

## Appendix C

### Regional Aquatic Invasive Species Management Plan Summaries

#### *Methods*

We reviewed regional AIS management plans, where available, and assessed how regional AIS panels consider climate change specifically, as well as how they generally provide for adaptation of strategies and actions under changing conditions. There are a total of seven regional plans. Several regional plans refer to AIS as aquatic nuisance species or ANS. To maintain consistency with regional plan language, this appendix generally uses ANS as a synonym for AIS. Regional plans examined include:

- Great Lakes Action Plan for the Prevention and Control of Nonindigenous Aquatic Nuisance Species
- Gulf of Mexico Aquatic Nuisance Species in the Gulf of Mexico: A Guide for Future Action by the Gulf of Mexico Regional Panel and the Gulf States
- Lake Champlain Basin Aquatic Nuisance Species Management Plan
- Midwest Region Aquatic Nuisance Species Action Plan
- Northeast Region Aquatic Nuisance Species Action Plan
- Southeast Region Aquatic Nuisance Species Action Plan
- Western Region Aquatic Nuisance Species Action Plan

The following summaries also discuss ways to incorporate climate considerations and adaptive management procedures into individual plan goals and strategies when revising plans.

## **Great Lakes Action Plan for the Prevention and Control of Nonindigenous Aquatic Nuisance Species**

### **Available at:**

<http://glc.org/ans/pdf/7-01GLactionplan.pdf> & <http://glc.org/ans/pdf/7-01GLaddendum.pdf>

### ***General Description of the Great Lakes Plan***

The *Great Lakes Action Plan for the Prevention and Control of Nonindigenous Aquatic Nuisance Species* was drafted by the Great Lakes Panel on Aquatic Nuisance Species (ANS) to promote a regional agenda that advances state and provincial efforts to develop and implement comprehensive ANS management. At present, state plans serve as the primary mechanisms for ANS prevention and control efforts in the Great Lakes-St. Lawrence region. The *Great Lakes Action Plan* calls for: regional and global approaches to ANS prevention and control, emphasis on prevention of new introductions, inter-jurisdictional cooperation, comprehensive multi-disciplinary research, and a coordinated and responsive management structure. The plan outlines three goals to address threats posed by ANS:

1. Prevent the unauthorized introduction of nonindigenous aquatic species;
2. Limit the spread of established ANS in the region; and
3. Minimize the harmful ecological economic, social, and public health impacts resulting from ANS already present.

In an addendum, the plan lists objectives and strategic actions designed to achieve these goals through management; research and monitoring; and information, education, and collaboration.

### ***Climate Change and Invasive Species in the Great Lakes***

Climate models project that temperatures in the Midwest may increase by as much as 5 to 10°F during the 21<sup>st</sup> century and that precipitation may increase by 10 to 30 percent (Easterling and Karl, 2001). However, evaporation is expected to increase due to warmer temperatures and other meteorological factors, leading to drier soils, reduced lake and river levels, and more drought-like conditions in many parts of the region. Models project lake level losses of up to five feet in the Great Lakes. In smaller lakes and rivers, increased evaporation will cause reduced flows, exacerbating water quality issues (Magnuson et al., 1997; Easterling and Karl, 2001). Heavy precipitation events are also expected to increase, which would wash nutrients and runoff from urban, agriculture, and construction sites into waterways (Magnuson et al. 1997). Warmer water temperatures may also make waterways more vulnerable to ANS invasions; aquatic ecosystems in the Midwest may experience a shift from coldwater fish species such as trout to warmer water species such as bass and catfish (Robillard and Fox, 2006; Jacobs et al. 2001). For example, Lake Superior Lakewide Management Plan notes that environmental conditions in the Lake Superior basin have prevented reproduction of zebra mussels to date, but that mild weather in recent years has allowed reproduction to occur in the St. Louis estuary. As the climate in the region warms, conditions in the Lake Superior basin may be more amenable to zebra mussel reproduction, allowing the species to become established in the ecosystem (U.S. Environmental Protection Agency, 2000).

### ***The Lake Superior Plan's Consideration of Climate***

The table below summarizes how the *Great Lakes Action Plan for the Prevention and Control of Nonindigenous Aquatic Nuisance Species* considers and incorporates the projected effects of climate change.

<b>Aspects of plan that may consider climate change</b>	<b>Score</b>
<b><i>Understanding and incorporating potential impacts resulting from climate change:</i></b>	
0 = no; 1 = briefly mentions; 2 = includes general discussion; 3 = includes quantitative info and/or specific examples	
Plan specifically mentions climate change	0
Plan acknowledges climatic boundaries of species	0
Plan demonstrates understanding of species and/or ecosystem sensitivity to changing conditions	0
Plan identifies research on the potential effects of species responding to changing conditions	0
Plan acknowledges regional differences in expected climate changes	0
<b><i>Capacity to adapt to changing conditions:</i></b>	
0 = no; 1 = implicitly (i.e. includes goals and strategies that can be used to account for changing conditions, but does not specify changing conditions as part of their purpose); 2 = yes, explicitly, in passing; 3 = yes, explicitly, and specifies associated goals and/or action items	
Plan accounts for changing conditions in its leadership and coordination goals and strategies	0
...prevention goals and strategies	0
...early detection/rapid response goals and strategies	0
...control and management goals and strategies	0
...restoration goals and strategies	0
...research goals and strategies	0
...information management goals and strategies	0
...education and public awareness goals and strategies	0
<b><i>Monitoring strategies:</i></b>	
0 = no; 1 = yes, briefly mentions; 2 = yes, but unclear how information will be used; 3 = yes, and specifies associated goals and/or action items	
Plan includes strategy to monitor for changing conditions	0
Plan includes strategy to utilize monitoring data	0
Plan includes strategy for managing/updating monitoring data	0
<b><i>Revision:</i></b>	
0 = no; 1 = yes, in passing; 2 = yes, and includes qualitative description; 3 = yes, and includes timeline and/or benchmarks for doing so	
Plan includes strategy for updating and incorporating new information	0
<b><i>Funding:</i></b>	
0 = no; 1 = a source is specified for a portion of the required funding; 2 = a source is specified for a portion of the required funding along with strategies for obtaining remaining funding; 3 = a source is specified for 100% of required funding	
Plan identifies dedicated funding source for implementation	0
<b>Total score:</b>	<b>0</b>

The Great Lakes plan does not consider the effects of climate change or changing environmental conditions in general in its recommendations, objectives, and/or strategic actions.

