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Experimental Populations: Do They Really Work and How Would We Know?

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DO THEY REALLY WORK AND HOW WOULD WE KNOW?

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Abstract

In response to the severe decline of the last remnant population of wild Atlantic salmon in the United States, the National Marine Fisheries Service and the U.S. Fish and Wildlife Service listed the Gulf of Maine distinct population segment of Atlantic salmon as endangered on November 17, 2000, pursuant to the Endangered Species Act of 1973 (ESA) as amended.

Other rivers within the Gulf of Maine distinct population segment have suitable salmon habitat, but currently do not support wild populations. These river systems could be potential sites for the reintroduction of a population through the utilization of the river-specific hatchery program. Reintroductions are addressed by section 10(j) of the ESA, which authorizes the establishment of experimental populations. The use of experimental populations to facilitate the recovery of other endangered species has been well documented; however, there is uncertainty as to whether these programs are truly contributing to recovery.

There is a pressing need to evaluate the importance of experimental populations as a recovery tool for endangered species. The literature reflects different perspectives as to how to evaluate the "success" of a reintroduction program. This thesis responds to this need by addressing the following three key research questions: 1) How do we attempt to evaluate the success of an experimental population program?; 2) How should success be defined in an Atlantic salmon experimental population program?; and 3) What implications are there for attempting to reintroduce a population of endangered Atlantic salmon in the Gulf of Maine (GOM) distinct population segment (DPS).

Based upon predominant themes in the reviewed literature, case studies examined,

and the collection of survey data, conclusions were drawn with respect to the three key research questions posed in the study. In general the "success" of reintroduction programs should be defined by the creation of self-sustaining populations in the wild. Specifically related to the creation of an experimental population of Atlantic salmon, "success" should be defined primarily by the creation of a self-sustaining population in conjunction with other goals that are ranked according to the relative contributions they could make to salmon recovery. There are several implications for attempting to reintroduce a population of Atlantic salmon including: the collection of additional scientific information; expansion of the range of persistent populations of Atlantic salmon into historic habitat; improved genetic integrity through "straying" and reduction of "hatchery effect." Results drawn from the literature and survey data indicate that the collection of additional scientific data may be significant. However, potential contributions of a reintroduction to straying, range expansion, and reduction of hatchery effect are likely to be minimal.

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Chapter 1:

The Decline of Atlantic Salmon in the United States

This thesis examines the use of experimental populations to facilitate the recovery of threatened/ endangered species. Throughout the last two centuries, Atlantic salmon have been threatened by directed commercial and recreational fisheries, water quality degradation, and obstructions to upstream passage. As a result of human-induced impacts Atlantic salmon populations have been in severe decline over the past century.

In response to the severe decline of the last remnant population of wild Atlantic salmon in the United States, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (collectively referred to as the Services) listed the Gulf of Maine (GOM) distinct population segment (DPS) of Atlantic salmon as endangered pursuant to the Endangered Species Act of 1973, as amended (ESA). The GOM DPS includes "all naturally reproducing wild populations and those river specific hatchery populations of Atlantic salmon having historical river-specific characteristics found north of and including tributaries of the lower Kennebec River to, but not including, the mouth of the St. Croix River at the U.S.-Canada border" (50 CFR 224.101). The Cove Brook, Dennys, Machias, East Machias, Narraguagus, Sheepscot, Ducktrap, and Pleasant (collectively-- DPS Rivers) are the rivers within the GOM DPS range that are known to have remnant populations of wild Atlantic salmon (50 CFR 224.101). Remnant populations in the 8 DPS Rivers persist at extremely low levels.

Other rivers within the GOM DPS have suitable salmon habitat, but currently do not support wild populations. These river systems could be potential sites for the reintroduction of a population through the utilization of the river-specific hatchery program. Reintroductions are addressed by section 10(j) of the ESA, which authorizes the establishment of experimental populations. Given the precarious state of the GOM DPS of Atlantic salmon, experimental populations have the potential to play a significant role in recovery. The use of experimental populations to facilitate the recovery of other endangered species has been well documented; however, there is uncertainty as to whether these programs are truly contributing to recovery.

There is a pressing need to evaluate the importance of experimental populations as a recovery tool for endangered species. Experimental populations have been established for a number of other terrestrial species for a variety of reasons (Leachman and Owens, 1998; Parsons, 1998). The issue of how to successfully reintroduce a species and what defines a "successful" reintroduction program are topics addressed in the literature on experimental populations and endangered species recovery strategies. The success of reintroduction programs can be measured in various ways. A review of rules published in the Federal Register to designate experimental populations indicates that follow-up monitoring, public outreach/education, enforcement, and natural reproduction could play a role as to whether the reintroduction is successful (Leachman and Owens, 1998; Parsons, 1998).

