mystinus*
	197	Grass rockfish	*Sebastes rastrelliger*
	198	Brown Irish lord	*Hemilepidotus spinosus*
	199	Rock gunnel	*Pholis gunnellus*
	200	Blue catfish	*Ictalurus furcatus*
	201	Channel catfish	*Ictalurus punctatus*
	202	White crappie	*Pomoxis annylaris*

ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
FISH	203	Warmouth	*Chaenobryttus gulosus*
	204	Redear sunfish	*Lepomis microlophus*
	205	Freshwater drum	*Aplodinotus grunnieus*
	206	Spotted sunfish	*Lepomis punctatus miniatus*
	207	Sea catfish	*Galeichthyes felis*
	208	Northern squawfish	*Ptychocheilus oregonensis*
	209	Peamouth	*Mylocheilus caurinus*
	210	Largescale sucker	*Catostomus macrocheilus*
	211	Brown bullhead	*Ictalarus nebulosus*
	212	Pumpkinseed	*Lepomis gibbosus*
	213	Gulf menhaden	*Brevoortia patronus*
	214	Gulf kingfish	*Menticirrhus littoralis*
	215	Sand seatrout	*Cynoscion arenarius*
	217	Gafftopsail catfish	*Bagre marinus*
	219	Pacific lamprey	*Entosphenus tridentatus*
	220	Sandroller	*Percopsis transmontana*
	221	Chiselmouth	*Acrocheilus alutaceus*
	222	Mottled sculpin	*Cottus bairdi*
	223	Rockfish	*Sebastes spp.*
	224	Surfperch	
	225	California halibut	*Paralichthys californicus*
	226	Tidewater goby	*Eucyclogobius newberryi*
	227	Prickly sculpin	*Cottus asper*
	228	Night smelt	*Spirinchus starksi*
	229	River redhorse	*Moxostoma carinatum*
	230	Pygmy whitefish	*Prosopium coulteri*
	231	Tadpole madtom	*Noturus gyrinus*
	232	Trout perch	*Percopsis omiscomaycus*
	233	Ninespine stickleback	*Pungitius pungitius*
	234	Johnny darter	*Etheostoma nigrum*
	235	Lake herring	*Coregonus artedii*
	237	Burbot	*Lota lota*
	238	Round whitefish (menomonee)	*Prosopium clindraceum*
	239	Splake	*Salvelinus namaycush + fontinalis*
	240	Greater redhorse	*Moxostoma valenciennesi*
	241	Striped shiner	*Notropis chrysocephalus*
	242	Redfin shiner	*Notropis umbratilis*
	243	Longear sunfish	*Lepomis megalotis*
	244	Golden redhorse	*Moxostoma erythrurum*
	245	Silver redhorse	*Moxostoma anisurum*
	246	Black bullhead	*Ictaluras melas*
	247	Emerald shiner	*Notropis atherinoides*
	248	Common shiner	*Notropis cornutus*
	249	Logperch	*Percina caprodes*
	250	Ruffe	*Gymnocephalus cernuus*
	251	Tiger musky	*Esox masquinongy x lucius*
	252	Yellow bass	*Morone mississippiensis*

ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
FISH	253	Butterfly fish	*Chaetodon sp.*
	254	Surgeon fish	*Acanthurus sp.*
	255	Damselfish	*Chromis sp.*
	256	Wrasse	*Thalassoma sp.*
	258	Hawaiian anchovy	*Stolephorus purpurens*
	259	Freshwater goby	*Awaous sp.*
	260	Barred sand bass	*Paralabrax nebulifer*
	261	Spotted sand bass	*Paralabrax maculatofasciatus*
	262	California corbina	*Menticirrhus undulatus*
	263	Shortfin corvina	*Cynoscion parvipinnis*
	264	Yellowfin croaker	*Umbrina roncador*
	265	Spotfin croaker	*Roncador stearnsii*
	266	Kelp bass	*Paralabrax clathratus*
	267	Opaleye	*Girella nigricans*
	268	Silver seatrout	*Cynoscion nothus*
	269	Gulf killifish	*Fundulus grandis*
	270	Longnose killifish	*Fundulus similis*
	271	Inland silverside	*Menidia beryllina*
	272	Rainbow runner	*Elegatis bipinnulata*
	273	Star drum	*Stellifer lanceolatus*
	274	Sheepshead minnow	*Cyprinodon variegatus*
	275	Least puffer	*Sphoeroides parvus*
	276	Red shiner	*Notropis lutrensis*
	277	Paddlefish	*Polyodon spathula*
	278	Little tunny	*Euthynnus alletteratus*
	279	Blue sucker	*Cycleptus elongatus*
	280	Sunfish	*Lepomis spp.*
	281	Seatrout	*Cynoscion sp.*
	282	Mullet	*Mugil spp.*
	283	Killifish	*Fundulus spp.*
	284	Flounder	*Paralichthys sp.*
	285	California barracuda	*Sphyraena argentea*
	286	Sole	
	287	Hardhead catfish	*Arius felis*
	288	Tripletail	*Lobotes surinamensis*
	289	Skipjack herring	*Alosa chrysochloris*
	290	Striped anchovy	*Anchoa hepsetus*
	291	Shiners	*Notropis spp.*
	292	Chain pickerel	*Esox niger*
	293	Southern hake	*Urophycis floridanus*
	294	Spotted hake	*Urophycis regius*
	295	Halfbeak	*Hyporhamphus unifasciatus*
	296	Diamond killifish	*Adenia xenica*
	297	Marsh killifish	*Fundulus confluentus*
	298	Saltmarsh topminnow	*Fundulus jenkinsi*
	299	Rainwater killifish	*Lucania parva*
	300	Sailfin molly	*Poecilia latipinnaa*

ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
FISH	301	Rough silverside	*Membras martinica*
	302	Gag grouper	*Mycteroperca microlepis*
	303	Permit	*Trachinotus falcatus*
	304	Rough scad	*Trachurus lathami*
	305	Red snapper	*Lutjanus campechanus*
	306	Gray snapper	*Lutjanus griseus*
	307	Lane snapper	*Lutjanus synagris*
	308	Rock sea bass	*Centropristis philadelphica*
	309	Spotfin mojarra	*Eucinostomus argenteus*
	310	Atlantic spadefish	*Chaetodipterus faber*
	311	Atlantic bonito	*Sarda sarda*
	312	Harvestfish	*Peprilus alepidotus*
	313	Gulf butterfish	*Peprilus burti*
	314	Broad flounder	*Paralichthys squamilentus*
	315	Blacktip shark	*Carcharhinus limbatus*
	316	Spinner shark	*Carcharhinus brevipinna*
	317	Bull shark	*Carcharhinus leucas*
	318	Atlantic sharpnose shark	*Rhizoprionodon terraenovae*
	319	Gulf sturgeon	*Acipenser oxyrhynchus desotoi*
	320	Atlantic bumper	*Chloroscombrus chrysurus*
	321	Atlantic cutlassfish	*Trichiurus lepturus*
	323	Atlantic stingray (stingaree)	*Dasyatis sabina*
	324	Bighead searobin	*Prionotus gibbesii*
	325	Blackcheek tonguefish	*Symphurus plagiusa*
	326	Bonnethead shark	*Sphyrna tiburo*
	327	Dwarf seahorse	*Hippocampus zosterae*
	328	Gar	*Lepisosteidae*
	329	Grass carp	*Ctenopharyngodon idella*
	330	Hammerhead	*Sphyrna lewini*
	331	Sharks	
	332	Tiger shark	*Galeocerdo cuvieri*
	333	Herring and shad	*Alosa spp.*
	334	Finetooth shark	*Carcharhinus isodon*
	335	Silversides	*Menidia spp.*
	336	Pearl darter	*Percina aurora*
	337	Freckled darter	*Percina lenticula*
	338	Frecklebelly madtom	*Noturus munitus*
	339	Bluenose shiner	*Pteronotropis welaka*
	340	Dusky shiner	*Notropis cummingsae*
	341	River goby	*Aqaous tajasica*
	342	Snail bullhead	*Ameiurus brunneus*
	343	Yellow jack	*Caranx bartholomaei*
	344	Bar jack	*Caranx ruber*
	345	Spotfin butterflyfish	*Chaetodon ocellatus*
	346	Mackerel scad	*Decapterus macarellus*
	347	Round scad	*Decapterus punctatus*
	348	Spottail pinfish	*Diplodus holbrooki*

ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
FISH	349	Cubbyu	*Equetus umbrosus*
	350	Tomtate	*Haemulon aurolineatum*
	351	Slippery dick	*Halichoeres bivittatus*
	352	Blue angelfish	*Holacanthus bermudensis*
	354	Scamp grouper	*Mycteroperca phenax*
	355	Red porgy	*Pagrus pagrus*
	356	Greater amberjack	*Seriola dumerili*
	357	Belted sandfish	*Serranus subligarius*
	358	Cocoa damselfish	*Pomacentrus variabilis*
	359	Longspine porgy	*Stenotomus caprinus*
	360	Sand perch	*Diplectrum formosum*
	361	Pearly razorfish	*Hemipteronotus novacula*
	362	Southern stingray	*Dasyatis americana*
	363	Inshore lizardfish	*Synodus foetans*
	364	Endangered anadromous fish	
	365	Rare fish	
	366	Hogchoker	*Trinectes maculatus*
	367	Alabama shad	*Alosa alabamae*
	368	Yellowfin menhaden	*Brevoortia smithi*
	369	Code goby	*Gobiosoma robustum*
	370	Finescale menhaden	*Brevoortia gunteri*
	371	Atlantic threadfin	*Polydactylus octonemus*
	372	Leatherjacket	*Oligoplites saurus*
	373	Silver jenny	*Eucinostomus gula*
	374	Naked goby	*Gobiosoma bosci*
	375	Bay whiff	*Citharichtys spilopterus*
	376	Fringed flounder	*Etropus crossotus*
	377	Gulf toadfish	*Opsanus beta*
	378	Atlantic needlefish	*Strongylura marina*
	379	Pipefish	*Syngnathus spp.*
	380	Texas pipefish	*Syngnathus fuscus affinis*
	381	Cusk eels	*Ophidion spp.*
	382	Mountain mullet	*Agonostomus monticola*
	383	Panamic sergeant major	*Abudefduf Troschelii*
	384	Spotted eagle ray	*Aetobatus narinari*
	385	Threebanded butterflyfish	*Chaetodon humeralis*
	386	Balloonfish	*Diodon holocanthus*
	387	Spotted porcupinefish	*Diodon hystrix*
	388	Flag cabrilla	*Epinephelus labriformis*
	389	Nassau grouper	*Epinephelus striatus*
	390	Panamic green moray	*Gymnothorax castaneus*
	391	Chamelion wrasse	*Halichoeres dispilus*
	392	Amarillo snapper	*Lutjanus argentiventris*
	393	Dusky sergeant major	*Nexilarius concolor*
	394	Pacific snake eel	*Ophichthus triserialis*
	395	Cortez angelfish	*Pomacanthus zonipectus*
	396	Banded wrasse	*Psuedojulis notospilus*

ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
FISH	397	Bumphead parrotfish	*Scarus perrico*
	398	Orangeside triggerfish	*Sufflamen verres*
	399	Sharpnose lizardfish	*Synodus scituliceps*
	400	Cortez rainbow wrasse	*Thalassoma lucasanum*
	401	Green jack	*Caranx caballus*
	402	Pacific crevalle jack	*Caranx caninus*
	403	Oceanic whitetip	*Carcharhinus longimanus*
	404	Black skipjack	*Euthynnus linneatus*
	405	Deepbody thread herring	*Opisthonema libertate*
	406	Gulf sierra	*Scomberomorus sierra*
	407	California needlefish	*Strongylora exilis*
	408		*Atracosteus tropicus*
	409		*Centropomus armatus*
	410		*Centropomus medius*
	411		*Centropomus robalito*
	412		*Eucinostomus sp.*
	413		*Anableps dovii*
	414		*Arius sp.*
	415		*Bagre sp.*
	416		*Diapterus sp.*
	417		*Galeichthys sp.*
	418		*Galeichthys jordani*
	419		*Melaniris guatemalensis*
	420		*Acanthurus triostegus*
	421		*Acanthurus xanthopterus*
	422		*Apogon dovii*
	423		*Lycodontis castaneus*
	424		*Narcine vermiculatus*
	425		*Raja equatoralis*
	426		*Sargocentron suborbitalis*
	427		*Stegastes acapulcoensis*
	428		*Anchovia sp.*
	429		*Selene orestedii*
	430		*Selene sp.*
	1015	Rays	
	1016	Skates	
	1017	Grunts	
	1018	Porgies	
	1019	Snappers	
	1022	Anadromous fish	
	1023	Eels	