### ***Building in Climate Change Information***

This section provides examples of how and where the management plan could incorporate climate change considerations to adapt management activities in the Great Lakes region.

- *Leadership and Coordination.* Collaboration objectives call for inter-jurisdictional cooperation on prevention and control measures, regulation, and education efforts. Coordination on the regional level offers the opportunity for states to share information

on climate-related ANS issues, including expanding ANS ranges, changing conditions, and adapting management to consider changing conditions. These measures will not only help states collaboratively identify species of concern, but also better prevent the establishment and spread of ANS.

- *Prevention.* Management objectives call for the assessment and characterization of pathways for ANS and the identification of high risk ANS. Efforts to assess risk and develop species lists should account for the effect of climate change on ecosystem vulnerability to ANS invasion and expanding species ranges and vectors.
- *Research.* Research objectives also call for the development of management strategies that address ANS threats. However, if ecosystem conditions change over time, management practices may lose effectiveness. Research should consider changing conditions in order to remain robust in the context of a changing climate.

**Gulf of Mexico**  
**Aquatic Nuisance Species in the Gulf of Mexico: A Guide for Future Action by the Gulf of Mexico Regional Panel and the Gulf States**

Available at: <http://www.olemiss.edu/orgs/SGLC/ANS.pdf>

***General Description of the Gulf of Mexico's Plan***

The Gulf of Mexico's 2003 *Guide for Future Action* examines the structure and activities of the Gulf of Mexico Regional Panel (GMRP) and offers recommendations for aquatic nuisance species (ANS) management for the individual Gulf States. The report summarizes actions the Gulf States have already taken to address ANS (actions are divided into the categories of coordination, prevention, regulation, control and management, and enforcement and implementation) and outlines recommended actions for each state to better address ANS threats. The report concludes with brief suggestions for future actions that the GMRP can take to better support interstate cooperation and to assist member states with the development and implementation of regional priorities. The plan asserts that the role of the panel is to facilitate information exchange among the Gulf States and to provide tools such as policy statements and model legislation. The report also briefly analyzes the structure and activities of the three other regional panels established by the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990: the Great Lakes, the Western Regional, and the Northeast Regional Panels.

***Climate Change and Invasive Species in the Gulf of Mexico***

Climate model projections for the Southeastern U.S. including some Gulf of Mexico states vary, although the major models project warming temperatures (Mearns et al., 2003; NAST, 2001). A Canadian model projects a high degree of warming, accompanied by lower soil moisture as evaporation increases. The Hadley model projects less warming and a 20 percent increase in precipitation (Burkett et al., 2001). Increased temperatures will likely increase stress on water quality. Waterbodies in the Southeast already receive significant pollution from intensive agricultural processes, urban development, and mining. Increased levels of precipitation and more frequent extreme precipitation events will flush more contaminated run-off into waterbodies, and higher temperatures will reduce dissolved oxygen levels in water (Gibson et al, 2005; Jacobs et al., 2001).

Climate models for the Gulf States project an increase in temperature, variations in precipitation, and peak flows in rivers. If all other factors remain the same, the higher freshwater inflow to the estuarine receiving basin will lower salinity, while increases in sea level could increase salinity levels (Mulholland et al., 1997). In general, models suggest that summer precipitation will increase by 10 to 25 percent for all of the Gulf States (Mulholland et al., 1997). Sea level is expected to rise but the degree of increase is uncertain (Mulholland et al., 1997). The region's salt marshes will be particularly affected, as they rely on the interaction of many factors affected by global climate change, including water salinity and nutrient availability (Burkett and Kusler, 2000).

***The Gulf of Mexico Plan's Consideration of Climate***

The table below summarizes how Gulf of Mexico's *Guide for Future Action* considers and incorporates the projected effects of climate change. Please note that the recommendations in

the plan are state-specific and generally focused on increasing state agency jurisdiction, authority, and resources, as opposed to specific management tasks that are outlined in other states' and regions' plans.

<b>Aspects of plan that may consider climate change</b>	<b>Score</b>
<b><i>Understanding and incorporating potential impacts resulting from climate change:</i></b>	
0 = no; 1 = briefly mentions; 2 = includes general discussion; 3 = includes quantitative info and/or specific examples	
Plan specifically mentions climate change	0
Plan acknowledges climatic boundaries of species	0
Plan demonstrates understanding of species and/or ecosystem sensitivity to changing conditions	0
Plan identifies research on the potential effects of species responding to changing conditions	0
Plan acknowledges regional differences in expected climate changes	0
<b><i>Capacity to adapt to changing conditions:</i></b>	
0 = no; 1 = implicitly (i.e. includes goals and strategies that can be used to account for changing conditions, but does not specify changing conditions as part of their purpose); 2 = yes, explicitly, in passing; 3 = yes, explicitly, and specifies associated goals and/or action items	
Plan accounts for changing conditions in its leadership and coordination goals and strategies	0
...prevention goals and strategies	0
...early detection/rapid response goals and strategies	0
...control and management goals and strategies	0
...restoration goals and strategies	0
...research goals and strategies	0
...information management goals and strategies	0
...education and public awareness goals and strategies	0
<b><i>Monitoring strategies:</i></b>	
0 = no; 1 = yes, briefly mentions; 2 = yes, but unclear how information will be used; 3 = yes, and specifies associated goals and/or action items	
Plan includes strategy to monitor for changing conditions	0
Plan includes strategy to utilize monitoring data	1
Plan includes strategy for managing/updating monitoring data	0
<b><i>Revision:</i></b>	
0 = no; 1 = yes, in passing; 2 = yes, and includes qualitative description; 3 = yes, and includes timeline and/or benchmarks for doing so	
Plan includes strategy for updating and incorporating new information	0
<b><i>Funding:</i></b>	
0 = no; 1 = a source is specified for a portion of the required funding; 2 = a source is specified for a portion of the required funding along with strategies for obtaining remaining funding; 3 = a source is specified for 100% of required funding	
Plan identifies dedicated funding source for implementation	0
<b>Total score:</b>	<b>1</b>

The Gulf of Mexico's *Guide for Future Action* does not explicitly address climate change, but it does support the use of monitoring programs to identify and track invasions, and therefore offers opportunities to consider changing conditions.