This thesis responds to confusion regarding the evaluation of reintroduction programs by addressing the following questions: How do we attempt to evaluate the success of an experimental population program? What implications are there for attempting to reintroduce a population of endangered Atlantic salmon in the GOM DPS? Could an experimental population of Atlantic salmon contribute to the genetic integrity of existing runs through "straying" (i.e., homing to non-natal stream) and reduce the incidence of "hatchery effect" (i.e., domestication due to hatchery conditions)? Would establishing an experimental population of Atlantic salmon be successful in expanding the range of persistent populations into unused portions of their historic range and avoid extinction due to a catastrophic event? These are questions that I will attempt to address and evaluate in my study.

Atlantic salmon are dynamic organisms with a life history that is both diverse and complex. These complexities are like a double-edged sword, they have allowed Atlantic salmon to evolve unique adaptations to specific ecosystems; however, they have also made them particularly vulnerable to environmental change and degradation. In this thesis I draw certain conclusions about past reintroduction programs and the relative contributions they have made to species recovery. I then use these conclusions and predominant opinions in the literature regarding the success of experimental population programs to assess whether or not an Atlantic salmon reintroduction program is likely to enhance the recovery and conservation of the GOM DPS.

In order to understand the role that a reintroduction program could play in recovery it is necessary to understand the life history of Atlantic salmon and the factors that have caused their demise. This chapter discusses the species life history, abundance and distribution, threats, the inadequacy of existing regulatory mechanisms, and the ESA listing process.

Life History of Atlantic Salmon:

Atlantic salmon are anadromous, which means adults migrate from the marine environment to their natal streams and rivers to spawn. Spawning migrations begin in the spring and continue throughout the summer into the fall. Migration patterns are primarily influenced by river temperature and instream water flow. Therefore, extreme weather patterns (e.g., drought, flood) may create variations in spawning migrations from year to year. Spawning occurs in October and November, after which "spawned out fish" (nicknamed kelt or black salmon) then return to sea or overwinter in the river system. Ideal spawning habitat is characterized by gravel substrate and well circulated water that keeps the eggs oxygenated (Baum, 1997).

The eggs then hatch into alevins or sac fry in the late spring and the yolk sac is gradually absorbed. Three to six weeks later the alevins emerge from the gravel to seek food and are then called fry. Survival to the fry stage is dependent on stream gradient, flow regimes, overwintering temperature, and the presence of competitors and/or predators. Within days the fry quickly develop into parr, which have camouflaging vertical stripes. Parr are extremely territorial and are abundant in areas with fairly deep and fast moving water. At approximately 2-3 years, parr undergo a transformation called smoltification. Changes that occur during smoltification prepare the parr for the transition from the freshwater environment to the marine environment.

Atlantic salmon spend one to three winters at sea before returning to their natal river to spawn. "Precocious male parr" are the exception to this rule, precocious parr become sexually mature before moving out to sea and spawn before entering the marine environment. Unlike Pacific salmon that are semelparous (i.e. spawn once then die), Atlantic salmon can spawn multiple times prior to death (Baum, 1997).

While ocean migrations still remain the most mysterious part of the Atlantic salmon life cycle, tagging studies conducted since 1962 have revealed some information about oceanic distribution and migration rates. Atlantic salmon from Maine have been tagged with external Carlin tags and have been recovered over vast areas of the North Atlantic Ocean (i.e. Greenland, Canada, U.S. coastal areas). Given that Atlantic salmon do not feed during spawning, the period of time they spend feeding in the oceanic environment prior to spawning is critical to survival. Therefore, ocean productivity and the health of natal river ecosystems are both important for the continued preservation and restoration of Atlantic salmon (Baum, 1997).

The Decline of Atlantic Salmon Populations in the United States:

The historic range of Atlantic salmon in the United States extended from the Housatonic River to the St. Croix River on the U.S./Canada boarder (NMFS and USFWS, 1999). The largest runs were in the Connecticut, Merrimack, Androscoggin, Kennebec, and Penobscot rivers (USFWS and NMFS, 1999). However, by the 1800's, Atlantic salmon runs were already seriously depleted. The impacts of commercial and recreational fishing, water quality degradation, and barriers to migration are some of the factors that led to their rapid decline (NMFS and USFWS, 1999). Despite attempted restoration efforts, the Atlantic salmon runs in southern New England were eliminated by 1865 and the only remaining runs were located in Maine (NMFS and USFWS, 1999).