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
HABITAT	algae	287	Umbrella algae	*Acetabularia sp.*
		288	Sea ferns	*Bryopsis sp.*
		289	Grape and Feather algae	*Caulerpa*
		290	Green fleece	*Codium sp.*
		291	Bone algae	*Galaxaura sp.*
		292	Common disk or Segmented algae	*Halimeda sp.*
		293	Petticoat algae	*Padina sp.*
		294		*Sargassum liebmanii*
	coral	147	Coral community	
		295	Gorgonid	*Gorgonidae*
		296		*Pacifigorgia sp.*
		297		*Balanophillia bairdiana*
		298		*Isis hippuris*
		299		*Pasiopora damicornis*
		300		*Posillopora damicornis*
		301		*Scolymia australis*
		302		*Tubastrea faulkneri*
		303		*Upsella sp.*
	fav	46	Horned bladderwort	*Utricularia cornuta*
		51	Spotted pondweed	*Potamogeton pulcher*
		89	Banana water lily	*Nymphaea mexicana*
		105	Pondweed	*Potamogeton spp.*
		116	Water lotus	*Nelumbo lutea*
		118	White water-lily	*Nymphaea odorata*
		165	Featherfoil	*Hottonia inflata*
		166	Floating pennywort	*Hydrocotyle ranunculoides*
		174	Lesser bladderwort	*Utricularia minor*
		176	Minute duckweed	*Lemna perpusilla*
		193	Small yellow pond lily	*Nuphar lutea pumila*
		215	Water lettuce	*Pistia stratiotes*
		216	Spatterdock	*Nuphar lutea*
		217	Water hyacinth	*Eichhornia crassipes*
		218	Duck weed	*Lemna spp.*
		219	Water lily	*Nymphaea spp.*
		221	Floating aquatic vegetation	
		304		*Eichornia crassipes*
	hardbottom	148	Hardbottom community	
		252	Hardbottom reef ledge	
		253	Hardbottom reef	
		305	Anemones	
		306		*Bunodactis mexicana*
		307	Green velvet anemone	*Palythoa ignotha*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	kelp	2	Bull kelp	*Nereocystis luetkeana*
		9	Giant kelp	*Macrocystis pyrifera*
	plant	59	Plant (E)	
		60	Plant (T)	
		61	Butterwort	*Pinguicula vulgaris*
		102	Maliciae	*Maliciae*
		214	Rare plants	
		254	Rare community	
	sav	7	Surfgrass	*Phyllospadix sp.*
		11	Eelgrass	*Zostera marina*
		48	Whorled water-milfoil	*Myriophyllum verticillatum*
		55	Flatleaf pondweed	*Potamogeton robbinsii*
		78	Turtle grass	*Thalassia testudinum*
		79	Shoal grass	*Halodule beaudettei*
		80	Widgeon grass	*Ruppia maritima*
		81	Manatee grass	*Syringodium filiforme*
		82	Southern naiad	*Najas guadalupensis*
		83	Water celery	*Vallisneria americana*
		84	Dwarf seagrass	*Halophila engelmannii*
		85	Seagrass	
		138	Coontail	*Ceratophyllum demersum*
		139	Egeria	*Egeria densa*
		140	Water stargrass	*Heteranthera dubia*
		141	Hydrilla	*Hydrilla verticillata*
		142	Eurasian water-milfoil	*Myriophyllum spicatum*
		143	Pondweed	*Potamogeton spp.*
		163	Cut-leaved water-milfoil	*Myriophyllum pinnatum*
		192	Slender water-milfoil	*Myriophyllum tenellum*
		213	Submersed aquatic vegetation	
		1025	Algal flats	
	upland	3	Menzies wallflower	*Erysimum menziesii*
		4	Beach layia	*Layia carnosa*
		8	Clover lupine	*Lupinus tidestromii*
		11	Sand (Monterey) gilia	*Gilia tenuiflora arenaria*
		12	Pitcher's thistle (Dune thistle)	*Cirsium pitcheri*
		13	Clustered broomrape	*Orobanche fasciculata*
		15	Spurge	*Euphorbia polygonifolia*
		16	Rock sandwort	*Minvartia michauxii michauxii*
		20	Wild bean	*Strophostyles helvola*
		21	Sea rocket	*Cakile edentula*
		22	Ginseng	*Panax quinquefolius*
		23	Broadleaf sedge	*Carex platyphylla*
		24	Thickspike wheatgrass	*Agropyron dasystachyum*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	upland	26	Sand reed	*Calamovilfa longifolia*
		29	Northern comandra	*Geocaulon lividum*
		30	Pale false foxglove	*Agalinis skinneriana*
		31	Dwarf lake iris	*Iris lacustris*
		35	Lake Huron tansy	*Tanacetum bipinnatum huronense*
		38	Beach peavine	*Lathyrus japonicus maritimus*
		42	Sand-heather	*Hudsonia tomentosa*
		44	Prairie fame-flower	*Talinum rugospermum*
		50	Sticky goldenrod	*Solidago simplex randii*
		52	Beach sumac	*Rhus aromatica var. arenaria*
		53	Black-fruit mountain-ricegrass	*Piptatherum racemosa*
		54	Chamomile grape-fern	*Botrychium matricariifolium*
		56	Clinton lily	*Clintonia borealis*
		62	Beautiful sedge	*Carex concinna*
		64	Spike trisetum	*Trisetum spicatum*
		69	Marin bent grass	*Agrostis blasdalei marinensis*
		71	Howells spineflower	*Chorizanthe howellii*
		74	Surf thistle	*Cirsium rhothophilum*
		75	Beach spectacle pod	*Dithyrea maritima*
		95	Chinese tallow	*Sapium sebiferum*
		120	Coastal gay-feather	*Liatris bracteata*
		121	Live oak	*Quercus virginiana*
		122	Pecan	*Carya illinoinensis*
		124	Grand prairie evening primrose	*Oenothera pilosella sessilis*
		125	Houston machaeranthera	*Machaeranthera aurea*
		126	Little bluestem	*Schizachyrium scoparium*
		127	Brownseed paspalum	*Paspalum plicatulum*
		128	Long-sepaled false dragonhead	*Physostegia longisepala*
		130	Scarlet catchfly	*Silene subciliata*
		131	Sea oats	*Uniola paniculata*
		132	Bitter panicum	*Panicum amarum*
		133	Seacoast bluestem	*Schizachyrium scoparium littoralis*
		136	Texas windmill-grass	*Chloris texensis*
		137	Threeflower broomweed	*Thurovia triflora*
		149	American chaffseed	*Schwalbea americana*
		159	Bristling panic grass	*Dichanthelium aciculare*
		184	Robin-run-away	*Dalibarda repens*
		186	Rough flatsedge	*Cyperus retrofractus*
		187	Sea-beach knotweed	*Polygonum glaucum*
		189	Sea-side evening primrose	*Oenothera humifusa*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	upland	207	Carolina goldenrod	*Solidago pulchra*
		210	Carolina spleenwort	*Asplenium heteroresiliens*
		211	Southern three-awned grass	*Aristida simpliciflora*
		212	Pine barren ruellia	*Ruellia pedunculata pinetorum*
		222	Florida privet	*Forestiera segregata*
		223	Tiny leaved buckthorn	*Sageretia minutiflora*
		226	Ashe's savory	*Calamintha ashei*
		229	Curtiss' milkweed	*Asclepias curtissii*
		231	Florida bonamia	*Bonamia grandiflora*
		232	Gulf hammock indian plantain	*Hasteola robertiorum*
		233	Florida mountain-mint	*Pycnanthemum floridanum*
		234	Florida three-awned grass	*Aristida rhizomophora*
		240	Okeechobee gourd	*Cucurbita okeechobeensis*
		244	Scrub holly	*Ilex opaca*
		255	Rare terrestrial plant	
		256	Threatened terrestrial plant	
		263	Huisache	*Acacia farnesiana*
		265	Mesquite	*Prosopis glandulosa*
		267	Cane bluestem	*Bothriochola barbinodis*
		271	False rhodesgrass	*Chloris pluriflora*
		272	Morning glories	*Ipomoea spp.*
		273	Granjeno	*Celtis pallida*
		274	Blackbrush	*Acacia rigidula*
		278	Welder machaeranthera	*Psilactis heterocarpa*
		279	Elmendorf's onion	*Allium elmendorfii*
		280	Wright's yellowshow	*Amoreuxia wrightii*
		281	Plains gumweed	*Grindelia oolepis*
		282	Texas stonecrop	*Lenophyllum texanum*
		283	Lila de los llanos	*Echeandia chandleri*
		284	South Texas ambrosia	*Ambrosia cheiranthifolia*
		308	Seaside heliotrope	*Heliotropium curassavicum*
		309	Beach morning glory	*Ipomoea pescaprae*
		310		*Jouvea pilosa*
		311		*Pectis arenaria*
		312		*Uniola pittieri*
		313	Aleutian shield-fern	*Polystichum aleuticum*
	wetland	5	Salt marsh bird's-beak	*Cordylantus maritimus maritimus*
		6	Western lily	*Lilium occidentale*
		10	Coastal dunes milkvetch	*Astragalus tener titi*
		14	Smartweed	*Polygonum careyi*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	wetland	17	Bald-rush	*Psilocarya scirpoides*
		18	Clubmoss	*Lycopodium appressum*
		19	Crimsoneyed rosemallow	*Hibiscus moscheutos moscheutos*
		25	Moonwort	*Botrychium lunaria*
		27	Garber's sedge (Elk sedge)	*Carex garberi*
		28	Chestnut sedge	*Fimbristylis puberula*
		32	Smooth phlox	*Phlox glaberrima*
		33	Seaside crowfoot	*Ranunculus cymbalaria*
		34	Sand dune willow	*Salix cordata*
		36	False asphodel	*Tofieldia glutinosa*
		37	Houghton's goldenrod	*Solidago houghtonii*
		39	Small floating manna-grass	*Glyceria borealis*
		40	Silverweed	*Potentilla anserina*
		41	Scirpus-like rush	*Juncus scirpoides*
		43	Reticulated nutrush	*Scleria reticularis*
		45	Leafy northern green orchis	*Platanthera hyperborea*
		47	Zigzag bladderwort	*Utricularia subulata*
		49	Variegated horsetail	*Equisetum variegatum*
		57	Brown-fruited rush	*Juncus pelocarpus*
		58	Capitate spikerush	*Eleocharis geniculata*
		63	Lenticular sedge	*Carex lenticularis*
		65	Grass-of-parnassus	*Parnassia palustris*
		66	Coast sedge	*Carex exilis*
		67	Michaux's sedge	*Carex michauxiana*
		68	Lake cress	
		70	Pt. Reyes blennosperma	*Blennosperma nanum robustum*
		72	Soft bird's-beak	*Cordylantus mollis mollis*
		73	Tamarack Swamp community	
		77	Intermittent coastal wetland	
		86	Alligatorweed	*Alternanthera philoxeroides*
		87	Arrowhead	*Sagittaris spp.*
		88	Bald cypress	*Taxodium distichum*
		90	Black needlerush	*Juncus roemerianus*
		91	Bull-tongue	*Sagittaria lancifolia*
		92	Bulrush	*Scirpus spp.*
		93	California bulrush	*Scirpus californicus*
		94	Cattails	*Typha spp.*
		96	Common reed	*Phragmites australis*
		97	Cordgrass	*Spartina spp.*
		98	Cutgrass	*Leersia oryzoides*
		99	Dwarf spikerush	*Eleocharis parvula*
		100	Glasswort	*Salicornia spp.*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	wetland	101	High-tide bush	*Iva frutescens*
		103	Olney's three-square	*Scirpus americanus*
		104	Dwarf palmetto	*Sabal minor*
		106	Rushes	*Juncus spp.*
		107	Salt grass	*Distichlis spicata*
		108	Salt marsh bulrush	*Scirpus robustus*
		109	Salt meadow cordgrass (wiregrass)	*Spartina patens*
		110	Saltwort	*Batis maritima*
		111	Seashore paspalum	*Paspalum vaginatum*
		112	Smooth cordgrass	*Spartina alterniflora*
		113	Spikerushes	*Eleocharis spp.*
		114	Sundews	*Drosera spp.*
		115	Tupelo	*Nyssa spp.*
		117	Water oak	*Quercus nigra*
		119	Giant cutgrass (Southern wild rice)	*Zizaniopsis miliacea*
		123	Correll's false dragon-head	*Physostegia correllii*
		129	Runyon's waterwillow	*Justicia runyonii*
		134	Gulfdune paspalum	*Paspalum monostachyum*
		135	Smooth blue-star	*Amsonia glaberrima*
		144	Carolina grasswort	*Lilaeopsis carolinensis*
		145	Seabeach amaranth	*Amaranthus pumilus*
		146	Yellow fringeless orchid	*Platanthera integra*
		150	Bur-marigold	*Bidens bidentoides*
		151	Seaside alder	*Alnus maritima*
		152	American cupscale	*Sacciolepis striata*
		153	Awl-leaved rush	*Juncus coriaceus*
		154	Barton's St. Johns-wort	*Hypericum adpressum*
		155	Black-based quillwort	*Isoetes melanopoda*
		156	Black-fruited spikerush	*Eleocharis melanocarpa*
		157	Bog asphodel	*Narthecium americanum*
		158	Boykin's lobelia	*Lobelia boykinii*
		160	Britton's spikerush	*Eleocharis brittonii*
		161	Clustered beaked rush	*Rhynchospora glomerata*
		162	Coast flatsedge	*Cyperus polystachyos*
		164	Cypress-swamp sedge	*Carex joorii*
		167	Fog fruit	*Phyla lanceolata*
		168	Glade spurge	*Euphorbia purpurea*
		169	Grass-like beaked rush	*Rhynchospora globularis*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	wetland	170	Knieskern's beaked rush	*Rhynchospora knieskernii*
		171	Koehn's tooth-cup	*Ammannia latifolia*
		172	Lace-lip ladies'-tresses	*Spiranthes laciniata*
		173	Larger buttonweed	*Diodia virginiana*
		175	Long's bulrush	*Scirpus longii*