### ***Building in Climate Change Information***

In light of the considerable impacts of climate change expected in the Gulf of Mexico region, especially the effects of rising sea levels on coastal marshes, the GMRP may wish to address climate change in its future efforts to coordinate state management activities. The following are examples of GMRP actions that could address climate change, as well as GMRP recommendations to the states that could account for changing conditions:

- *Leadership and Coordination.* The guide recommends that the GMRP issue policy statements to identify regional goals and priorities, focus and direct state goals, and urge states to direct resources toward certain activities in order to facilitate regional coordination. These regional goals and priorities should address climate change; if states direct resources toward research and programs that deal with the effects of climate change, important advances in management will be made. Success stories from one state may be very helpful for other states experiencing similar impacts of changing conditions, such as sea level rise and effects on regionally spread ANS such as salvinia and nutria.

The guide also offers state-specific recommendations. The report strongly suggests that Florida, Alabama, Mississippi, and Texas develop comprehensive ANS management plans so that state agencies have priorities and goals for species and pathways. The development of new plans offers the opportunity for states to craft their comprehensive management plans with the effects of climate change in mind. Risk assessments of ANS threats based on the effects of climate change and habitat restoration in climate change-impacted salt marshes, for example, could be incorporated into these plans.

- *Prevention.* The guide also addresses states' assessments of ANS risks. The guide recommends that Florida establish a program for risk assessment, and that Alabama, Mississippi, Louisiana, and Texas establish "clean lists" of species allowed into the state. Assessment of the invasion risk posed by a non-native species should take into account changing conditions that may in the near future favor the species' ability to survive, as well as those that may limit native species' abilities to survive; the loss of native species may free up resources necessary to allow an exotic species to become established.

## **Lake Champlain Basin Aquatic Nuisance Species Management Plan**

Available at: <http://www.northeastans.org/pdf/lcbansplan2000.PDF>

### ***General Description of Lake Champlain's Plan***

The Lake Champlain Basin *Aquatic Nuisance Species Management Plan* was approved in May 2000. The Plan was coordinated by the Vermont Department of Environmental Conservation and the New York State Department of Environmental Conservation in cooperation with state and federal agencies, lake groups, and the research communities in New York, Vermont, and Quebec.<sup>1</sup> The goals of the plan are:

1. Prevent new introductions of ANS into the Lake Champlain Basin;
2. Limit the spread of established ANS populations into uninfested waters; and
3. Abate harmful ecological, socioeconomic, and public health and safety impacts resulting from infestations of ANS.

In order to accomplish these goals, the plan outlines the following objectives:

1. Coordinate plan implementation;
2. Fill information gaps;
3. Select target ANS;
4. Evaluate ANS management alternatives;
5. Implement management actions that eradicate and/or prevent the spread of ANS; and
6. Increase general awareness and understanding of ANS issues.

Each objective is accompanied by associated strategies and actions. The plan also describes ANS problems in the Lake Champlain Basin, authorities and programs related to ANS management, and a list of priority actions for implementation in the two years following the release of the plan.

### ***Climate Change and Invasive Species in Lake Champlain***

Climate models project that minimum winter temperatures in the Northeast will increase from 2.9°C to 5.3 °C by 2100 depending on the model (Hayhoe et al., 2007). Models offer varying projections for changes in precipitation, ranging from increases of up to 30 percent in summer months by 2100 in the summer to decreases or small change in winter months (Hayhoe et al., 2007). Temperature and precipitation changes are likely to increase water temperature in the region's waterbodies, which will affect species survival, dissolved oxygen levels, and nutrient content (Hayhoe et al., 2007). The precipitation regime (amount and timing of rainfall and the size of snowpack and spring runoff) greatly influences the lake's ecosystem. Changes to this regime as a result of climate change could negatively affect habitat for lake species and may

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<sup>1</sup> The plan was developed in cooperation with Environment Canada; Lake Champlain Basin Program; Lake Champlain Committee; New York State Parks, Recreation and Historic Preservation; New York State Soil and Water Conservation Committee; Quebec Ministry of the Environment; Vermont Department of Fish and Wildlife; Vermont Department of Forest, Parks and Recreation; United States Environmental Protection Agency; United States Fish and Wildlife Service; and University of Vermont.



facilitate the spread of ANS already present in the Lake Champlain Basin (The Nature Conservancy). For example, the common reed (*Phragmites australis*) is identified in the plan as an ANS already established in the basin. Altered conditions and habitat availability due to climate change may allow *Phragmites* to spread further.

***The Lake Champlain Plan’s Consideration of Climate***

The table below summarizes how the *Lake Champlain Basin Aquatic Nuisance Species Management Plan* considers and incorporates the projected effects of climate change.

<b>Aspects of plan that may consider climate change</b>	<b>Score</b>
<b><i>Understanding and incorporating potential impacts resulting from climate change:</i></b>	
0 = no; 1 = briefly mentions; 2 = includes general discussion; 3 = includes quantitative info and/or specific examples	
Plan specifically mentions climate change	0
Plan acknowledges climatic boundaries of species	0
Plan demonstrates understanding of species and/or ecosystem sensitivity to changing conditions	0
Plan identifies research on the potential effects of species responding to changing conditions	0
Plan acknowledges regional differences in expected climate changes	0
<b><i>Capacity to adapt to changing conditions:</i></b>	
0 = no; 1 = implicitly (i.e. includes goals and strategies that can be used to account for changing conditions, but does not specify changing conditions as part of their purpose); 2 = yes, explicitly, in passing; 3 = yes, explicitly, and specifies associated goals and/or action items	
Plan accounts for changing conditions in its leadership and coordination goals and strategies	0
...prevention goals and strategies	0
...early detection/rapid response goals and strategies	1
...control and management goals and strategies	1
...restoration goals and strategies	0
...research goals and strategies	0
...information management goals and strategies	0
...education and public awareness goals and strategies	0
<b><i>Monitoring strategies:</i></b>	
0 = no; 1 = yes, briefly mentions; 2 = yes, but unclear how information will be used; 3 = yes, and specifies associated goals and/or action items	
Plan includes strategy to monitor for changing conditions	0
Plan includes strategy to utilize monitoring data	3
Plan includes strategy for managing/updating monitoring data	3
<b><i>Revision:</i></b>	
0 = no; 1 = yes, in passing; 2 = yes, and includes qualitative description; 3 = yes, and includes timeline and/or benchmarks for doing so	
Plan includes strategy for updating and incorporating new information	3
<b><i>Funding:</i></b>	
0 = no; 1 = a source is specified for a portion of the required funding; 2 = a source is specified for a portion of the required funding along with strategies for obtaining remaining funding; 3 = a source is specified for 100% of required funding	
Plan identifies dedicated funding source for implementation	1
<b>Total score:</b>	<b>12</b>

While the Lake Champlain Basin plan does not specifically consider climate change effects, it does include a strong monitoring strategy for ANS. Furthermore, the plan’s framework does present ample opportunity to introduce climate change considerations.