In response to the extirpation of southern populations in the late 1800's, artificial propagation and stock transfers were used to supplement wild populations throughout the remaining Maine runs. The majority of early hatcheries used a combination of Canadian and U.S. broodstock for artificial propagation (NMFS and USFWS, 1999). The Penobscot was the primary source for U.S. broodstock until the decline of these runs led to a lack of availability and increased prices. As a result, the use of Canadian broodstock became more prevalent throughout the 20^{th} Century (NMFS and USFWS, 1999). It was not until the advent of the 1992 river specific propagation program that all use of foreign broodstock ceased (NMFS and USFWS, 1999). The current GOM DPS is still heavily influenced by artificial propagation. However, the current river specific propagation program significantly reduces the loss of adaptive genetic traits and the introduction of potentially harmful alleles (NMFS and USFWS, 1999). While contemporary hatchery programs have been an important factor in supporting the continued existence of the GOM DPS, they do not address other activities in the coastal zone that continue to pose a threat (e.g. agriculture, aquaculture, forestry, and water use) or the inadequacy of existing regulatory mechanisms (NMFS and USFWS, 1999).

Habitat destruction, aquaculture, fisheries, early non-river--specific hatchery programs, and disease/predation have been the major factors that have contributed to the decline of the GOM DPS (NMFS and USFWS, 1999). Habitat destruction due to existing and expanding industries (e.g., agriculture, forestry, and hydropower) has resulted in water quality degradation and outright habitat loss. A direct correlation has been made between the placement of unnatural barriers (dams) and subsequent salmon population declines (NMFS and USFWS, 1999). The expected expansion of blueberry and cranberry operations will continue to contribute to agricultural runoff and low instream flow as a result of water withdrawals. The blueberry industry currently irrigates approximately 6000 acres of land; however, that is expected to increase to 12,000 acres by 2005 (Maine Atlantic Salmon Task Force, 1997). Forestry adversely affects spawning habitat due to the increase in woody debris, silt, and streambank erosion that harvesting produces (NMFS and USFWS, 1999). Other factors continue to contribute to habitat degradation and loss (e.g., acid rain, road construction, urban development) and forestry, agriculture, and hydropower represent only some of the threats to Atlantic salmon habitat and survival (NMFS and USFWS, 1999).

Over the past two centuries, commercial and recreational fisheries have devastated Atlantic salmon populations in Maine. Commercial and recreational fisheries targeting Atlantic salmon are currently prohibited in Maine; however, bycatch in other fisheries is still a source of potential mortality (16 U.S.C. §§ 1801 *et seq*; 12 M.R.S.A. 9902). Although the State of Maine began to limit the direct harvest of Atlantic salmon over the last few decades, foreign commercial fisheries throughout the

North Atlantic continued to target Atlantic salmon (NMFS and USFWS, 1999). The migratory nature of the GOM DPS makes them susceptible to commercial fisheries in West Greenland, Labrador, Nova Scotia, and Newfoundland (NMFS and USFWS, 1999; NMFS, 2004). As previously mentioned, tagging studies enabled scientists to track migratory movements and observe the percentage of tagged fish taken in foreign commercial fishing operations.

In 1982 the United States joined the North Atlantic Salmon Conservation Organization (NASCO) (16 U.S.C. §§ 3601-3608). NASCO is an international treaty organization that is charged with managing Atlantic salmon in the North Atlantic Ocean (North Atlantic Salmon Conservation Organization website, www.nasco.org). The purpose of NASCO is to manage salmon through a cooperative program of conservation, restoration, and enhancement of North Atlantic stocks. One of the primary goals of the organization is to help control the exploitation by one member group of Atlantic salmon that originated within the territory of another member nation (North Atlantic Salmon Conservation Organization website, www.nasco.org). Given the migratory nature of the GOM DPS, this goal was an important motivating factor for the involvement of the U.S. in NASCO (NMFS and USFWS, 1999).