		177	Mudweed	*Limosella subulata*
		178	New Jersey rush	*Juncus caesariensis*
		179	Pine Barren boneset	*Eupatorium resinosum*
		180	Pumpkin Ash	*Fraxinus profunda*
		181	Puttyroot	*Aplectrum hyemale*
		182	Rare-flowering beaked rush	*Rhynchospora rariflora*
		183	Red goosefoot	*Chenopodium rubrum*
		185	Rough cottongrass	*Eriophorum tenellum*
		188	Sea-beach milkwort	*Glaux maritima*
		190	Virginia joint-vetch	*Aeschynomene virginica*
		191	Short-fruited rush	*Juncus brachycarpus*
		194	Small-headed beaked rush	*Rhynchospora microcephala*
		195	Snowy orchid	*Platanthera nivea*
		196	Stinking fleabane	*Pluchea foetida*
		197	Stout smartweed	*Polygonum densiflorum*
		198	Swamp-pink	*Helonias bullata*
		199	Thread-leaved beaked rush	*Rhynchospora filifolia*
		200	Twisted spikerush	*Eleocharis tortilis*
		201	Virginia thistle	*Cirsium virginianum*
		202	Walter's St. John's-wort	*Triadenum walteri*
		203	Whorled nut rush	*Scleria verticillata*
		204	Wrinkled jointgrass	*Coelorachis rugosa*
		205	Alabama canebrake pitcher-plant	*Sarracenia rubra spp. alabamensis*
		206	Saltmarsh spikerush	*Eleocharis halophila*
		208	Godfrey's sandwort	*Minuartia godfreyi*
		209	Spring flowering goldenrod	*Solidago verna*
		220	Prairie white-fringed orchid	*Platanthera leucophaea*
		224	Greenfly orchid	*Epidendrum conopseum*
		225	Dense-flowered groundsel-tree	*Baccharis glomeruliflora*
		227	Bartram's ixia	*Sphenostigma coelestina*
		228	Chapman's sedge	*Carex chapmanii*
		230	Fall-flowering pleat-leaf	*Nemastylis floridana*
		235	Florida willow	*Salix floridana*
		236	Florida hartwrightia	*Hartwrightia floridana*
		237	Lake-side sunflower	*Helianthus carnosus*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	wetland	238	Large-flowered grass-of-parnassus	*Parnassia grandifolia*
		239	Ocala vetch	*Vicia ocalensis*
		241	Piedmont jointgrass	*Mnesithea tuberculosa*
		242	Pond spice	*Litsea aestivalis*
		243	Scrub bay	*Persea humilis*
		245	Slender-leaved dragon-head	*Physostegia leptophylla*
		246	Green milkweed	*Asclepias viridula*
		247	Catesby's lily	*Lilium catesbaei*
		248	Spoon-flower	*Peltandra sagittifolia*
		249	St. John's susan	*Rudbeckia nitida*
		250	Yellow star anise	*Illicium parviflorum*
		251	Variable-leaf crownbeard	*Verbesina heterophylla*
		257	Rare wetland/aquatic plant	
		258	Threatened wetland/ aquatic plant	
		259	Gulf cordgrass	*Spartina spartinae*
		260	Key grass (shoregrass)	*Monanthochloe littoralis*
		261	Sea ox-eye daisy	*Borrichia frutescens*
		262	Groundsel tree	*Baccharis halimifolia*
		264	Sea-blite	*Suaeda spp.*
		266	Black mangrove	*Avicennia germinans*
		268	Salt marsh bulrush	*Scirpus maritimus*
		269	Sea lavender	*Limonium carolinianum*
		270	Coastal dropseed	*Sporobolus virginicus*
		275	Redbay	*Persea borbonia*
		276	Marshelder dodder	*Cuscuta attenuata*
		277	Roughseed sea-purslane	*Sesuvium trianthemoides*
		285	Camphor daisy	*Machaeranthera phyllocephala*
		286	Sea purslane	*Sesuvium portulacastrum*
INVERT	bivalve	1	Washington clam	*Saxidomus nuttallii*
		18	Pismo clam	*Tivela stultorum*
		19	Blue mussel	*Mytilus edulis*
		20	California mussel	*Mytilus californianus*
		21	Washington butter clam	*Saxidomus giganteus*
		22	Common egg cockel	*Laevicardium laevigatum*
		23	Horse clam	*Tresus capax*
		24	Gaper clam	*Tresus nuttallii*
		25	Softshell clam	*Mya arenaria*
		26	Japanese littleneck clam	*Venerupis japonica*
		27	Flat-tipped piddock (rock)	*Penitella penita*
		28	Pacific razor clam	*Siliqua patula*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	bivalve	29	Pacific littleneck clam	*Protothaca staminea*
		32	Geoduck	*Panope generosa*
		33	Spiny scallop	*Chlamys hastata*
		34	Atlantic deep-sea scallop	*Placopecten magellanicus*
		35	Rock scallop	*Hinnites multirugosus*
		36	Reddish scallop	*Chlamys rubida*
		38	Native Pacific oyster	*Ostrea lurida*
		41	Bay scallop	*Argopecten irradians*
		42	Northern quahog (hard clam)	*Mercenaria mercenaria*
		43	American oyster (eastern)	*Crassostrea virginica*
		48	Arctic surfclam	*Mactromeris polynyma*
		52	Bean clam	*Donax gouldii*
		56	Wart-necked piddock	
		58	Sunset clam	*Gari californica*
		59	Rough-sided little-necked clam	*Palphia staminea*
		66	California jackknife clam	*Tagelus californianus*
		67	Spiny cockle	*Cardium quadrigenarium*
		68	Clipped semele clam	*Semele sp.*
		76	Nuttall cockle	*Clinocardium nuttallii*
		77	Razor clam (eastern)	*Ensis directus*
		79	Pacific oyster	*Crassostrea gigas*
		80	Ribbed mussel	*Volsella demissa*
		81	Northern horsemussel	*Modiolus modiolus*
		82	Brackishwater clam	*Rangia cuneata*
		89	Speckled scallop	*Argopectin circularis*
		94	Southern quahog (hard clam)	*Mercenaria campechiensis*
		95	Dwarf surf clam	*Mulinia lateralis*
		98	Mussels	*Lithophaga*
		100	Quahog spp. (hard clam)	*Mercenaria spp.*
		102	Calico scallop	*Argopecten gibbus*
		104	Mississippi pigtoe	*Pleurobema beadleanum*
		105	White heelsplitter	*Lasmigona complanata complanata*
		106	Alabama spike	*Elliptio arca*
		107	Squawfoot	*Strophitus undulatus*
		108	Alabama hickorynut	*Obovaria unicolor*
		117	St. Johns elephantear	*Elliptio monroensis*
		118	Florida lance	*Elliptio waltoni*
		125	Coquinas	*Donax spp.*
		131	Oysters	*Ostrea spp.*
		132	Pearl oyster	*Pinctata mazatlanica*
		134		*Anadara grandis*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	bivalve	135		*Anadara similis*
		136		*Anadara tuberculosa*
		137		*Brachydontes semilaevis*
		139		*Mytella sp.*
		140		*Mytella guyanensis*
		141		*Mytella strigata*
		142		*Ostrea corteziensis*
		143		*Ostrea iridescens*
		144		*Ostrea palmula*
		173	Disjunct cleftclam	*Conchocele disjuncta*
		174	Broad yoldia	*Yoldia thraciaeformis*
		175	Crisscrossed yoldia	*Yoldia scissurata*
		176	Trenched nutclam	*Nuculana fossa*
		177	Elegant softshell clam	*Mya elegans*
		178	Truncate softshell clam	*Mya truncata*
		179	False softshell clam	*Mya pseudoarenaria*
		180	Siberia softshell clam	*Mya uzenensis*
		181	Alaska razor clam	*Siliqua alta*
		182	Arctic roughmya	*Panomya arctica*
		183	Ample roughmya	*Panomya ampla*
		184	Arctic hiatella	*Hiatella arctica*
		185	Crenulate astarte	*Astarte crenata*
		186	Boreal tridonta	*Tridonta borealis*
		187	Alaska great tellin	*Tellina lutea*
		188	Bent-nose macoma	*Macoma nasuta*
		189	Chalky macoma	*Macoma calcarea*
		190	Heavy macoma	*Macoma brota*
		191	Flat macoma	*Macoma moesta*
		257	Black mussel	*Musculus niger*
		258	Discordant mussel	*Musculus discors*
		259	Weathervane scallop	*Patinopectin caurinus*
		260	Arctic pink scallop	*Chlamys pseudislandica*
	cephalopod	30	Octopus	*Octopus spp.*
		37	Pacific Coast squid	*Loligo opalescens*
		73	Squid	*Loligo peali*
		119	Bay squid	*Lollinguncula brevis*
		123	Two-spotted octopus	*Octopus bimaculatus*
		124	Common Atlantic octopus	*Octopus vulgaris*
		145		*Octopus chierchiae*
		170	Eastern Pacific bobtail squid	*Rossia pacifica*
		171	Magistrate armhook squid	*Berryteuthis magister*
		172	Giant octopus	*Octopus dofleini*
	chordate	146		*Urochordata*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	crab	13	Flame-streaked box crab	*Calappa flammea*
		14	Dungeness crab	*Cancer magister*
		15	Red rock crab	*Pachygrapsus crassipes*
		16	Puget Sound king crab	*Paralithodes sp.*
		17	Northern kelp crab	*Pugettia producta*
		39	Red king crab	*Paralithodes camtschatica*
		40	Tanner crab	*Chionoecetes bairde*
		44	Horseshoe crab	*Limulus polyphemus*
		49	Blue crab	*Callinectes sapidus*
		70	Purple shore crab	*Hemigrapsus nudus*
		74	Stone crab	*Menippe spp.*
		75	Golden king crab	*Lithodes aequispina*
		88	Samoan crab	*Scylla serrata*
		91	Rock crabs	*Cancer spp.*
		93	Crustacean	
		96	Ghost crab	*Ocypode quadrata*
		99	Surf crab	*Arenaeus cribrarius*
		120	Gulf stone crab	*Menippe adina*
		121	Lesser blue crab	*Callinectes similis*
		126	Blue crabs	*Callinectes spp.*
		127	Black land crab	*Gecarcinus lateralis*
		147		*Cardisoma crassum*
		148		*Menippe frontalis*
		149		*Ucides occidentalis*
		192	Blue king crab	*Paralithodes platypus*
		193	Scarlet king crab	*Lithodes couesi*
		194	Brown box crab	*Lopholithodes foraminatus*
		195	Red box crab	*Lopholithodes mandtii*
		196	Rhinoceros crab	*Rhinolithodes wosnessenskii*
		197	Flatspine triangle crab	*Phyllolithodes papillosus*
		198	Fuzzy crab	*Acantholithodes hispidus*
		199	Soft crab	*Hapalogaster grebnitzkii*
		200	Scaled crab	*Placetron wosnessenskii*
		201	Pinch bug	*Munida quadrispina*
		202	Snow crab	*Chionoecetes opilio*
		203	Grooved tanner crab	*Chionoecetes tanneri*
		204	Triangle tanner crab	*Chionoecetes angulatus*
		205	Graceful kelp crab	*Pugettia gracilis*
		206	Arctic lyre crab	*Hyas coarctatus*
		207	Pacific lyre crab	*Hyas lyratus*
		208	Pygmy rock crab	*Cancer oregonensis*
		209	Hair crab	*Erimacrus isenbeckii*
		210	Helmet crab	*Telmessus cheiragonus*
		211	Graceful decorator crab	*Oregonia gracilis*
		212	Splendid hermit	*Labidochirus splendescens*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	crab	213	Wideband hermit	*Elassochirus tenuimanus*
		214	Purple hermit	*Elassochirus cavimanus*
		215	Pacific red hermit	*Elassochirus gilli*
		216	Aleutian hermit	*Pagurus aleuticus*
		217	Alaskan hermit	*Pagurus ochotensis*
		218	Hermit crab	*Pagurus spp.*
		1001	Crabs	
		1024	Hermit crabs	
	crayfish	78	Western Pacific crayfish	*Pacifastacus leniusculus*
		83	River crayfish	*Procambrus acutus*
		84	Red swamp crayfish	*Procambrus clarkil*
		85	Pacific river crayfish	*Pacifistacus trowbridgil*
		103	Camp Shelby burrowing crawfish	*Fallicambarus gordoni*
		109	Black Creek crayfish	*Procambarus pictus*
		110	Big-cheeked cave crayfish	*Procambarus delicatus*
		116	Silver Glen Springs cave crayfish	*Procambarus attiguus*
	echinoderm	86	Red sea urchin	*Strongylocentrotus franciscanus*
		128	Impatient sea cucumber	*Holothuria impatiens*
		129	Panama brittle star	*Ophioderma panamense*
		150		*Astrodyctium sp.*
		151		*Diadema mexicanum*
		152		*Echinometra vanbrunti*
		153		*Holothuria inhabilis*
		154		*Mellitella sp.*
		155		*Mellitella stokesii*
		156		*Ophiocoma aetheops*
		157		*Ophiocoma alexandri*
		159		*Pharia pyramidata*
		160		*Phataria unifascialis*
		161		*Selenkothuria lubrica*
		162		*Toxopneustes roseus*
		219	Green urchin	*Strongylocentrotus droebachiensis*
		220	Fragile urchin	*Allocentrotus fragilis*
		221	Heart urchin	*Brisaster latifrons*
	gastropod	31	Japanese abalone	*Haliotis kamtschatkana*
		46	Channeled whelk	*Busycon canaliculatum*
		47	Knobbed whelk	*Busycon carica*
		55	Wavy top snail	*Astraea undosa*
		60	Abalone	*Haliotis spp.*
		61	Red abalone	*Haliotis rufescens*
		62	Black abalone	*Haliotis cracherodii*
		63	Green abalone	*Haliotis fulgens*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	gastropod	64	White abalone	*Haliotis sorenseni*
		65	Pink abalone	*Haliotis corrugata*
		87	California brackish water snail	*Tryonia imitator*