***Building in Climate Change Information***

Considering the effects climate change is projected to have on the Lake Champlain Basin, the regional ANS management plan could benefit from incorporating climate change considerations into its strategic objectives. The following examples describe how the plan might incorporate climate change considerations:

- *Prevention.* Objective C calls for ANS staff to determine which ANS and pathways of introduction should be targeted for management actions. In this prioritization process, staff are to consider species' colonization potential and ecological impacts. This process would be more robust if the assessment of colonization potential accounted for changes in the basin's ecosystems as a result of climate change. Increased precipitation, for example, may make habitat more suitable for certain ANS, increasing their colonization potential. It could also make habitat less suitable for certain native species, allowing ANS to more easily become established.

Objective E relates to the implementation of management actions that eradicate or prevent the introduction or spread of ANS. Strategy E4 includes the consideration of new legislation and regulations controlling the propagation, sale, collection, possession, importation, purchase, cultivation, distribution, and introduction of ANS. When considering new legislation or regulations, policymakers might consider the increased vulnerability of the Lake Champlain Basin to ANS as a result of climate change.

- *Research.* As part of the plan's effort to fill information gaps (Objective B), Strategy B1 calls for surveys of existing ANS within the Lake Champlain Basin, ANS with the potential to enter the basin, and pathways of introduction. Strategy B2, the study of the ecological role of ANS, calls for a literature search for potentially invasive species in order to determine the extent to which they could impact basin ecosystems if introduced. Strategy B3 is the creation of a central repository of information on ANS of concern, including emerging and ongoing control strategies. As mentioned above, ANS' potential to enter the basin depends significantly on the suitability of ecosystem conditions. Research on species' with a high invasive potential should include species' whose invasive potential might increase with changing conditions.

## **Midwest Region Aquatic Nuisance Species Action Plan**

**Available at:** <http://www.protectyourwaters.net/ansreport/MWActionPlan.pdf>

### ***General Description of the Midwest Region's Plan***

The *Midwest Region Aquatic Nuisance Species (ANS) Action Plan* is a product of the *ANS Regulations and Enforcement Workshop*, held in Indianapolis, Indiana on December 12, 2004. The goal of the workshop, the last in a series of four, was to develop a regional assessment of ANS issues that can be addressed through increased coordination and communication among entities in the region. Coordinated by the International Association of Fish and Wildlife Agencies (IAFWA), the plan incorporates input and comments from state and federal agencies dealing with fisheries and law enforcement, nongovernmental organizations, universities, IAFWA and the Midwest Association of Fish and Agencies (MAFWA). The plan identifies the following as highest priority issues for immediate action:

1. Funding;
2. Preventing new introductions and the spread of ANS;
3. Early detection and rapid response;
4. Economic data and public education;
5. Understanding federal ANS laws;
6. Partnerships and coordination;
7. Model legislation and definitions;
8. Internet sales and shipments;
9. Regulated species lists;
10. Training on species identification;
11. International cooperation; and
12. Control and management.

Each priority issue is accompanied by action items at the regional level and a procedure for implementation. The plan also includes: background information on the workshop; attendees' comments on the barriers to achieving the outlined actions; how MAFWA and its partners can organize to pursue the action agenda; what would motivate continued involvement; and next steps.

### ***Climate Change and Invasive Species in the Midwest Region***

Climate models project that temperatures in the Midwest may increase by as much as 5 to 10°F during the 21<sup>st</sup> century and that precipitation may increase by 10 to 30 percent (Easterling and Karl, 2001). However, evaporation is expected to increase due to warmer temperatures and other meteorological factors, leading to drier soils, reduced lake and river levels, and more drought-like conditions in many parts of the region. Models project lake level losses of up to five feet in the Great Lakes. In smaller lakes and rivers, increased evaporation will cause reduced flows, exacerbating water quality issues (Magnuson et al. 1997, Easterling and Karl, 2001). Heavy precipitation events are also expected to increase, which would wash nutrients and runoff from urban, agriculture, and construction sites into waterways (Magnuson et al. 1997). Warmer water temperatures may also make waterways more vulnerable to ANS invasions; aquatic ecosystems

in the Midwest may experience a shift from coldwater fish species such as trout to warmer water species such as bass and catfish (Robillard and Fox, 2006; Jacobs et al. 2001).

***The Midwest Region Plan’s Consideration of Climate***

The table below summarizes how the *Midwest Region ANS Action Plan* considers and incorporates the projected effects of climate change.

<b>Aspects of plan that may consider climate change</b>	<b>Score</b>
<b><i>Understanding and incorporating potential impacts resulting from climate change:</i></b>	
0 = no; 1 = briefly mentions; 2 = includes general discussion; 3 = includes quantitative info and/or specific examples	
Plan specifically mentions climate change	0
Plan acknowledges climatic boundaries of species	0
Plan demonstrates understanding of species and/or ecosystem sensitivity to changing conditions	0
Plan identifies research on the potential effects of species responding to changing conditions	0
Plan acknowledges regional differences in expected climate changes	0
<b><i>Capacity to adapt to changing conditions:</i></b>	
0 = no; 1 = implicitly (i.e. includes goals and strategies that can be used to account for changing conditions, but does not specify changing conditions as part of their purpose); 2 = yes, explicitly, in passing; 3 = yes, explicitly, and specifies associated goals and/or action items	
Plan accounts for changing conditions in its leadership and coordination goals and strategies	1
...prevention goals and strategies	0
...early detection/rapid response goals and strategies	0
...control and management goals and strategies	0
...restoration goals and strategies	0
...research goals and strategies	0
...information management goals and strategies	0
...education and public awareness goals and strategies	0
<b><i>Monitoring strategies:</i></b>	
0 = no; 1 = yes, briefly mentions; 2 = yes, but unclear how information will be used; 3 = yes, and specifies associated goals and/or action items	
Plan includes strategy to monitor for changing conditions	0
Plan includes strategy to utilize monitoring data	0
Plan includes strategy for managing/updating monitoring data	0
<b><i>Revision:</i></b>	
0 = no; 1 = yes, in passing; 2 = yes, and includes qualitative description; 3 = yes, and includes timeline and/or benchmarks for doing so	
Plan includes strategy for updating and incorporating new information	2
<b><i>Funding:</i></b>	
0 = no; 1 = a source is specified for a portion of the required funding; 2 = a source is specified for a portion of the required funding along with strategies for obtaining remaining funding; 3 = a source is specified for 100% of required funding	
Plan identifies dedicated funding source for implementation (includes suggested funding sources)	0
<b>Total score:</b>	<b>3</b>

While the Midwest Region’s plan does not explicitly consider climate change, it does provide opportunity to increase attention to regional ANS issues, which include changing conditions.