The aquaculture industry has been expanding since the early 1970's. The worldwide production of farmed Atlantic salmon in 1998 was 710,342 tons, which was 295 times the nominal catch of Atlantic salmon in the North Atlantic (NMFS and USFWS, 1999). U.S. Atlantic salmon aquaculture production has substantially increased from 10 metric tons (mt) in 1984 to 12,250 mt in 1997 (Honey et al., 1993;

Baum, 1997). Disease, pollution, and escapement of aquaculture fish are the main threats to wild fish from aquaculture. The aquaculture industry mainly uses net pens in protected bays and coves for production, which creates the potential for interactions between wild and farmed fish. The accumulation of excess feed and byproducts such as antibiotics, and density of fish have been found to be breeding grounds for disease (e.g., Infectious Salmon Anemia virus, Salmon Swimbladder Sarcoma Virus). While an increase in diseases and pollution in important river ecosystems has direct effects on wild populations, the escapement of aquaculture fish also has a substantial impact on wild populations of Atlantic salmon. Evidence shows that interactions between aquaculture fish and wild populations results in increased competition for food and habitat, disruption of natural spawning behavior, and disease transfer (Clifford et al 1998; Youngson and Verspoor, 1998). The escapement of aquaculture salmon, which have less genetically adaptive and diverse traits, may also compromise the genetic variability of wild Atlantic salmon (NMFS and USFWS, 1999).

Agriculture, aquaculture, hydropower, fisheries, and forestry are all activities that are regulated by a variety of state and federal statutes. These regulations were constructed to address potential threats that certain activities pose to Atlantic salmon and their habitat. However, in some cases existing regulations have not been implemented or enforced properly and therefore have not adequately addressed threats faced by wild populations. These five major activities and the associated threats (i.e., water withdrawals, recreational fishing mortality, habitat destruction, disease and aquaculture impacts) remain poorly regulated and have been identified as the major factors contributing to population decline (NMFS and USFWS, 1999).

Water withdrawals from Maine rivers are not a federally permitted activity. Three bodies are responsible for the management of water withdrawals in the State of Maine. The Land and Water Resources Council (LWRC) and the Land Use Regulatory Commission (LURC) have the authority to approve water withdrawals for irrigation and can regulate withdrawals depending upon water levels necessary for species survival. However, LURC and LWRC only manage water withdrawals in organized towns; water withdrawals in unorganized towns are completely unregulated. Both unregulated and regulated water withdraws occur within the watersheds that support wild populations of Atlantic salmon. The Maine Department of Environmental Protection (DEP) is currently in the process of developing a program to manage water withdrawals on a statewide basis (NMFS, 2004).

Prior to the National Marine Fisheries Service and U.S. Fish and Wildlife Service (collectively referred to as the Services) decision to list the GOM DPS as endangered, recreational fisheries were permitted by the Maine Atlantic Salmon Commission (ASC) in the DPS rivers identified by the Services. Although direct harvest was illegal, a catch and release fishery for salmon was allowed. The ASC has the authority to promulgate regulations governing recreational fisheries; however, efforts to close the DPS rivers to all salmon fishing were unsuccessful (ASRSC, 1995).

As previously mentioned, the State of Maine is one to the top U.S. producers in the aquaculture industry. Regulations require aquaculture facilities to operate in accordance with a number of standards. In the past the importation and placement of European strains in aquaculture facilities was partially addressed (NMFS and USFWS, 1999). Under section 10 of the Rivers and Harbors Act, the Army Corps of Engineers (ACOE) prohibited the placement of European hybrids and strains in sea cages (NMFS and USFWS, 1999). However, in the past these permit conditions were loosely enforced (NMFS and USFWS, 1999). The recent release, however, of the Services' biological opinion on the Corps' proposed modification of existing section 10 permits contain additional conditions that complement and reinforce existing regulations creating a regulatory framework that governs all aspects of the operation of aquaculture facilities (NMFS, 2003). The Services will be more involved in the implementation and enforcement of the new special permit conditions included in the biological opinion given the listed status of the species and continuing federal oversight.

In addition to the special conditions for the protection of Atlantic salmon included in all section 10 permits issued, the State of Maine also has stringent fish health requirements that apply to the aquaculture industry and conservation hatchery programs (12 M.R.S.A. 6071 and 6074). The aquaculture industry currently vaccinate their fish against many infectious diseases; however, despite these requirements new disease threats have emerged. The ISA virus recently appeared in aquaculture facilities in close proximity to the DPS rivers and a similar outbreak of ISA virus occurred in a USFWS hatchery, compromising the Services' river-specific stocking program (NMFS and USFWS, 1999).