		90	Lightning whelk	*Busycon contrarium*
		101	Queen conch	*Strombus gigas*
		111	Blue Spring hydrobe	*Aphaostracon asthenes*
		112	Blue Spring siltsnail	*Cincinnatia parva*
		113	Dense hydrobe	*Aphaostracon pycnus*
		114	Enterprise siltsnail	*Cincinnatia monroensis*
		130	California sea hare	*Aplysia californica*
		163		*Acanthinia brevidentada*
		164		*Fasciolaria princeps*
		165		*Purpura sp.*
		222	Great slippersnail	*Crepidula grandis*
		223	Arctic moonsnail	*Natica clausa*
		224	Rusty moonsnail	*Natica russa*
		225	Pale moonsnail	*Polinices pallidus*
		226	Oregon triton	*Fusitriton oregonensis*
		227	Alaska volute	*Arctomelon stearnsii*
		228	Oblique whelk	*Colus hypolispus*
		229	Hall's colus	*Colus halli*
		230	Keeled aforia	*Aforia circinata*
		231	Dall's drill	*Eupleura muriciformis*
		232	Polar whelk	*Buccinum polare*
		233	Angular whelk	*Buccinum angulosum*
		234	Sinuous whelk	*Buccinum plectrum*
		235	Ladder whelk	*Buccinum scalariforme*
		236	Helmut whelk	*Neptunea magna*
		237	Lyre whelk	*Neptunea lyrata*
		238	Pribilof whelk	*Neptunea pribiloffensis*
		239	Fat whelk	*Neptunea ventricosa*
		240	Northern neptune	*Neptunea heros*
		241	Little neptune	*Neptunea communis*
		242	Warped whelk	*Volutopsius deformis*
		243	Left-handed whelk	*Volutopsius harpa*
		244	Large melon whelk	*Volutopsius melonis*
		245	Fragile whelk	*Volutopsius fragilis*
		246	Tulip whelk	*Volutopsius middendorffii*
		247	Shouldered whelk	*Volutopsius stefanssoni*
		248	Volute whelk	*Volutopsius castaneus*
		249	Threaded whelk	*Volutopsius filosus*
		250	Kennicott's beringius	*Beringius kennicottii*
		251	Northern beringius	*Beringius beringii*
		252	Stimpson's beringius	*Beringius stimpsoni*
		253	Friele's beringius	*Beringius frielei*
		254	Kroyer's plicifis	*Plicifusus kroyeri*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	gastropod	255	Thick-ribbed whelk	*Colus spitzbergensis*
		256	Thin-ribbed whelk	*Colus herendeenii*
	insect	115	Scrub tiger beetle	*Cicindela scabrosa*
	lobster	45	Northern lobster	*Homarus americanus*
		54	California spiny lobster	*Panulirus interruptus*
		72	Spiny lobster	*Panulirus argus*
		166		*Panulirus gracilis*
	shrimp	4	Pink shrimp	*Penaeus duorarum*
		5	Ocean pink shrimp	*Pandalus jordani*
		6	Maine shrimp	*Pandalus borealis*
		7	Sidestripe shrimp	*Pandalopsis dispar*
		8	Spot shrimp	*Pandalus platyceros*
		10	Humpy shrimp	*Pandalus goniurus*
		11	Dock shrimp	*Pandalus danae*
		12	Broken-back shrimp	*Heptacarpus spp.*
		50	White shrimp	*Penaeus setiferus*
		51	Brown shrimp	*Penaeus aztecus*
		69	Bay ghost shrimp	*Callianassa californiensis*
		71	Rock shrimp	*Sicyonia brevirostris*
		92	Penaeid shrimp	*Penaeus spp.*
		97	Grass shrimp	*Palaemonetes spp.*
		122	Mantis shrimp	*Squilla empusa*
		133	Blue shrimp	*Penaeus stylirostris*
		167		*Atya crassa*
		168		*Macrobrachium tenellum*
		169		*Penaeus vannamei*
		261	Coonstriped shrimp	*Pandalus hypsinotus*
		262	Yellowleg pandalid	*Pandulus tridens*
		263	Shortscale eualid	*Eualus suckleyi*
		264	Arctic eualid	*Eualus fabricii*
		265	Greenland shrimp	*Eualus macilentus*
		266	Circumpolar eualid	*Eualus gaimardii*
		267	Barbed eualid	*Eualus barbatus*
		268	Stiletto coastal shrimp	*Heptacarpus stylus*
		269	Stout coastal shrimp	*Heptacarpus brevirostris*
		270	Spiny lebbeid	*Lebbeus groenlandicus*
		271	Polar lebbeid	*Lebbeus polaris*
		272	Arctic argid	*Argis dentata*
		273	Kuro shrimp	*Argis lar*
		274	Twospine crangon	*Crangon communis*
		275	Ridged crangon	*Crangon dalli*
		276	Sevenspine bay shrimp	*Crangon septemspinosa*
		277	Sculptured shrimp	*Sclerocrangon boreas*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
M_MAMMAL	dolphin	6	Harbor porpoise	*Phocoena phocoena*
		17	Bottlenose dolphin	*Tursiops truncatus*
		20	Northern right-whale dolphin	*Lissodelphis borealis*
		21	Atlantic spotted dolphin	*Stenella plagiodon*
		45	Pacific white-sided dolphin	*Lagenorhynchus obliquidens*
		46	Risso's dolphin	*Grampus griseus*
		47	Dall's porpoise	*Phocoenoides dalli dalli*
		49	Spotted dolphin	*Stenella attenuata*
		50	Spinner dolphin	*Stenella longirostris*
		60	Common dolphin	*Delphinus delphis*
		61	Stenellid dolphin	*Stenella sp.*
		86	Atlantic white-sided dolphin	*Lagenorhynchus acutus*
		87	Rough-toothed dolphin	*Steno bredanensis*
	manatee	10	West Indian manatee	*Trichechus manatus*
	pinniped	1	Northern (Steller) sea lion	*Eumetopias jubatus*
		2	Harbor seal	*Phoca vitulina*
		3	Northern fur seal	*Callorhinus ursinus*
		14	Gray seal	*Halichoerus grypus*
		15	Bearded seal	*Erignathus barbatus*
		16	Walrus	*Odobenus rosmarus*
		22	California sea lion	*Zalophus californianus*
		23	Guadalupe fur seal	*Arctocephalus townsendi*
		24	Northern elephant seal	*Mirounga angustirostris*
		51	Hawaiian monk seal	*Monachus schauinslandi*
		84	Hooded seal	*Cystophora cristata*
		85	Harp seal	*Pagophilus groenlandicus*
		91	Spotted seal	*Phoca largha*
		92	Ringed seal	*Pusa hispida*
		93	Ribbon seal	*Histriophoca fasciata*
		94	Pacific walrus	*Odobenus rosmarus*
	polar bear	90	Polar bear	*Ursus maritimus*
	sea_otter	7	Sea otter	*Enhydra lutris*
	whale	4	Killer whale	*Orcinus orca*
		5	Little (Pacific) blackfish	*Peponocephala electra*
		9	Beluga whale	*Delphinapterus leucas*
		11	Fin whale	*Balaenoptera physalus*
		12	Minke whale	*Baleonoptera acutorostrata*
		13	Humpback whale	*Megaptera novaeangliae*
		18	Pygmy sperm whale	*Kogia breviceps*
		19	Shortfin pilot whale	*Globicephala macrorhynchus*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	whale	26	Gray whale	*Eschrichtius robustus*
		27	Sei whale	*Balaenoptera borealis*
		29	Blue whale	*Balaenoptera musculus*
		48	Sperm whale	*Physeter catodon*
		81	Northern right whale	*Eubalaena glacialis*
		82	Dwarf sperm whale	*Kogia simus*
		83	Long-finned pilot whale	*Globicephala melaena*
		88	Bryde's whale	*Balaenoptera edeni*
		89	Endangered whale	
		95	Bowhead whale	*Balaena mysticetus*
		96	Goose-beaked whale	*Ziphius cavirostris*
		97	Bering Sea beaked whale	*Mesoplodon stejnegeri*
		98	Northern Pacific Bottle-nosed whale	*Berardius bairdii*
REPTILE	alligator	1	American crocodile	*Crocodylus acutus*
		3	American alligator	*Alligator mississippiensis*
		43	Cayman	*Cayman crocodylus*
	amphibian	14	Crawfish frog	*Rana areolata*
		15	Pig frog	*Rana grylio*
		27	Mud salamander	*Pseudotriton montanus*
		28	Red salamander	*Pseudotriton ruber*
		29	Florida gopher frog	*Rana capito aesopus*
		33	Rare frog	
		36	Rare salamander	
		41	Black-spotted newt	*Notophthalmus meridionalis*
		42	Sheep frog	*Hypopachus variolosus*
	lizard	31	Florida scrub lizard	*Sceloporus woodi*
		34	Rare lizard	
		44	Black iguana	*Ctenosaura similis*
		45	Common iguana	*Iguana iguana*
	snake	11	Atlantic salt marsh snake	*Nerodia fasciata taeniata*
		12	Gulf salt marsh snake	*Nerodia clarkii clarkii*
		17	Texas garter snake	*Thamnophis sirtalis annectens*
		23	Black pine snake	*Pituophis melanoleucus lodingi*
		24	Eastern indigo snake	*Drymarchon corais couperi*
		25	Rainbow snake	*Farancia erytrogramma*
		26	Gulf crayfish snake	*Regina rigida sinicola*
		30	Florida pine snake	*Pituophis melanoleucuc mugitus*
		37	Rare snake	
		40	Texas scarlet snake	*Cemophora coccinea lineri*
		46	Sea snake	*Pelamis platurus*
	turtle	2	Green sea turtle	*Chelonia mydas mydas*
		4	Kemp's ridley sea turtle	*Lepidochelys kempii*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	turtle	5	Leatherback sea turtle	*Dermochelys coriacea*
		6	Loggerhead sea turtle	*Caretta caretta*
		7	Diamondback terrapin	*Malaclemys terrapin*
		8	Pacific green sea turtle	*Chelonia mydas agassizi*
		9	Hawksbill sea turtle	*Eretmochelys imbricata*
		10	Pacific hawksbill sea turtle	*Eretmochelys imbricata bissa*
		13	Turtles	
		16	Texas diamondback terrapin	*Malaclemys terrapin littoralis*
		18	Mississippi diamond-back terrapin	*Malaclemys terrapin pileata*
		19	Alabama red-bellied turtle	*Pseudemys alabamensis*
		20	Mangrove terrapin	*Malaclemys terrapin rhizophorarum*
		21	Gopher tortoise	*Gopherus polyphemus*
		22	Yellow-blotched map turtle	*Graptemys flavimaculata*
		32	Spotted turtle	*Clemmys guttata*
		35	Threatened turtle	
		38	Endangered sea turtle	
		39	Threatened sea turtle	
		47	Olive ridley	*Lepidochelys olivacea*
		48		*Kinosternon scorpioides*
		49		*Rhinochemys pulcherrima*
		50		*Trachemys scripta*
T_MAMMAL	bear	55	Brown bear	*Ursus arctos horribilis*
		56	Black bear	*Ursus americanus*
		102	Louisiana black bear	*Ursus americanus luteolus*
		103	Florida black bear	*Ursus americanus floridanus*
	canine	54	Gray wolf	*Canis lupus*
		57	Red fox	*Vulpes vulpes*
		63	Coyote	*Canis latrans*
		64	Gray fox	*Urocyon cinereoargenteus*
		67	Red wolf	*Canis rufus*
		123	Arctic fox	*Alopex lagopus*
	feline	62	Bobcat	*Lynx rufus*
		65	Mountain lion	*Felis concolor*
		66	Ocelot	*Felis pardalis*
		70	Florida panther	*Felis concolor coryi*
		108	Wildcat	*Felis yagouaroundi*
		109	Margay	*Felis wiedii*
		124	Lynx	*Lynx lynx*
	small mammal	8	Northern river otter	*Lutra canadensis*
		36	Beaver	*Castor canadensis*
		37	Muskrat	*Ondatra zibethicus*
		38	Mink	*Mustela vison*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	small mammal	39	Shorttail weasel	*Mustela erminea*
		40	Longtail weasel	*Mustela frenata*
		41	Saltmarsh harvest mouse	*Reithrodontomys naviventris*
		42	Santa Cruz harvest mouse	*Reithrodontomys megalotis santacruzae*
		43	Nutria	*Myocastor coypus*
		44	Northern raccoon	*Procyon lotor*
		52	Striped skunk	*Mephitis mephitis*
		53	Long tailed weasel	*Mustel frenata*
		58	Meadow vole	*Microtus pennsylvanicus*
		59	Morro Bay kangaroo rat	*Dipodomys heermanni morroensis*
		68	Anastasia Island beach mouse	*Peromyscus polionotus phasma*
		69	Choctawhatchee beach mouse	*Peromyscus polionotus allophrys*
		71	Key Largo cotton mouse	*Peromyscus gossypinus allapaticola*
		72	Key Largo woodrat	*Neotoma floridana smalli*
		73	Lower Keys marsh rabbit	*Sylvilagus palustris hefneri*
		74	Mangrove fox squirrel	*Sciurus niger avicennia*
		75	Perdido Key beach mouse	*Permyscus polionotus trissyllepsis*
		76	Florida saltmarsh vole	*Microtus pennsylvanicus dukecampbelli*
		77	Silver rice rat	*Oryzomys argentatus*
		78	Southeastern beach mouse	*Peromyscus polionotus niveiventris*
		79	Southern mink	*Mustela vison mink*
		80	St. Andrews beach mouse	*Peromyscus polionotus peninsularis*
		89	Alabama beach mouse	*Peromyscus polionotus ammobates*
		101	Dismal swamp southeastern shrew	*Sorex longirostris fisheri*
		104	Florida long-tailed weaseal	*Mustela frenata peninsulae*
		105	Round-tailed muskrat	*Neofiber alleni*
		106	Rare rodent	
		107	Threatened rodent	
		110	Spider monkey	*Ateles geoffroyi*
		111	Nine-banded armadillo	*Dasypus novemcinctus*
		112	White-nosed coati	*Nasua narica*
		113	Tamandua	*Tamandua mexicana (tetradactyla)*
		114		*Agouti paca*
		115		*Coendou mexicanus*
		116		*Dasyprocta punctata*