***Building in Climate Change Information***

This section provides examples of how and where the management plan could incorporate climate change considerations to adapt management activities in the Midwest region.

- *Leadership and Coordination.* Issue 6 of the plan addresses partnerships and coordination, including involving external organizations such as nongovernmental organizations and industry in promoting ANS policy and agendas. These provisions call for expanding coordination and attention to regional ANS issues. Coordination on the regional level offers the opportunity for states to share information on climate-related ANS issues, including expanding ANS ranges, changing conditions, and adapting management to consider changing conditions.
- *Prevention.* Issue 2 relates to preventing new introductions and the spread of ANS, including the development of a method for evaluating species to determine if they should be allowed to enter a state or the country. Issue 9 involves coordinating and communicating regulated species lists among the states and developing federal guidance for uniformity between states. Efforts to assess risk and develop species lists could also account for the effect of climate change on ecosystem vulnerability to ANS invasion and expanding species ranges and vectors.
- *Education and Public Awareness.* Issue 4 promotes the compilation and use of economic data to generate interest in and support for ANS issues from sport fishing and hunting communities. This includes the production of economic data on ANS impacts and the education of policymakers and the public. Analyses of economic impacts from ANS should also take climate change effects into account and be communicated to the public.

## Northeast Region Aquatic Nuisance Species Action Plan

Available at: <http://www.protectyourwaters.net/ansreport/NEActionPlan.pdf>

### ***General Description of the Northeast Region Plan***

The *Northeast Region Aquatic Nuisance Species (ANS) Action Plan* is based on the results of the *ANS Regulations and Enforcement Workshops* held in Ocean City, Maryland on April 28, 2004 and Atlantic City, New Jersey on September 29, 2004. The workshops, coordinated by the Association of Fish and Wildlife Agencies (AFWA), involved various Northeast entities, including state directors, fish chiefs, ANS coordinators, nongovernmental organizations, and federal agencies. The plan, which focuses on regional cooperation and coordination (as opposed to on-the-ground management actions), identifies the following high priority issues: funding for state and regional ANS management actions; coordination and communication among ANS lists among members of the Northeast Association of Fish and Wildlife Agencies (NEAFWA); development of mechanisms for tracking and controlling Internet sales and other shipments; and development of ANS screening and risk assessment tools. Each priority issue is accompanied by corresponding priority issues at the regional level and a process for implementation. The plan also includes background information on the workshop (including how they were developed, who attended, and the results of participant evaluations).

### ***Climate Change and Invasive Species in the Northeast Region***

Climate models project that minimum winter temperatures in the Northeast will increase from 2.9°C to 5.3 °C by 2099 depending on the model (Hayhoe et al., 2007). Models offer varying projections for changes in precipitation, ranging from increases of up to 30 percent in winter months by 2099 to decreases or small changes in summer months (Hayhoe et al., 2007). Temperature and precipitation changes are likely to increase water temperature in the region’s waterbodies, which will affect species survival, dissolved oxygen levels, and nutrient content (Hayhoe et al., 2007). Increased water temperatures may also increase the region’s susceptibility to invasion by ANS. In Massachusetts, for example, water hyacinth may be limited in its establishment by its inability to overwinter in the harsh New England climate. However, as water temperatures increase, water hyacinth communities that become established during the summer may be able to survive the winter (Massachusetts Department of Natural Resources, 2003).

### ***The Northeast Region Plan’s Consideration of Climate***

The table below summarizes how the *Northeast Region ANS Action Plan* considers and incorporates the projected effects of climate change.

Aspects of plan that may consider climate change	Score
<b><i>Understanding and incorporating potential impacts resulting from climate change:</i></b>	
0 = no; 1 = briefly mentions; 2 = includes general discussion; 3 = includes quantitative info and/or specific examples	
Plan specifically mentions climate change	0
Plan acknowledges climatic boundaries of species	0
Plan demonstrates understanding of species and/or ecosystem sensitivity to changing conditions	0
Plan identifies research on the potential effects of species responding to changing conditions	0
Plan acknowledges regional differences in expected climate changes	0

<b>Capacity to adapt to changing conditions:</b>	
0 = no; 1 = implicitly (i.e. includes goals and strategies that can be used to account for changing conditions, but does not specify changing conditions as part of their purpose); 2 = yes, explicitly, in passing; 3 = yes, explicitly, and specifies associated goals and/or action items	
Plan accounts for changing conditions in its leadership and coordination goals and strategies	0
...prevention goals and strategies	0
...early detection/rapid response goals and strategies	0
...control and management goals and strategies	0
...restoration goals and strategies	0
...research goals and strategies	0
...information management goals and strategies	0
...education and public awareness goals and strategies	0
<b>Monitoring strategies:</b>	
0 = no; 1 = yes, briefly mentions; 2 = yes, but unclear how information will be used; 3 = yes, and specifies associated goals and/or action items	
Plan includes strategy to monitor for changing conditions	0
Plan includes strategy to utilize monitoring data	0
Plan includes strategy for managing/updating monitoring data	0
<b>Revision:</b>	
0 = no; 1 = yes, in passing; 2 = yes, and includes qualitative description; 3 = yes, and includes timeline and/or benchmarks for doing so	
Plan includes strategy for updating and incorporating new information	0
<b>Funding:</b>	
0 = no; 1 = a source is specified for a portion of the required funding; 2 = a source is specified for a portion of the required funding along with strategies for obtaining remaining funding; 3 = a source is specified for 100% of required funding	
Plan identifies dedicated funding source for implementation	0
<b>Total score:</b>	<b>0</b>

The Northeast Region’s plan does not consider climate change effects or changing environmental conditions in general.