In response to drastic population declines and the ineffectiveness of existing regulations to limit potentially harmful coastal zone activities, the Services began an extensive ESA listing analysis. In 1991 the Services designated Atlantic salmon in 5 rivers in Downeast Maine (Narraguagus, Pleasant, Machias, East Machias, and Dennys) as Category 2 candidate species under the ESA (i.e. species proposed for listing) (NMFS and USFWS, 1999). In 1993 the Services received identical petitions from RESTORE: The North Woods, Biodiversity Legal Foundation, and Jeffrey Elliot to list U.S. Atlantic salmon as endangered (NMFS and USFWS, 1999). The Services conducted an extensive status review in 1995 and determined that available biological information indicated the species described in the petition did not meet the definition of a species under the ESA (NMFS and USFWS, 1999). The species described in the petition was U.S. Atlantic salmon. The Services believed though that the populations of Atlantic salmon in Maine made up one distinct population segment. However, after reviewing additional biological information during this status review, the Services proposed to list 7 DPS in 7 rivers as threatened. The proposed rule contained a special rule under 4(d) of the ESA, which would allow the Secretary of Commerce or Interior to promulgate special regulations for threatened species that allow certain activities to occur that would otherwise be prohibited acts under the ESA (60 FR 50530 September 29, 1995).

In response to this provision in the Act, Governor Angus King of Maine convened a task force to develop a Conservation Plan for the management and regulation of activities that may influence the 7 DPS rivers. The Conservation Plan was submitted in 1997 for review by the Services (Maine Atlantic Salmon Task Force, 1997). The Services subsequently withdrew the proposed rule to list 7 DPSs in 7 rivers in Maine and in the same notice redefined the 7 DPSs identified in 7 rivers to be one DPS identified as the GOM DPS (62 FR 66325 December 18, 1997). The definition of the DPS was redefined to acknowledge that if more naturally spawning Atlantic salmon were discovered in other river systems, they too would be included as part of the listing (65 FR 69459 November 17, 2000).

In 1999, the Services received an update on the status of the Conservation Plan and the programs implemented under the Plan from the State of Maine. The Services cited recreational fisheries, water use and several other examples as activities that the State of Maine had not adequately addressed through the implementation of the Conservation Plan (65 FR 69459 November 17, 2000). The State responded that two years was not adequate time to implement the Plan and insufficient funding further contributed to the inability of the State to enforce certain provisions in the Plan (65 FR 69459 November 17, 2000). Dissatisfied with the actions taken by the State of Maine under the Plan, the Services reconvened the Biological Review Team (BRT) to conduct a new status review (65 FR 69459 November 17, 2000; 16 U.S.C. 1531 et seq.).

Section 4(a)(1)(A-D) of the ESA requires that listing decisions be made on the basis of the best scientific information available. As a result, the BRT examined two critical questions during its ESA status review: 1) is the entity in question a "species" as defined by the ESA; and, if so, 2) is the species in danger of extinction or likely to become so? To answer the first question, the BRT had to establish whether or not the GOM population could be defined as "distinct" under the ESA. To determine if a population is distinct, straying rates, recolonization rates, and genetic differences must be examined (Utter, 1980). Based upon information from the BRT, the Services recognized that although the GOM DPS was not genetically pure, it did represent a significant evolutionary legacy of Atlantic salmon in the U.S.

The abundance of the GOM population was the second factor assessed (16 U.S.C. 1531 et seq.). Throughout the entire range of the DPS, adult returns were found to be extremely low and the conservation escapement (the number of adults needed to fully use spawning habitat) goal was far below optimum levels (NMFS and USFWS, 1999). After conducting a new extinction risk assessment, the BRT advised the Services that the GOM DPS was at risk of extinction throughout all or significant portion of its range (NMFS and USFWS, 1999). This led to the publication of the final rule to list the GOM DPS as endangered on November 17, 2000 (65 FR 69459 November 17, 2000). The GOM DPS includes populations of Atlantic salmon in the Sheepscot, Ducktrap, Narraguagus, Pleasant, Machias, East Machias, and Dennys Rivers and Cove Brook. Hatchery populations were also included under the listing because they were deemed as essential to recovery and genetically and morphologically resembled wild populations; however, they will not be taken into consideration in any delisting decisions (16 U.S.C. 1531 et seq.). Therefore, the Services will have to determine if the GOM DPS is recovered and then delist the species based upon the number of individuals in the wild as opposed to the number of wild broodstock in the hatchery used to supplement wild populations.

Chapter 2:

The Endangered Species Act and Experimental Populations

The purpose of this chapter is to outline the regulatory framework of experimental population designations and the way that experimental populations are used as a recovery tool. The literature is divided over the success of experimental populations, how a successful reintroduction program should be defined, and the contribution that reintroduction programs make to the conservation and recovery of species. To evaluate the potential role of an experimental population in the recovery of endangered Atlantic salmon in the GOM DPS, these issues must be addressed. This chapter sets the stage for evaluating these critical questions by outlining the statute authorizing experimental population designations, Congressional intent behind the law, and the regulatory implications of reintroduction programs. It is important to understand the purpose of the experimental population statute and the reason Congress passed this statute, to understand why the ongoing discussion of determining and defining a successful experimental population program is important when designating experimental populations.