ELEMENT	SUB-ELEMENT	SPECIES NO.	COMMON NAME	SCIENTIFIC NAME
	small mammal	126	American marten	*Martes americana*
		127	Wolverine	*Gulo gulo*
		128	Lemming	*Dicrostonyx sp.*
		129	Ground squirrel	*Spermophilus sp.*
		130	Hare	*Lepus sp.*
	ungulate	25	Florida key deer	*Odocoileus virginianus clavium*
		30	Columbia white-tailed deer	*Odocoileus virginianus leucurus*
		31	White-tailed deer	*Odocoileus virginianus*
		32	Mule deer	*Odocoileus hemionus*
		33	Black-tailed deer	*Odocoileus hemionus columbianus*
		34	Elk	*Cervus canadensis*
		35	Roosevelt elk	*Cervus canadensis roosevelti*
		100	Wild hog	*Sus scrofa*
		117	Moose	*Alces alces*
		118	Caribou	*Rangifer tarandus*
		119	American bison	*Bos bison*
		120	Mountain goat	*Oreamnos americanus*
		121	Muskox	*Ovibos moschatus*
		122	Dall's sheep	*Ovis dalli*
		125	Sitka black-tailed deer	*Odocoileus hemionus sitkensis*

Appendix B

ESI-GIS Data Dictionary

BASEMAP

GEOGRAPHIC THEMES	VARIABLE NAMES	DESCRIPTION	ATTRIBUTE VALUES
ESI (ARCS)	ESI (10, 10, C)	Shoreline classification	Ranges from 1 through 10 with various combinations and subcategories
	LINE (1, 1, C)	Geographic feature	S = Shoreline I = Index for map/quad boundary H = Hydrography P = Pier B = Breakwater F or M = Non-shoreline arcs that form the boundary for a flat or marsh polygon
	SOURCE_ID (6, 6, I)	Source code for shoreline arcs	0 = Digital 1 = Low-altitude overflight 2 = Aerial photograph 3 = Digitized off paper topo 4 = Digitized off scanned topo 5 = National Wetlands Inventory digital data
	ENVIR (1, 1, C)	Physiographic region	E = Estuarine L = Lacustrine R = Riverine
ESI (POLYS)	ESI (10, 10, C)	Habitat classification	7 and 9 = Flats 10A, 10B, 10C, and 10D = Marshes U = Unclassified holes
	WATER_CODE (1, 1, C)	Land and water designations	L = Land W = Water
HYDRO (ARCS)	LINE (1, 1, C)	Geographic feature	Same as above
	SOURCE_ID (6, 6, I)	Source code for shoreline arcs	Same as above
HYDRO (POLYS)	WATER_CODE (1, 1, C)	Land and water designations	Same as above
HYDRO (ANNO)	GEOG	Geography annotations	Names of islands or points
	HYDRO	Hydrology annotations	Names of inlets, rivers, ponds, lakes, bays, oceans, and coves
	SOC	Human-use annotations	Names of beaches, wildlife reserves and preserves, state and country, marine sanctuaries, cities, and parks
INDEX (POLYS)	TILE-NAME (32, 32, C)	Map number	1 through N, where N = number of maps in atlas
	TOPO-NAME (255, 255, C)	USGS 1:24,000 quadrangle name with latest data	See the metadata report for a complete list of quad names and dates
	SCALE (7, 7, I)	Map production scale	For 11 by 17 inch paper, the scale ranges from 1:45,000 to 1:55,000—only the denominator is entered.
	MAPANGLE (4, 8, F, 3)	Angle to rotate data to plot vertically	Ranges from 0 to 2 degrees
	PAGESIZE (6, 6, C)	Hardcopy map size	Usually 11 by 17 for full size and inset maps vary. See the metadata report for a complete list of pagesizes

BIOLOGY

GEOGRAPHIC THEMES	VARIABLE NAMES	DESCRIPTION	ATTRIBUTE VALUES
BIRDS (POLYS)	ID (10, 10, I)	Unique identifier which links to POLY_LUT lookup table	Integer concatonating the atlas number, the element number, and the polygon number
FISH (POLYS)	ID (10, 10, I)	Same as BIRDS	Same as BIRDS
FISH (ARCS)	ID (10, 10, I)	Unique identifier which links to ARC_LUT lookup table	Same as BIRDS
HABITATS (POLYS)	ID (10, 10, I)	Same as BIRDS	Same as BIRDS
INVERT (POLYS)	ID (10, 10, I)	Same as BIRDS	Same as BIRDS
M_MAMMAL (POLYS)	ID (10, 10, I)	Same as BIRDS	Same as BIRDS
NESTS (POINTS)	ID (10, 10, I)	Unique identifier which links to PNTS_LUT lookup table	Same as BIRDS
REPTILES (POLYS)	ID (10, 10, I)	Same as BIRDS	Same as BIRDS
T_MAMMAL (POLYS)	ID (10, 10, I)	Same as BIRDS	Same as BIRDS

LOOKUP TABLES	VARIABLE NAMES	DESCRIPTION	ATTRIBUTE VALUES
POLY_LUT	RARNUM (6, 6, I)	Link to BIORES data table	Number ranging from 1 through the number of unique combinations of species, their seasonalities, and their concentrations
	ID (10, 10, I)	Link to polygon data layers	Integer concatonating the atlas number, the element number, and the polygon number
ARC_LUT	RARNUM (6, 6, I)	Same as POLY_LUT	Same as POLY_LUT
	ID (10, 10, I)	Link to arc data layers (FISH)	Same as POLY_LUT
PNTS_LUT	RARNUM (6, 6, I)	Same as POLY_LUT	Same as POLY_LUT
	ID (10, 10, I)	Link to point data layers (NESTS)	Same as POLY_LUT

DATA TABLES	VARIABLE NAMES	DESCRIPTION	ATTRIBUTE VALUES
BIORES	RARNUM (6 ,6, I)	Resource at risk number which is linked to RARNUM in POLY_LUT, ARC_LUT, and PNTS_LUT and can have multiple records with the same RARNUM	Number ranging from 1 through the number of unique combinations of species, their seasonalities, their concentrations, and the geographic and seasonality sources.
	SPECIES_ID (5, 5, I)	Identification number	Unique number within each element. The species numbers do not change between ESI atlases; they are used across the United States
	CONC (20, 20, C)	Concentration of the species	May be descriptive or a number of individuals and must be documented in the metadata