***Building in Climate Change Information***

This section provides an example of how and where the management plan could incorporate climate change considerations to adapt management activities in the Northeast Region.

- *Prevention.* Issue 2 involves improving regulation and enforcement through coordination of regulated species lists among states in the region. The plan calls on states to develop a shared methodology and scientific criteria for creating lists and to implement interstate agreements on the development of regional restricted species lists. The development of list criteria should include climate change information that affects ANS’ invasive potential and ecosystem alterations such as increased stream flows. These considerations are also important for Issue 4, the improvement of ANS screening and risk assessment tools. Risk assessment of ANS could similarly account for the Northeast’s increased sensitivity to ANS invasion as a result of climate change.

## **Southeast Region Aquatic Nuisance Species Action Plan**

**Available at:** <http://www.protectyourwaters.net/ansreport/SEActionPlan.pdf>

### ***General Description of the Southeast Region's Plan***

The *Southeast Region Aquatic Nuisance Species (ANS) Action Plan* is a product of the *ANS Regulations and Enforcement Workshop*, held in Hilton Head, South Carolina on October 30, 2004. The purpose of the workshop was to confirm the prioritization of issues in the region and identify steps to draft an action plan to address these issues. The workshop and resulting action plan was coordinated by the International Association of Fish and Wildlife Agencies (IAFWA). Participants included representatives of fisheries and law enforcement interests in state and federal agencies. The plan identifies the following as the highest priority issues for immediate action:

1. Locate funding for state and regional ANS management;
2. Coordinate ANS lists among Southeast states;
3. Describe and enhance regulatory authority within Southeast states and at regional and national levels;
4. Coordinate regional ANS management;
5. Generate support from external organizations by developing and distributing economic impact information; and
6. Enhance state and regional capability for ANS detection and rapid response.

Each of these issues is accompanied by priority actions at the regional level and a step-by-step process for implementation. The plan also includes information on the workshop, including a description of its development, participant reviews, and the agenda.

### ***Climate Change and Invasive Species in the Southeast Region***

Although climate model projections for the Southeast vary, the major models both project warming temperatures (Burkett et al., 2001; Mulholland et al., 1997). The Canadian model projects a high degree of warming, accompanied by lower soil moisture as evaporation increases. The Hadley model shows less warming and a 20 percent increase in precipitation (Burkett et al., 2001). Water bodies in the Southeast already suffer from pollution from intensive agricultural processes, urban development, and mining, and increased precipitation and more frequent extreme precipitation events will flush more contaminated run-off into water bodies. Higher temperatures will also reduce dissolved oxygen levels in water (Mulholland et al., 1997). Sea-level rise is also projected for the region. Flooding and erosion will result from sea-level rise and increasing storm surges. The region will experience coastal wetland loss, reduced habitat for cool water fisheries, and the conversion of freshwater inflows into estuaries (Burkett et al., 2001; Mulholland et al., 1997).

These ecosystem changes may benefit ANS that are more tolerant of poor water quality than native species. In coastal regions, ANS may become established as freshwater areas become increasingly saline. New conditions may also make native species more susceptible to viral ANS. Largemouth Bass Virus (LMBV) has been found in fish in a number of Southeastern



states. The virus has a higher mortality rate in bass when fish are living in stressful conditions, including warm-water temperatures and poor water quality (Inendino et al., 2005; Grant et al., 2003). As climate change increases these two conditions, it is possible that states in the region may experience LMBV-related fish kills.

***The Southeast Region Plan’s Consideration of Climate***

The table below summarizes how the *Southeast Region ANS Action Plan* considers and incorporates the projected effects of climate change.

<b>Aspects of plan that may consider climate change</b>	<b>Score</b>
<b><i>Understanding and incorporating potential impacts resulting from climate change:</i></b>	
0 = no; 1 = briefly mentions; 2 = includes general discussion; 3 = includes quantitative info and/or specific examples	
Plan specifically mentions climate change	0
Plan acknowledges climatic boundaries of species	0
Plan demonstrates understanding of species and/or ecosystem sensitivity to changing conditions	0
Plan identifies research on the potential effects of species responding to changing conditions	0
Plan acknowledges regional differences in expected climate changes	0
<b><i>Capacity to adapt to changing conditions:</i></b>	
0 = no; 1 = implicitly (i.e. includes goals and strategies that can be used to account for changing conditions, but does not specify changing conditions as part of their purpose); 2 = yes, explicitly, in passing; 3 = yes, explicitly, and specifies associated goals and/or action items	
Plan accounts for changing conditions in its leadership and coordination goals and strategies	1
...prevention goals and strategies	0
...early detection/rapid response goals and strategies	0
...control and management goals and strategies	0
...restoration goals and strategies	0
...research goals and strategies	0
...information management goals and strategies	0
...education and public awareness goals and strategies	0
<b><i>Monitoring strategies:</i></b>	
0 = no; 1 = yes, briefly mentions; 2 = yes, but unclear how information will be used; 3 = yes, and specifies associated goals and/or action items	
Plan includes strategy to monitor for changing conditions	0
Plan includes strategy to utilize monitoring data	0
Plan includes strategy for managing/updating monitoring data	0
<b><i>Revision:</i></b>	
0 = no; 1 = yes, in passing; 2 = yes, and includes qualitative description; 3 = yes, and includes timeline and/or benchmarks for doing so	
Plan includes strategy for updating and incorporating new information	0
<b><i>Funding:</i></b>	
0 = no; 1 = a source is specified for a portion of the required funding; 2 = a source is specified for a portion of the required funding along with strategies for obtaining remaining funding; 3 = a source is specified for 100% of required funding	
Plan identifies dedicated funding source for implementation	0
<b>Total score:</b>	<b>1</b>

While the Southeast Region’s plan does not consider climate change, it does provide opportunity to incorporate changing conditions as they arise into its efforts to coordinate ANS management at the regional level.

***Building in Climate Change Information***

This section provides examples of how and where the management plan could incorporate climate change considerations to adapt management activities in the Southeast.

- *Leadership and Coordination.* Issue 2 in the plan calls for the coordination of ANS lists. The plan also suggests member agencies increase consistency among states by developing screening and risk assessment tools. These efforts should be designed to account for projected effects of climate change. Changing conditions are likely to influence the ability of ANS to become established, as well as ecosystem vulnerability to invasions. Risk assessments at the regional level also allow for lists to be comprehensive, and coordination of lists will ensure that species that may easily become established under changing conditions can be addressed by neighboring states.