Section 10(j) of the ESA and Congressional Intent:

The Endangered Species Act was enacted in 1973 to protect species that are threatened or endangered from extinction and to prevent the destruction or curtailment of habitat that is critical to the survival of the species. Over the past three decades more species have been added to the endangered species list than have been removed from the list as a result of recovery (USFWS website, www.usfws.gov). Listing species under the ESA and implementing strategies to recover listed species have been delicate issues due to the regulatory constraints that are often placed on industry groups, state government, and the use of public resources. For example, the endangered listing of the GOM DPS resulted in the promulgation of regulations that have prohibited all recreational fishing in the rivers known to have remnant populations of wild Atlantic salmon (65 FR 69459 November 17, 2000). Federal agencies are now also required to consult on all actions that are authorized, funded, or carried out by the agency to ensure their actions will not result in adverse impacts to the GOM DPS (65 FR 69459 November 17, 2000; 16 U.S.C. 1531 et seq.). This type of increased regulatory authority by the federal government resulted in a certain degree of public opposition to listings and recovery actions. The opposition to many listings and difficulty in implementing recovery measures ultimately led Congress to come up with more creative measures to promote recovery without introducing an additional regulatory burden on industry or the public. Section 10(j) of the ESA was a product of these creative actions.

On May 17, 1982 the House Committee on Merchant Marine and Fisheries, and the Senate Committee on the Environment and Public Works considered legislation authorizing appropriations to carry out the purposes of the act from 1983 through 1985 (H.R. Rep. 97-567, 1982 U.S.C.C.A.N. 2807) and several amendments were proposed in the legislation to encourage more efficient and effective implementation of the ESA for species conservation and recovery. The proposed amendments included actions to: (1) speed up the process by which species are added to or subtracted from the endangered and threatened species list; (2) facilitate the consultation and exemption processes which are designed to resolve conflicts between species protection and development; (3) exempt certain incidental takings; and (4) clarify the handling of experimental populations of endangered species. This legislation was initially introduced on April 21, 1982, following a series of oversight hearings held by the House subcommittee on Fisheries and Wildlife Conservation and the Environment (H.R. Rep. 97-567, 1982 U.S.C.C.A.N. 2807). These hearings focused on the operation and administration of the ESA, specifically in relation to US involvement in Convention on International Trade in Endangered Species (CITES), and finally experimental population designation (H.R. Rep. 97-567, 1982 U.S.C.C.A.N. 2807).

The House Report articulated the desire of Congress to increase the flexibility of federal and state fish and wildlife managers to reintroduce species into their historical range. Congress recognized that while wildlife managers supported reintroductions as a sound recovery strategy, in reality managers were reluctant to voluntarily reintroduce populations of threatened and endangered species due to the political opposition that often resulted from the introduction of additional ESA restrictions on society in the reintroduction area. Industry groups were particularly concerned with reintroductions and the potential for such reintroductions to halt development projects due to increased regulatory burden as a result of the ESA. On

September 17, 1982, Congress amended section 10 of the ESA to include section (j) that defined the term “experimental population” (50 CFR 17.73). Congress defined experimental populations as follows:

> Any population (including any offspring arising solely therefrom) that has been so designated in accordance with the procedures of this subpart but only when, and at such times as the population is wholly separate geographically from non-experimental populations of the same species. Where part of an experimental population overlaps with natural populations of the same species on a particular occasion, but is wholly separate at other times, specimens of the experimental population will not be recognized as such while in the area of overlap. Thus, such a population shall be treated as experimental only when the times of geographic separation are reasonably predictable (50 CFR 17.73).

Congress also restricted the application of several sections of the ESA in order to ease the regulatory burden of species reintroductions on the public, thereby easing potential opposition by industry groups, the general public, or other interested parties (H.R. Conf. Rep. 97-835, 1982 U.S.C.C.A.N. 2860).