DATA TABLES	VARIABLE NAMES	DESCRIPTION	ATTRIBUTE VALUES
BIORES	SEASON_ID (2, 2, I)	A number to differentiate the same species, but different seasonal distributions	Values range from 1 to N and have no implied meaning. These link to the SEASONAL data table
	G_SOURCE (6, 6, I)	Unique identifier for the geographic source	Value ranging from 1 through the total number of sources and links to SOURCES data table.
	S_SOURCE (6, 6, I)	Unique identifier for the seaosnality source	Same as G_SOURCE
	ELEMENT (10, 10, C)	Category of species	BIRD FISH HABITAT INVERT M_MAMMAL REPTILE T_MAMMAL
	EL_SPE (6, 6, C)	Concationation of first character of the ELEMENT and the SPECIES_ID	B00001-BNNNNN F00001-FNNNNN H00001-HNNNNN I00001-INNNNN M00001-MNNNNN R00001-RNNNNN T00001-TNNNNN Where N is up 5 digits
	EL_SPE_SEA (8, 8, C)	Concationation of first character of the ELEMENT, the SPECIES_ID, and the SEASON_ID	Same as EL_SPE with the addition of SEASON_ID
SOURCES	SOURCE_ID (6, 6, I)	Unique identifier for each source used in the atlas and link to BIORES and SOC_DATA	1-N
	ORIGINATOR (35, 35, C)	Person or organization who provided the data	Text
	DATE_PUB (10, 10, I)	Publication or data collection date if interview with resource expert	Formatted as month-year
	TITLE (80, 80, C)	Name of the data set, publication, or contents of information gathered from interview	Text
	DATA_FORMAT (80, 80, C)	Media	Hardcopy map, text, or table; personal knowledge; or digital data
	PUBLICATION (120, 120, C)	Citation if application	Text
	SCALE (20, 20, C)	Source scale denominator	1-N (i.e., 24000)
	TIME_PERIOD (22, 22, C)	Range of time when data was collected	Text
SPECIES	SPECIES_ID (5, 5, I)	Number identifying a species	Unique number within each element. The species numbers do not change between ESI atlases; they are used across the U.S.
	NAME (35, 35, C)	Species common name	Appendix A
	GEN_SPEC (45, 45, C)	Scientific name	Appendix A

DATA TABLES	VARIABLE NAMES	DESCRIPTION	ATTRIBUTE VALUES
SPECIES	DATE_PUB (10, 10, I)	Publication date for Natural Heritage Program global status list	Formatted as month-year
	ELEMENT (10 ,10, C)	Category of species	Same as BIORES
	SUBELEMENT (10, 10, C)	Element sub-group	Appendix A
	NHP (10, 10, C)	Natural Heritage Program global rank	text varies
	EL_SPE (6, 6, C)	Concationation of first character of the ELEMENT and the SPECIES_ID	BOOOO1-BNNNNN FOOOO1-FNNNNN HOOOO1-HNNNNN IOOOO1-INNNNN MOOOO1-MNNNNN ROOOO1-RNNNNN TOOOO1-TNNNNN Where N is up 5 digits
STATUS	ELEMENT (10 ,10, C)	Category of species	Same as BIORES
	SPECIES_ID (5, 5, I)	Number identifying a species	Unique number within each element. The species numbers do not change between ESI atlases; they are used across the United States
	STATE (2, 2, C)	State abbreviation	Standard two-letter code
	S_F (3, 3, C)	State and/or Federal status	S = State F = Federal S/F = State and Federal
	T_E (3, 3, C)	Threatened and/or endangered	T = Threatened E = Endangered T/E = Threatened and endangered E/T = Endangered and threatened
	DATE_PUB (10, 10, I)	Publication date for the federal and state status list	Formatted as month-year (i.e., 91995)
	EL_SPE (6, 6, C)	Concationation of first character of the ELEMENT and the SPECIES_ID	BOOOO1-BNNNNN FOOOO1-FNNNNN HOOOO1-HNNNNN IOOOO1-INNNNN MOOOO1-MNNNNN ROOOO1-RNNNNN TOOOO1-TNNNNN Where N is up 5 digits
SEASONAL	ELEMENT (10, 10 ,C)	Category of species	Same as BIORES
	SPECIES_ID (5, 5, I)	Number identifying a species	Same as BIORES
	SEASON_ID (2, 2, I)	A number code used to differentiate the same species, but different seasonal distributions	Same as BIORES

DATA TABLES	VARIABLE NAMES	DESCRIPTION	ATTRIBUTE VALUES
SEASONAL	JAN (1, 1, C)	Present in January	X = present; blank = not present
	FEB (1, 1, C)	Present in February	Same as JAN
	MAR (1, 1, C)	Present in March	Same as JAN
	APR (1, 1, C)	Present in April	Same as JAN
	MAY (1, 1, C)	Present in May	Same as JAN
	JUN (1, 1, C)	Present in June	Same as JAN
	JUL (1, 1, C)	Present in July	Same as JAN
	AUG (1, 1, C)	Present in August	Same as JAN
	SEP (1, 1, C)	Present in September	Same as JAN
	OCT (1, 1, C)	Present in October	Same as JAN
	NOV (1, 1, C)	Present in November	Same as JAN
	DEC (1, 1, C)	Present in December	Same as JAN
	EL_SPE_SEA (8, 8, C)	Link to BREED data table	Concatonation of ELEMENT, SPECIES_ID, and SEASON_ID
BREED	EL_SPE_SEA (8, 8, C)	Same as SEASONAL data table	Same as SEASONAL data table
	MONTH (2, 2, i)	Species a month (can have up to twelve records per EL_SPE_SEA)	1-12
	BREED1 (1, 1, C)	Reproductive or life-state activities. For each element, there is a different definition:	Y = occuring N = not occuring
		BIRD = nesting	
		FISH = spawning	
		INVERT = spawning	
		M_MAMMAL = calving	
		REPTILE = nesting	
	BREED2 (1, 1, C)	Same as BREED1 except:	Y = occuring N = not occuring
		BIRD = laying	
		FISH = outmigration	
		INVERT = larvae	
		M_MAMMAL = pupping	
		REPTILE = hatching	
	BREED3 (1, 1, C)	Same as BREED1 except:	Y = occuring N = not occuring
		BIRD = hatching	
		FISH = larvae	
		INVERT = mating	
		M_MAMMAL = molting	
		REPTILE = internesting	
	BREED4 (1, 1, C)	Same as BREED1 except:	Y = occuring N = not occuring
		BIRD = fledging	
		FISH = juvenile	
		INVERT = juvenile	
	BREED5 (1, 1, C)	Same as BREED1 except:	Y = occuring N = not occuring
		FISH = adults	
		INVERT = adults	

HUMAN-USE

GEOGRAPHIC THEMES	VARIABLE NAME	DESCRIPTION	ATTRIBUTE VALUES
MGT (POLYS)	TYPE (2, 2, C)	Code identifying a human-use feature	B = Beach IR = Indian Reservation MS = Marine Sanctuary NP = National Park P = Regional or State Park WR = Wildlife Refuge
	ID (10, 10, I)	Unique identifier which links to SOC_LUT lookup table	Integer containing the atlas number, the element number, and the polygon number
SOCECON (ARCS)	TYPE (2, 2, C)	Code identifying a human-use feature	B = Beach IB = International Border IR = Indian Reservation P = Pipeline R = Road, transportation, or bridge SB = State Border
SOCECON (POINTS)	TYPE (2, 2, C)	Code identifying a human-use feature	A = Airport A2 = Access AQ = Aquaculture AS = Archaeological Site BR = Boat Ramp CF = Commercial Fishing CG = Coast Guard CP = Campground DV = Diving F = Ferry F2 = Factory H = Hoist HP = Helipad HS = Historical Site HW - Hazardous Waste Site LD = Lock and Dam LS = Log Storage M = Marina MZ = Mining OF = Oil Facilities PF = Platform RF = Recreational Fishing S = Subsistence W = Well WI = Water Intake
	ID (10, 10, I)	Same as MGT	Same as MGT

LOOKUP TABLES	VARIABLE NAMES	DESCRIPTION	ATTRIBUTE VALUES
SOC_LUT	HUNUM (6, 6, I)	Identification number linked to HUNUM in the SOC_DATA data table	Integer ranging from 1 through the number of unique human-use features
	ID (10, 10, I)	Same as MGT	Same as MGT

DATA TABLE	VARIABLE NAME	DESCRIPTION	ATTRIBUTE VALUES
SOC_DATA	HUNUM (6, 6, I)	Same as SOC_LUT	Same as SOC_LUT
	TYPE (20, 20 ,C)	Type of human-use feature	ACCESS AIRPORT AQUACULTURE ARCHAEOLOGICAL SITE BEACH BOAT RAMP CAMPGROUND COAST GUARD COMMERCIAL FISHING DIVING FACTORY FERRY HAZARDOUS WASTE SITE HELIPAD HISTORICAL SITE HOIST INDIAN RESERVATION INTERNATIONAL BORDER LOCK AND DAM LOG STORAGE MARINA MARINE SANCTUARY MINING NATIONAL PARK OIL FACILITIES PARK (REGIONAL OR STATE) PIPELINE PLATFORM RECREATIONAL FISHING STATE BORDER SUBSISTENCE WATER INTAKE WELL WILDLIFE REFUGE
	NAME (40, 40, C)	The name of the facility	Used for water intakes, aquaculture sites, and other features, if available
	CONTACT (80, 80, C)	Person location to contact	If available
	PHONE (20, 20, C)	Phone Number	If available
	G_SOURCE (6, 6, I)	Geographic source number	Value ranging from 1 through the total number of sources. This is a link to SOURCES data table
	A_SOURCE (6, 6, I)	Attribute source number	Same as G_SOURCE

Appendix C

ESI Atlas Identification Numbers

ATLAS NUMBER	ATLAS NAME	ATLAS NUMBER	ATLAS NAME
1	Lake Ontario	36	Georgia
2	Western Lake Michigan	37	St. Johns River, Florida
3	Lake Huron	38	Oregon–Columbia River
4	Northern Lake Michigan	39	Washington–Strait of Juan de Fuca and Northern Puget Sound
5	Southern Lake Michigan	40	Washington–Central and Southern Puget Sound
6	Lake Superior	41	Columbia River
7	Northern California	42	Eastern Lake Michigan
8	Central California	43	St. Lawrence River
9	Southern California	44	St. Marys River
10	Southeast Alaska	45	Massachusetts
11	Cook Inlet	46	Connecticut
12	Delaware/New Jersey/Pennsylvania	47	Maryland
13	Upper Coast Texas	48	Midcoast Maine
14	Texas–Galveston Bay	49	Downeast Maine
15	Mid Coast Texas	50	Southern Maine and New Hampshire
16	South Coast Texas	51	New York Harbor
17	Lake Erie	52	Hudson River
18	West Florida	53	New York–Long Island
19	West Peninsula Florida, Vol. 1	54	Rhode Island
20	West Peninsula Florida, Vol. 2	55	Virginia
21	South Florida	56	Alaska: Bristol Bay Region
22	East Florida	57	Alaska: Shelikof Strait Region
23	West Florida Region 2	58	Alaska: Norton Sound and Pribilof Islands
24	West Florida Region 3	59	Alaska: Prince William Sound
25	Apalachicola River, Florida	60	Alaska: Cook Inlet/Kenai Peninsula (1985)
26	West Peninsula	61	Alaska: Southern Peninsula
27	South Florida, Vol. 1	62	American Somoa
28	South Florida, Vol. 2	63	Mariana Islands, Vol. 1
29	Northeast Florida	64	Mariana Islands, Vol. 2
30	San Francisco, California	65	Hawaii
31	Alabama	66	Puerto Rico
32	Mississippi	67	U.S. Virgin Islands
33	Louisiana	68	Leaf River, Mississippi
34	South Carolina	69	Kodiak
35	North Carolina	101	Gulf of Aqaba

Appendix D

Creating "Regions" from Biology Polygon Data Layers

Creating "Regions" from Biology Polygon Data Layers

For users who have Arc/INFO®, the polygon data layers (BIRDS, FISH, HABITATS, M_MAMMAL, REPTILES, SHELLFSH, and T_MAMMAL) may be topologically stored as "regions" and eliminate the need for the lookup tables. To convert the polygons to regions the following commands may be used:

```
joinitem incover.pat poly_lut incover.pat ID ID

polyregion incover outcover bio

regiondissolve incover outcover bio rarnum

regionclean incover
```

After creating the new region data layer delete the original data layer (i.e., BIRDS) and rename the recently generated coverage.

Appendix E

Integrating NOAA's ELMR Database and ESI Biology Data Layers and Data Tables

The three fundamental steps associated with the integration process (Figure E-1) are: 1) develop seasonal salinity isohalines by 5 parts per thousand (ppt) for each estuary; 2) update fish and invertebrate species distribution and abundance data; and 3) via GIS technology, organize species distribution data by biologically relevant estuarine salinity zones.