Issue 4 suggests regional ANS management coordination. This requires the identification and discussion of differences among the states about which species are of highest concern. Risks are to be ranked to determine regional and state management strategies. Again, risks assessments that consider the effects of changing conditions on ANS' invasive potential may account for ANS threats more effectively.

- *Education and Public Awareness.* Issue 5 calls for the generation of support from external organizations by developing and distributing economic impact information. The plan calls for states to describe potential and actual impacts resulting from ANS invasions, generate interest in ANS issues and support from fishing and hunting communities, and achieve balanced media coverage. These economic impacts can also be framed within the context of climate change effects. Climate change is already expected to take an economic toll on portions of the region's timber and agricultural industries (Burkett et al., 2001), and the additional impacts of ANS will exacerbate effects.

## **Western Region Aquatic Nuisance Species Action Plan**

**Available at:** <http://www.protectyourwaters.net/ansreport/WestActionPlan.pdf>

### ***General Description of the Western Region's Plan***

The *Western Region Aquatic Nuisance Species (ANS) Action Plan* is based on discussions and findings from the *ANS Regulations and Enforcement Workshop*, held July 24, 2004 in Sun Valley, Idaho. The workshop, which was coordinated by the International Association of Fish and Wildlife Agencies, sought to confirm the prioritization of ANS issues in the Western region and to identify steps to draft an action plan to address these issues. The resulting action plan incorporates contributions from state and federal agencies, nongovernmental organizations, universities, and consultants. The plan identifies the following as highest priority issues for immediate development and coordination:

1. Funding for state and regional ANS management programs (both regulation/policy and law enforcement);
2. Training for law enforcement officers on species identification;
3. External organizations to promote ANS policy and agendas;
4. Development of screening and risk assessment tools;
5. Mechanisms for tracking and controlling internet sales;
6. Lists of contacts and protocols for rapid response;
7. Regional organizational structure to address ANS;
8. ANS lists among states and clarified definitions in regulation and policy approaches; and
9. Effective, ongoing communication about federal ANS laws.

Each of these priority issues is accompanied by a list of actions items. The plan also includes information on the workshop (including participants and the results of participant evaluations) and a list of “additional actions” that have taken place since the workshop.

### ***Climate Change and Invasive Species in the Western Region***

In the western states, climate change models project a rapid warming—annual average temperatures are expected to increase by 3 to 4°F by the 2030s and by 8 to 11°F by the 2090s (Parson et al., 2001). For example, models project that annual temperatures in California will increase by 2.3 to 5.8 °C (4 to 10°F) during the time period between 2070 and 2090 (Hayhoe et al., 2006). Models also project an increase in winter precipitation and a decrease in summer precipitation, with an annual average precipitation increase from 10 to 30 percent (Parson et al., 2001). However, predictions for California project an annual decrease in precipitation (Hayhoe et al., 2006). These changes in precipitation are likely to lead to earlier melting of snow pack, increased flooding in rain-fed rivers, and summer water shortages. Models also project more extreme wet and dry years (Parson et al., 2001).

Rising sea levels will threaten many coastal wetlands and the species they support. Non-native species are likely to continue to have significant impacts on western ecosystems. Climate change may also facilitate the spread and establishment of AIS in the west. For example, water hyacinth in Washington is thought to be limited in its ability to become established because of

the state's cold winters (Washington Department of Fish and Wildlife, 2001). As increasing temperatures warm water bodies in the region, the waters of Washington may be more suitable for water hyacinth, allowing the plant to become widely established.

***The Western Region Plan's Consideration of Climate***

The table below summarizes how the *Western Region ANS Action Plan* considers and incorporates the projected effects of climate change.

<b>Aspects of plan that may consider climate change</b>	<b>Score</b>
<b><i>Understanding and incorporating potential impacts resulting from climate change:</i></b>	
0 = no; 1 = briefly mentions; 2 = includes general discussion; 3 = includes quantitative info and/or specific examples	
Plan specifically mentions climate change	0
Plan acknowledges climatic boundaries of species	0
Plan demonstrates understanding of species and/or ecosystem sensitivity to changing conditions	0
Plan identifies research on the potential effects of species responding to changing conditions	0
Plan acknowledges regional differences in expected climate changes	0
<b><i>Capacity to adapt to changing conditions:</i></b>	
0 = no; 1 = implicitly (i.e. includes goals and strategies that can be used to account for changing conditions, but does not specify changing conditions as part of their purpose); 2 = yes, explicitly, in passing; 3 = yes, explicitly, and specifies associated goals and/or action items	
Plan accounts for changing conditions in its leadership and coordination goals and strategies	0
...prevention goals and strategies	0
...early detection/rapid response goals and strategies	1
...control and management goals and strategies	0
...restoration goals and strategies	0
...research goals and strategies	0
...information management goals and strategies	0
...education and public awareness goals and strategies	0
<b><i>Monitoring strategies:</i></b>	
0 = no; 1 = yes, briefly mentions; 2 = yes, but unclear how information will be used; 3 = yes, and specifies associated goals and/or action items	
Plan includes strategy to monitor for changing conditions	0
Plan includes strategy to utilize monitoring data	0
Plan includes strategy for managing/updating monitoring data	0
<b><i>Revision:</i></b>	
0 = no; 1 = yes, in passing; 2 = yes, and includes qualitative description; 3 = yes, and includes timeline and/or benchmarks for doing so	
Plan includes strategy for updating and incorporating new information	0
<b><i>Funding:</i></b>	
0 = no; 1 = a source is specified for a portion of the required funding; 2 = a source is specified for a portion of the required funding along with strategies for obtaining remaining funding; 3 = a source is specified for 100% of required funding	
Plan identifies dedicated funding source for implementation	0
<b>Total score:</b>	<b>1</b>

Although the Western Region plan does not consider climate change, it does provide opportunity within its recommended actions for developing a rapid response strategy that accounts for current conditions across the region.

***Building in Climate Change Information***

This section provides examples of how and where the management plan could incorporate climate change considerations to adapt management activities in the Western Region.