Regulatory Implications of Experimental Population Designation:

The ESA and the legislative history of section 10(j) demonstrate that Congress intended to give the Secretary of Commerce or the Secretary of Interior great flexibility in recovering protected species through the establishment of experimental populations. Section 10 (j) of the ESA authorizes the National Marine Fisheries Service and United States Fish and Wildlife Service (the Services) to establish experimental populations of threatened and/or endangered species to facilitate recovery. Congress determined that all experimental populations should be treated as if they are threatened species, which reduces the protection that these individuals are afforded under the ESA. Therefore, protections that are normally afforded to endangered species do not apply. This is one of the critical characteristics of the experimental population provision in the ESA, because it gives the Secretary of Commerce or the Secretary of Interior greater flexibility in managing and recovering listed species and has led to enhanced public support for species reintroductions. The ESA provides general requirements for experimental population designation; however, there is little detail regarding how key terms in the ESA are defined and/or should be applied. In an attempt to clarify ambiguous language in the ESA, the USFWS developed regulations that provide additional guidance on experimental population designations. The following list provides the major regulatory requirements in the ESA and in the USFWS regulations (50 CFR 17.73-17.78).

In accordance with the ESA (16 U.S.C. 1531 et seq.):

1. Each experimental population must be determined to be either essential or nonessential to the recovery of the species. If the loss of an experimental population is likely to jeopardize the continued existence of the species, then it is designated as an "essential experimental population." All other experimental populations are designated as "nonessential" (16 U.S.C. 1531 et seq.).
2. Experimental populations must be geographically separate from non-experimental populations of the same species. In areas where an experimental population overlaps with the listed population, the experimental status does

not apply and reintroduced individuals are afforded the full protection of the ESA (16 U.S.C. 1531 et seq.).

3. Establishment of an experimental population must further the conservation of the species (16 U.S.C. 1531 et seq.).
4. Critical habitat can only be designated for essential experimental populations outside of areas of overlap with non-experimental populations (16 U.S.C. 1531 et seq.).
5. For the purposes of section 7, essential experimental populations should be treated as a threatened species. A nonessential experimental population should be treated as a species proposed for listing except when it occurs within a National Wildlife Refuge or National Park System (16 U.S.C. 1531 et seq.).

In accordance with the USFWS Regulations (50 CFR 17.73-17.78)

1. Experimental populations must be reintroduced into the historic range of the listed species and outside the current range of the species (50 CFR 17.73-17.78).
2. It must be likely that the experimental population will become established and survive into the foreseeable future (50 CFR 17.73-17.78).
3. The effect of establishing an experimental population for species recovery must be weighed with the effect of reintroduction on resource utilization in that particular area (50 CFR 17.73-17.78).
4. The effect that existing or anticipated Federal/ State/ Private activities may have on an experimental population must be evaluated (50 CFR 17.73-17.78).

The National Marine Fisheries Service has not yet designated an experimental population for any species within its jurisdiction; therefore, NMFS has yet to create regulations to guide a designation.

Essential versus Non-essential Experimental Population Designation:

There is a significant difference between designating an experimental population as essential or nonessential to recovery. The protections afforded to an experimental population are dependent upon the classification of essential or non-essential. Experimental populations can be designated as "essential" if they are determined to be essential to the recovery of the species or distinct population segment. Experimental populations can be designated as nonessential if they are not determined to be essential to recovery of the species or distinct population segment.

Section 7 of the ESA is one of the most intrusive sections of the ESA and gives the USFWS and NMFS major regulatory oversight over other federal projects. Section 7 requires other federal agencies to consult with the Services for any projects that are federally authorized, funded, or carried out, that may affect a federally listed species or result in the destruction or adverse modification of critical habitat. If projects are likely to adversely affect an endangered species, the Services have to provide Reasonable and Prudent Measures (RPMs) along with Terms and Conditions to avoid the incidental take of a protected species (USFWS and NMFS, 1998). Incidental take of an endangered or threatened species is prohibited under the ESA, therefore, the RPMs drafted by the Services seek to minimize incidental take. If, however, a project could jeopardize the species as a whole or a distinct population of the species, then the Services must provide Reasonable and Prudent Alternatives, which, essentially, are alternative methods for completing the project or carrying out the actions that will not result in jeopardizing the listed species (USFWS and NMFS, 1998).