The ELMR fish and invertebrate polygons organize the species spatial and temporal distribution data via salinity zones. Salinity analysis for the National Estuarine Inventory (NEI) estuarine systems focuses on two three-month periods (high- and low-salinity time periods) and one transitional salinity time period. These periods represent the typical high-, transitional-, and low-salinity conditions experienced under average seasonal freshwater inflow conditions. This organizational structure results in estuarine salinity zone polygons that are synonymous with the fish distribution polygons. Salinity is chosen to provide the underlying structure for portraying the fisheries information since it is a primary factor affecting the distribution of estuarine species (Bulger et al. 1993; Monaco et al. in review). In addition, ELMR data are organized by month to account for the influence of water temperature.

The spatial and temporal distribution of ELMR's categorical relative abundance data are assigned to estuaries based on regional and local fisheries science experts, survey reports, peer-reviewed literature, and existing quantitative data. Species relative abundance rankings (highly abundant, abundant, common, rare, and not present) are determined by month for each of the selected species (Nelson 1991; Monaco 1995).

The relative abundance of a species are classified using the following species categories (Nelson 1991):

Figure E-1 this page (sideways—ELMR Flowchart)

- Highly Abundant (5) - species is numerically dominant relative to other species within an assemblage.
- Abundant (4) - species is often encountered in substantial numbers relative to other species within an assemblage.
- Common (3) - species is generally encountered but not in large numbers; does not imply an even distribution over a specific salinity zone.
- Rare (2) - species is present, but not frequently encountered.
- No information available (1) - no data available, and after expert review it was determined that even an educated guess would not be appropriate.

There is approximately an order of magnitude difference in species abundance between each of these categories (Monaco 1995).

Fish and invertebrate relative abundance and seasonal life-stage data are aggregated for the seasonality data shown on the ESI maps. A hierarchical method uses the relative abundance information for the juvenile life-stage in the appropriate time period as the default. Using this method, the relative abundance information shown in the atlas represents the juvenile life-stage for the vast majority of the months. When juveniles are not present in a given month, information from the adult and larval life-stage is used, in that order. An ELMR supplement to the ESI atlas is available for those seeking a more detailed explanation of fish and invertebrate distribution and relative abundance data (Battista and Monaco 1996a). However, in the ESI-GIS, all abundance values for all life-stages are stored in the BREED table.

As stated in Chapter 3, special concentration area polygons are included on the ESI maps for selected fish and invertebrate species to provide additional detail beyond ELMR-based distributions. For fish, these areas would emphasize important spawning, nursery, and migratory areas; and for invertebrates they would include harvested shellfish beds. Furthermore, these polygons may be attributed with concentration data for fish and invertebrates when this information is requested and when the data is available. Threatened or endangered species are an example of biological resources that warrant the development of this additional special concentration polygons.

NOAA conducts an array of GIS procedures to spatially integrate the ELMR data with the salinity information. The isohalines that define the salinity zones are modeled in time and space using GIS contouring techniques that use data from long-term point

sampling stations. ELMR fishery data are then integrated with the salinity polygon features using unique attributes and digital relates between various tables. A unique attribute is created to enable the integration process that is a combination of salinity zone, estuary, and life-stage. Thus, separate time period, estuary, and life-history tables are linked in time and space. The ELMR data are completely merged into the BIORES, SEASONAL, and BREED data tables and the polygons are merged into the FISH and INVERT data layers. The RARNUMs and IDs are calculated and lookup tables are created.

The specific process to integrate ELMR into ESI follows:

- Create working copies of files received.
- Import species table from ORACLE into INFO file called SPECIES.DAT.
- Clean up ELMR.DAT for conversion.
- Create separate INFO files for each element and life stage.
- Aggregate ELMR.DAT file to determine the abundance values for the species and all life stages.
- Split AGGELMR.DAT file into separate INFO files based on ELEMENT.
- Create WILDHAB ids.
- Aggregate data based on unique ids found for each WILDHAB.
- Redefine items on all files in order to create SEASON_ID.
- Join all files together based on SPE_WH item; call the files RPI*ELEM*JOIN.DAT.
- Run a frequency on each RPI*ELEM*JOIN.DAT file for SPECIES_ID and all months called RPI*ELEM*JOIN.FRE; create an item called LU_ID.
- Create SEASON_IDs.
- Create INFO file called SEASONAL.
- Create INFO file called BIORES.

Appendix F

Quality Control Procedures for Delivering ESI Data

CHECKS THAT MUST ALWAYS BE PERFORMED:

1. Make sure your tolerances are set (fuzzy must be 0.002!) and precision is double before creating masters and then make sure all tolerances are correct before proceeding.

2. Create unique IDs.

3. Make sure to delete unnecessary vertices from arcs (ef arc;select all; unsplit none).

4. Check all items in the data tables—they must match the current data structure.

5. Check all topologies and delete any that are not necessary (e.g., nodes on the INDEX coverage).

6. Make sure there are no missing or duplicate labels.

7. Make sure all coverages have the CORRECT projection definition.

8. Run elspe.aml and elspesea.aml. Check all IDs and all lookup tables (THIS IS DESCRIBED IN EACH TABLE SECTION).

9. Drop RARNUM from coverages when the LUTs checkout.

10. Erase all unnecessary INFO® files.

11. Merge the coverage lookup tables into poly and pnt.

12. Convert Oracle® tables to INFO®.

13. Check all INFO® files for duplicates and/or unused records.

14. Create relates between all the data tables and to the coverages to check the logical consistency.

15. Project all coverages to decimal degrees; rebuild topology; and export into the tape/dd directory. Export all INFO® files and put in both the tape//dd and tape//utm (or whatever projection the

atlas was done in). The result is all data is in both directories as export files only.

16. Tar the tape directory (for example, cd tape; tar cvf /dev/rmt/c201d1l). Always use low density.

17. Write the dataset name, date, your name, data size, and command used to write the tape on both the tape and the tape box. Send overnight to client with the final metadata and the Data Deliverables status.

ESI Coverage

1. In Arcedit©, ec mstresi and zoom into the first "quad", check all dangles, polygon labels, and arc attributes. Check for slivers and edgematching problems using the INDEX as a bc. Make sure de node dangle is on. Fill the polys on WATER_CODE to make sure that land and water is correct.

2. Check all items on QA Checklist.

3. Run frequency on esi.aat using ESI and LINE, which lists each unique combination of the two items. Check for incorrect associations or attribute values. All values of the ESI item must conform to current classification rules.

   Check the ENVIR item so that all arcs attibuted with a valid ESI value also have either E, L, or R. If the arc has "U" in ESI, then ENVIR = "U". Run another frequency for SOURCE_ID and make sure all are documented and check each source on-screen to verify they are correct.

4. In arc> dissolve mstresi mstresi2 all# net, which eliminates unnecessary arcs (interior quad bnds). Check to make sure that no water or land was deleted.

5. In Arcedit®, ef arc; relate to lpoly and rpoly; sel line = 'H' and ESI = 'U' and lpoly//water_code = 'L' and rpoly//water_code = 'L'. Delete these streams; then check to see that the remaining arcs are correct.

6. Rebuild topology; in AE> ef arc; sel line = 'l'; res lpoly//esi = 'U'; res rpoly//esi = 'U'; delete; check all remaining data. If OK, then save as mstresi2, and rebuild.

7. To remove the extra water and land labels that no longer have polygons, use createlabels. Make sure to check the final ESI to make sure water and land fill correctly.

8. Update metadata document and make sure you have source data and originator for any aerial photography that was used.

HYDRO Coverage

1. Master HYDRO (MSTRHYDRO) is created from the MSTRESI coverage after step 3 from above has been completed (it has been checked for all attributes).

2. Dropitem MSTRHYDRO.AAT ENVIR and ESI and ESI from the .PAT.

3. Dissolve mstrhydro mstrhydro2 all# net.

4. Check to make sure all land and water is correct and that all dangles are truly streams.

SOC_DATA Table

1. In INFO®; SEL NAME = " ";MOVEIT TYPE TO NAME". This copies the type to the name field so there are no blanks.

2. Run a frequency on all items except the HUNUM. In INFO®, if FREQUENCY > 1, then extra records are in SOC_DATA that

don't need to be there. Re-calculate SOC_DATA HUNUM to first HUNUM, edit SOC_LUT, and calculate the same old HUNUMs to new value (use the Arcedit® atool ch.aml to reduce the amount of typing). The resulting SOC_DATA table looks like the following:

REC. NO.	HUNUM
754	6 Hazardous Waste Site
755	7 Airport
756	7 Airport
757	9 Aquaculture
758	10 Water Intake
759	11 Water Intake
760	12 Airport
761	13 Recreational Fishing
762	13 Recreational Fishing
763	13 Recreational Fishing
764	13 Recreational Fishing
765	13 Recreational Fishing
766	13 Recreational Fishing
767	13 Recreational Fishing
768	13 Recreational Fishing
769	13 Recreational Fishing
770	13 Recreational Fishing
771	13 Recreational Fishing
772	13 Recreational Fishing
773	13 Recreational Fishing
774	13 Recreational Fishing
775	13 Recreational Fishing
776	13 Recreational Fishing
777	13 Recreational Fishing
778	13 Recreational Fishing
779	13 Recreational Fishing
780	13 Recreational Fishing
781	13 Recreational Fishing
782	13 Recreational Fishing
783	13 Recreational Fishing

Where all the same data has the same hunum:

- Make sure you check all of the records using a relate from the lut to the coverages to make sure the item TYPE in the coverage matches the data.

- Erase frequency file and re-run. Check again for frequency > 1 and, if OK, erase old SOC_DATA and copyinfo SOC_DATA.FR to SOC_DATA. Delete frequency INFO® file.

3. If time allows, need to re-calculate the HUNUM item so that it is sequential. However, you need to re-calculate at the same time across all three files (MGT.PATMGT, SOCECON.PAT, and SOC_DATA). To do this, you need to run a cursor in arc using relates from SOC_DATA to both MGT and SOCECON coverages.

4. Check the validity of each SOC_DATA record to both the SOCECON and MGT coverages by setting up a relate in arcedit (edit SOC_DATA INFO):

Relate Name:	MGT
Table:	mgt.patmgt
Database:	info
Item:	HUNUM
Column:	hunum
Relate Type:	LINEAR
Relate Access:	RW

Relate Name:	SOC
Table:	socecon.pat
Database:	info
Item:	HUNUM
Column:	hunum
Relate Type:	LINEAR
Relate Access:	RW

- List hunum,mgt//hunum,soc//hunum

  Are there any records not associated with either coverage? If so, delete them

- Select hunum = mgt//hunum

  List hunum,mgt//hunum,type,mgt//type

  Are there any records which have different types between the attribute and the coverage? If so, find out what the correct type is by looking at data sheets and original maps. Do the same for soc relate

- Select all

  List hunum,mgt//hunum,soc//hunum

5. Update Chapter 5 of the metadata for all items and associated attributes.

BIORES Table

1. Make sure amlpath is /user2/gis/projects/amls and &r elspe biores and &r elspesea biores.

2. Check for duplicate records frequency biores biores.fr

   - rarnum
   - el_spe_sea
   - end
   - end
   - info
   - arc
   - Select BIORES.FR
   - RES FREQUENCY > 1
   - Are there the same number of records in BIORES and BIORES.FR? If not, select FREQUENCY > 1 and find out

which RARNUMs have duplicates. The reason for the duplicates is either: 1) when overlapping regions are converted to polys, the new RARNUM contains the contents of both regions and there may be a conflict in the data (same species–different concentration); or 2) one polygons has the same data listed more than once with maybe a slight change–or none at all–and this is not noticed during the review.

- Was BIO_RES_UNIQ copied from Oracle® to INFO®?
- Was Oracle® data checked for extra records not used in the coverages and RARNUMs in coverages with no data in Oracle®?

3. Sort RARNUM and EL_SPE_SEA.

4. In Arcedit®, set up relate to all bio coverages and list all RARNUMs to make sure there are no extras that are not being used. To check for extras, keep reselecting rarnum ne relate// rarnum until you haveve gone through all coverages. If you are left with 0 selected, then there are no extra records in BIORES.