- *Leadership and Coordination.* Issue 7 of the plan proposes enhancement of the regional organizational structure for addressing ANS, and Issue 8 proposes coordination of ANS lists among states and the clarification of definitions for regulation and policy. States in the region could incorporate climate change information into this structure by planning communication strategies and sharing information on the regional effects of climate change, as well as changes in habitats and species ranges.
- *Prevention.* The plan calls for the development of screening and risk assessment tools for ANS identification and management (Issue 4). This includes the identification of groups of species and ecosystems where the greatest threat exists and the prioritization of these risks. Risk assessment of ANS could also account for the projected effects of climate change, including shifts in precipitation, nutrient availability, and temperature. Changing conditions may make some habitats more favorable to some ANS, thereby facilitating establishment.
- *Early Detection/Rapid Response.* Issue 6 of the plan outlines the development of a regional rapid response strategy. This section calls for more communication and cooperation among states and awareness of what is happening in other states, the region, and the nation. Attention to how ecosystems may be affected by climate change and how ANS are responding to changing conditions in other states and regions can help western states be better prepared to address these effects.

## References

- Burkett, V; Kusler, J. (2000) Climate change: Potential impacts and interactions in wetlands of the United States. *J Am Water Res Assoc* 36(2): 313-320.
- Burkett, V; Ritschard, R; McNulty, S; O'Brien, JJ; Abt, R; Jones, J; Hatch, U; Murray, B; Jagtap, S; Cruise, J. (2001) Potential consequences of climate variability and change for the southeastern United States. In National Assessment Synthesis Team eds., *Climate change impacts on the United States: the potential consequences of climate variability and change*. Cambridge, England: Cambridge University Press; pp. 137-164.
- Easterling, DR; Karl, TR. (2001) Potential consequences of climate variability and change for the midwestern United States. In National Assessment Synthesis Team eds., *Climate change impacts on the United States: the potential consequences of climate variability and change*. Cambridge, England: Cambridge University Press; pp. 167-188.
- Gibson, CA; Meyer, JL; Poff, NL; Hay, LE; Georgakakos, A. (2005) Flow regime alterations under changing climate in two river basins: Implications for freshwater ecosystems. *River Res Appl* 21 (8): 849-864.
- Grant, EC; Philipp, DP; Inendino, KR; Goldberg, TL. (2003) Effects of temperature on the susceptibility of largemouth bass to largemouth bass virus. *J Aquat Anim Health* 15 (3): 215-220.
- Hayhoe, K; Cayan, D; Field, CB; Frumhoff, PC; Maurer EP; Miller, NL; Moser, SC; Scheider, SH; Cahill, KN; Cleland, EE; Dale, L; Drapek, R; HANemann, RM; Kalkstein, LS; Lenihan, J; Lunch, CK; Neilson, RP; Sheridan, SC; Verville, JH. (2006) Emissions pathways, climate change, and impacts on California. *Proc Natl Acad Sci* 101(34):12422-12427.
- Hayhoe, K; Wake, CP; Huntington, TG; Luo, LF; Schwartz, MD; Sheffield, J; Wood, E; Anderson, B; Bradbury, J; DeGaetano, A; Troy, TJ; Wolfe, D. (2007) Past and future changes in climate and hydrological indicators in the US Northeast. *Clim Dynamics* 28(4): 381-407.
- Inendino, KR; Grant, EC; Philipp, DP; Goldberg, TL. (2005) Effects of factors related to water quality and population density on the sensitivity of juvenile largemouth bass to mortality induced by viral infection. *J Aquat Anim Health* 17(4):304-314.
- Jacobs, B; Adams, B; Gleick, P. (2001) Potential consequences of climate variability and change for the water resources of the United States. In National Assessment Synthesis Team eds., *Climate change impacts on the United States: the potential consequences of climate variability and change*. Cambridge, England: Cambridge University Press; pp. 405-435.
- Magnuson, JJ; Webster, KE; Assel, RA; Bower, CJ; Dillon, PJ; Eaton, JG; Evans, HE; Fee, EJ; Hall, RI; Mortsch, LR; Schindler, DW; Quinn FH. (1997) Potential effects of climate changes on aquatic systems: Laurentian Great Lakes and Precambian shield region. *Hydrol Processes* 11(8):825-871.
- Massachusetts Department of Natural Resources. (2003) Potential invader: water hyacinth. Available online at <http://www.mass.gov/dcr/waterSupply/lakepond/factsheet/water%20hyacinth.pdf> [accessed Apr. 26, 2007].
- Mearns, LO; Giorgi, F., McDaniel, L., and Shields, C. 2003. Climate scenarios for the southeastern US based on GCM and regional model simulations. *Clim Change* 60 (1-2): 7-35.
- Mulholland, PJ; Best, GR; Coutant, CC; Hornberger, GM; Meyer, JL; Robinson, PJ; Stenberg, JR; Turner, RE; Francisco, V-H; Wetzel, RG. (1997) Effects of climate change on freshwater ecosystems of the south-eastern United States and the Gulf Coast of Mexico. *Hydrol Processes* 11(8):949-970.

Parson, EA. (2001) Potential consequences of climate variability and change for the Pacific Northwest. In National Assessment Synthesis Team eds., *Climate change impacts on the United States: the potential consequences of climate variability and change*. Cambridge, England: Cambridge University Press; pp. 247-280.

Robillard, M.M. and Fox, M.G. 2006. Historical changes in abundance and community structure of warmwater piscivore communities associated with changes in water clarity, nutrients, and temperature. *Can J Fish Aquat Sci* 63 (4): 798-809.

The Nature Conservancy. *Conserving Lake Champlain's Biological Diversity*. Available online at [http://www.nature.org/wherewework/northamerica/states/vermont/files/nature\\_conservancy\\_lake\\_champlain\\_biodiversity\\_report.pdf](http://www.nature.org/wherewework/northamerica/states/vermont/files/nature_conservancy_lake_champlain_biodiversity_report.pdf) [accessed Apr. 30, 2007].

U.S. EPA (U.S. Environmental Protection Agency). (2000) *Lake Superior lakewide management plan, chapter 10: aquatic nuisance species*. Available online at <http://gleams.altarum.org/glwatershed/lamps/lakesuperior/2000/LS%20chapter%2010.pdf> [accessed Apr. 26, 2007].

Washington Department of Fish and Wildlife. (2001) *Aquatic nuisance species management plan*. Available online at <http://wdfw.wa.gov/fish/ans/2001ansplan.pdf> [accessed Apr. 26, 2007].