   - Edit biores info

Relation Name:	pnt
Table Identifier:	pnts_lut
Database Name:	info
INFO Item:	rarnum
Relate Column:	rarnum
Relate Type:	linear
Relate Access:	rw
Relation Name:	poly
Table Identifier:	poly_lut
Database Name:	info
INFO Item:	rarnum
Relate Column:	rarnum
Relate Type:	linear
Relate Access:	rw

```
Relation Name:      sel all
                    sel rarnum = pnt//rarnum
Relate Name:        LUT
Table:              pnts_lut
Database:           info
Item:               ID
Column:             id
Relate Type:        LINEAR
Relate Access:      RW

Relate Name:        PNT
Table:              pnts_lut
Database:           info
Item:               RARNUM
Column:             rarnum
Relate Type:        LINEAR
Relate Access:      RW

Relate Name:        POLY
Table:              poly_lut
Database:           info
Item:               RARNUM
Column:             rarnum
Relate Type:        LINEAR
Relate Access:      RW
Continue?

Relate Name:        COV
Table:              nests.pat
Database:           info
Item:               ID
Column:             id
Relate Type:        LINEAR
Relate Access:      RW
```

Edit BIORES info

Select rarnum = pnt//rarnum (make sure there are no records with no connection to the cov - NESTS)

List rarnum,pnt//rarnum,pnt//cov//id

Select RARNUM = poly//rarnum

5. Do not export the tables until they have all been checked.

SPECIES Table

1. Make sure you change ELEMENT = PLANT to HABITAT and SHELLFISH to INVERT.

2. Make sure amlpath is /user2/gis/projects/amls and &r elspe species.

3. Sort on EL_SPE.

4. In Arcedit®, set up relate to BIORES on EL_SPE and select EL_SPE NE BIO//EL_SPE. Make sure no records are selected (all are used in BIORES).

5. Set up relate to status and select EL_SPE = sta//el_spe. Are there the same number of records selected as in STATUS?

6. Check and edit the subelement list in Section 2.3 of the metadata. For example:

RECORD	ELEMENT	SPECIES_ID	EL_SPE
1	BIRD	1	B00001
2	BIRD	8	B00008
3	BIRD	17	B00017
4	BIRD	18	B00018
5	BIRD	20	B00020
6	BIRD	21	B00021
7	BIRD	23	B00023
8	BIRD	26	B00026
9	BIRD	33	B00033

SEASONAL Table

1. Run ELSPESEA seasonal.
2. Select EL_SPE_SEA NE BIO//EL_SPE_SEA. Make sure there are no records selected.
3. Select el_spe_sea ne bre//el_spe_sea. 0 element(s) now selected.

BREED Table

1. Make sure there are no blanks in any item. If there are, check Oracle® table and make sure the BREED items that are blank are supposed to be N or some other value!
2. In INFO®, select all, sort on EL_SPE_SEA and MONTH.
3. List all records to check that EL_SPE_SEA was updated correctly.
4. In Arcedit®, edit BREED info:
    - Select all
    - relate add
    - sea
    - seasonal
    - info
    - el_spe_sea
    - el_spe_sea
    - linear
    - rw

    - sel el_spe_sea ne sea//el_spe_sea
    - (make sure no recs are selected)

- sel month = 2
- 559 element(s) now selected
- Arcedit®: res sea//feb ne 'X'; res sea//feb ne '2'; res sea//feb ne '3';
- res sea//feb ne '4'; res sea//feb ne '5'

(Do this for each month to make sure BREED and SEASONAL match.)

SOURCES Table

1. Frequency sources sources.fr (all items except SOURCE_ID). Check for FREQUENCY > 1 and list all records to see how similar the data are.

2. Set up relates in Arcedit® as follows:

Relate Name:	BIO_S
Table:	biores
Database:	info
Item:	SOURCE_ID
Column:	s_source
Relate Type:	LINEAR
Relate Access:	RW

Relate Name:	BIO_G
Table:	biores
Database:	info
Item:	SOURCE_ID
Column:	g_source
Relate Type:	LINEAR
Relate Access:	RW

Relate Name: SOC_G
Table: soc_data
Database: info
Item: SOURCE_ID
Column: g_source
Relate Type: LINEAR
Continue?
Relate Access: RW

Relate Name: SOC_A
Table: soc_data
Database: info
Item: SOURCE_ID
Column: a_source
Relate Type: LINEAR
Relate Access: RW

3. Sel SOURCE_ID = bio_g//g_source, list title,bio_g//element and make sure the titles match the ELEMENT category. For example:

TITLE = BIRD CONCENTRATION AREAS FOR COASTAL GEORGIA

BIO_G//ELEMENT = BIRD

2

TITLE = SHELLFISH BEDS, SHELLFISH HARVEST SITES, BEACHES, AND ACCESS FOR COASTAL GEORGIA

BIO_G//ELEMENT = INVERT

3

TITLE = WATERFOWL CONCENTRATIONS AND OTHER RESOURCES FOR ALTAMAHA WMA

BIO_G//ELEMENT = BIRD

4

TITLE = NATURAL RESOURCES FOR LITTLE ST. SIMONS ISLAND, GA

BIO_G//ELEMENT = BIRD

5

TITLE = HUMAN-USE RESOURCES FOR FORT PULASKI NATIONAL MONUMENT

BIO_G//ELEMENT = BIRD

Number 5 needs to be checked further. During the review phase of the project, this source added an access location, but the data compiler did not update the title of the data source.

4. Continue checking all four source relates and make sure the titles match the elements.

ARC_LUT, POLY_LUT & PNTS_LUT

1. In Arcedit®, repeatedly set up relates to each coverage and then res id ne rel//id and make sure there are no records left over.

Arcedit: sel all
726 element(s) now selected
Arcedit: relate add
Relation Name: cov
Table Identifier: birds.pat
Database Name: info
INFO Item: id
Relate Column: id
Relate Type: linear
Relate Access: rw
Relation Name
Arcedit: res id ne cov//id
436 element(s) now selected
Arcedit: relate add

Relation Name: cov
Table Identifier: fish.pat
Database Name: info
INFO Item: id
Relate Column: id
Relate Type: linear
Relate Access: rw
Relation Name:
Arcedit: res id ne cov//id
217 element(s) now selected
Arcedit: relate add
Relation Name: cov
Table Identifier: habitats.pat
Database Name: info
INFO Item: id
Relate Column: id
Relate Type: linear
Relate Access: rw
Relation Name:
Arcedit: res id ne cov//id
205 element(s) now selected
Arcedit: relate add
Relation Name: cov
Table Identifier: invert.pat
Database Name: info
INFO Item: id
Relate Column: id
Relate Type: linear
Relate Access: rw
Relation Name:
Arcedit: res id ne cov//id
43 element(s) now selected
Arcedit: relate add
Relation Name: cov

Table Identifier: m_mammal.pat
Database Name: info
INFO Item: id
Relate Column: id
Relate Type: linear
Relate Access: rw
Relation Name:
Arcedit: res id ne cov//id
37 element(s) now selected
Arcedit: relate add
Relation Name: cov
Table Identifier: offshore.pat
Database Name: info
INFO Item: id
Relate Column: id
Relate Type: linear
Relate Access: rw
Relation Name:
Arcedit: res id ne cov//id
32 element(s) now selected
Arcedit: relate add
Relation Name: cov
Table Identifier: reptiles.pat
Database Name: info
INFO Item: id
Relate Column: id
Relate Type: linear
Relate Access: rw
Relation Name:
Arcedit: res id ne cov//id
0 element(s) now selected

2. Make sure all records in LUT match in BIORES.

NESTS *Coverage*

1. To check these data, or any point data, you must check the geographic integrity of the locations. To do this, you need to check whether the same location is used more than once for multiple records (or sitings in NHP). These multiple points must be reduced to a single location and attribute data converted to multiple records (i.e., one-to-many). This process converts a "flat" data set to a "relational" data set that is not "redundant".

2. addxy <cov> point
   frequency <cov>.pat <cov>.fr
   x-coord
   y-coord
   end

   in tables or info
   sel <COV>.FR
   RES FREQUENCY > 1
   LIST
   Q STOP

3. In Arcedit®, select x-coord = listed rec.; list and delete extra point; update BIO_RES with new WILDHAB or RARNUM, depending on the stage of the project and associated multiple records; update point with correct RARNUM.

4. It is very important to catch these incorrect data earlier in the data stage in order to reduce data errors later on and to minimize data checking and correction time at the end of the project.

5. In Arcedit®, set up a relate between BIO_OBS (ef point) and BIORES using RARNUM, select all, list RARNUM,DAT// RARNUM. Make sure all points have RARNUM values > 0 and all have matching RARNUMs in BIORES.

6. COPYINFO BIORES BIO_OBS.DAT JOINITEM BIO_OBS.DAT BIO_OBS.PAT BIO_OBS.DAT RARNUM el_spe_sea

joinitem bio_obs.dat species bio_obs.dat el_spe el_spe_sea
info
arc
sel BIO_OBS.DAT
RES BIO_OBS# = 0
PURGE
Y
Q STOP
FREQUENCY BIO_OBS.DAT BIO_OBS.FR
Enter the 1st item: ELEMENT
Enter the 2nd item: SPECIES_ID
Enter the 3rd item: NAME
Enter the 4th item: END

Enter the 1st item: END

sel BIO_OBS.FR
LIS ELEMENT,SPECIES_ID,NAME PR
SPOOL
ERASE BIO_OBS.FR
Q STOP

- Put list in appropriate section of metadata.
- Do these records match data entry?
- Check the correctness of this list against original documents.
- ERASE BIO_OBS.DAT when all checks out.

BIRDS (and All Other Biology Polygon Coverages)

1. List BIRDS.PATBIO.

- All regions have RARNUMs?
- Region topology correct (REGIONERRORS)?
- No dangles, slivers, gaps?
- Any polys with no region?

Fix any spatial problems before checking the data.

2. In Arcedit®, set up a relate between BIRDS (ef REGION.BIO) and BIORES using RARNUM, select all, list RARNUM,DAT// RARNUM. Make sure all regions have RARNUM values > 0 and all have matching RARNUMs in BIORES.

3. COPYINFO BIORES BIRDS.DAT

   JOINITEM BIRDS.DAT BIRDS.PATBIO BIRDS.DAT RARNUM EL_SPE_SEA

   joinitem birds.dat species birds.dat el_spe el_spe_sea
   info
   arc
   sel BIRDS.DAT
   RES BIO# = 0
   PURGE
   Y
   res ELEMENT NE 'BIRD'
   PURGE
   Y
   Q STOP

4. Frequency birds.dat birds.fr
   Enter the 1st item: element
   Enter the 2nd item: species_id
   Enter the 3rd item: name
   Enter the 4th item: end
   Enter the 1st item: end

5. Select BIRDS.FR

```
LIST ELEMENT,SPECIES_ID,NAME pr
spool
erase BIRDS.FR
y
```

If everything is correct then erase:

```
sel birds.dat
erase birds.dat
y
```

THEME NAME:_____ **DATE:** _____

FEATURE CLASS	SUBCLASS	NO. OF FEATURES
ARCS		
POLYGONS		
NODES		
C-POLYS		
POINTS		
ANNOTATION		
SECONDARY FEATURES		
TICS		
ARC SEGMENTS		
POLYGON LABELS		
TOLERANCES		
FUZZY =	DANGLE =	
COVERAGE BOUNDARY		
XMIN =	XMAX =	
YMIN =	YMAX =	

BIOLOGY

Check holes: _____

C-Poly errors: _____

Polys not in regions: _____

Topology: polys: _____

c-polys: __Projection defined:

Unnecessary nodes:

GENERAL

Edgematched:_____

Label errors: _____

Slivers:

Dangles:

ESI

LINE values: _____SOCECON values:

SOURCE_ID values:_____

ESI values: ____C-POLY_MGT values:

WATER_CODE values:_____

Topology: arcs:_____

polygons:_____

Gaps in ESI: _____

2, 7 + 9 = 'W': _____

10 = 'L': Polys not in c-polys:_____

SOCECON

RARNUM values: _____

Topology: arcs:

points: _____

polys:

c-polys:

c-polys errors:_____

QA/QC by: _____

GIS Manager: _____

Figure F-1. GIS technician's QA/QC form.

COVERAGE NAME: _____ DATE: _____

BIRDS	ESI	FISH	HYDRO	HABITATS	INDEX	INVERT	M_MAMMAL	NESTS	REPTILES	SOCECON	T_MAMMAL	MISC	
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Topology
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Missing or Duplicate Labels
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Tolerance
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Projection Defined
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Create Unique IDs and Lookup Tables
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Order and Syntax of Items
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Check Lookup Labels
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Drop RARNUM from Coverages
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Erase Unnecessary Files from Project Directory
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Merge Lookup Tables
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Convert Databases
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Check databases of variable names and order
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Check SOURCES for Extras and Duplicates
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Check SOCECON for Extras and Duplicates
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Make README File
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Export All Data
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Make Tar Tape (low density)

Figure F-2. GIS Manager's final QA/QC form.