Essential experimental populations are treated as threatened species for the purposes of section 7 of the ESA and, therefore, federal agencies are required to consult with the Services on major federal actions (USFWS and NMFS, 1998; 50 CFR 17.73-17.78). Nonessential experimental populations are treated as species proposed for listing for the purposes of section 7 and, therefore, federal agencies would only be subject to confer under section 7(a)4 on major federal actions (USFWS and NMFS, 1998; 50 CFR 17.73-17.78). Section 7(a)4 requires federal agencies to confer with the Services only if the proposed federal action is likely to jeopardize the continued existence of the species or destroy or adversely modify proposed critical habitat (USFWS and NMFS, 1998; 50 CFR 17.73-17.78). The Services may request a conference after reviewing material revealing that a proposed activity might jeopardize the continued existence of the species (USFWS and NMFS, 1998; 50 CFR 17.73-17.78). Section 7 is one of the most rigorous regulatory mechanisms in the ESA, given that it affords the Services extensive oversight of federal projects. As a result, without relaxations in the requirement for federal agencies to consult on projects that may adversely affect listed species, reintroductions would be virtually impossible because political opposition from federal agencies and other individuals could be too great. Federal agencies would be unlikely to participate in a recovery action that would introduce additional responsibilities to consult under section 7 in new areas not previously occupied by listed species. Therefore, the relaxation of the requirement for federal agencies to consult pursuant to section 7 is perhaps one of the most critical elements Congress created in section 10(j).

While species reintroductions do result in less of a regulatory burden on other federal agencies, the general public, and industry groups in comparison to the full protections usually afforded to listed species under the ESA, the process is by no means simple. Designation of an experimental population does require formal rulemaking, therefore the Services must commit significant resources to such a designation. The requirement to engage in formal rulemaking was intended by Congress to provide the Services with the opportunity to consider public comments and provide the opportunity for the Services to promulgate special regulations for each experimental population that would address the specific needs of that particular population (H.R. Conf. Rep. 97-835, 1982 U.S.C.C.A.N. 2860). Given that experimental populations are treated like threatened species (i.e. essential experimental populations) or species proposed for listing (i.e. nonessential experimental populations) in relation to the protections they are afforded under the ESA, the Services are required to draft a 4(d) rule to outline the various prohibitions.

Designation of an experimental population is also subject to review under the National Environmental Policy Act (NEPA). Major federal government actions that have the potential to impact the environment both positively and negatively are subject to NEPA analysis (50 CFR 17.73-17.78; 40 CFR 1500-1508). The scope of the required analysis depends upon the potential impacts of the action on the environment and whether a similar type of action has been reviewed. The scope of analysis required under NEPA is three tiered (40 CFR 1500-1508). Actions for which there have been extensive previous analysis on a similar action can be categorically excluded from review because it is assumed that the proposed action would not have any additional effects that were not considered in a previous review (40 CFR 1501.2-1501.4). Categorical Exclusions (CEs) are also applied to actions that will result in no impact or no significant impact on the environment (40 CFR 1501.2-1501.4).

Actions that are likely to have a significant impact require the completion of in depth analysis. An Environmental Assessment (EA) is a document that analyzes the positive and negative impacts of the proposed project and examines any potential direct, indirect, or cumulative impacts (40 CFR 1501.2-1501.4). If the EA comes to a finding of significant impact, an Environmental Impact Statement (EIS) would be required to complete the analysis (40 CFR 1501.2-1501.4). An EIS requires the analysis of alternatives to the proposed action, presents the potential affects of the alternatives, and allows for public review (40 CFR 1501.2-1501.4)

In addition to the NEPA analysis, designation of an experimental population also requires that the term "population" be defined during the rulemaking process (50 CFR 17.73-17.78). The population can be defined in terms of the reintroduction location, migratory patterns of the species, and/or other characteristics that would allow the population to be identified independently of other listed populations. The reintroduction area must also be defined in the rule independently of the population definition. Defining the reintroduction area is one of the significant challenges in designating an experimental population of Atlantic salmon. Annual changes in habitat availability within certain river systems, changes from year to year in the life stage of individuals being reintroduced, and the objectives of the reintroductions, make it extremely difficult to determine which rivers would be ideal as reintroduction locations. The Services have had discussions regarding a possible Atlantic salmon experimental population program and the potential contributions such a program would have on species recovery. Through these discussions certain rivers have been identified as potential reintroduction sites. The following section outlines these potential reintroduction sites and why the Services started considering an experimental population designation for Atlantic salmon.

An Atlantic Salmon Experimental Population Program in the GOM DPS:

Atlantic salmon in the GOM DPS are highly endangered. The species has been extirpated throughout most of its historic range and despite restoration and recovery efforts the species has continued to decline over the past decade. In an effort to combat the rapid decline of the species, a captive breeding program was established at Craig Brook National Fish Hatchery (CBNFH), located in East Orland Maine, to produce fish that could supplement natural reproduction (referred to as the conservation stocking program). However, the captive propagation program at CBNFH that is used for conservation stocking purposes has suffered from the opposite problem, instead CBNFH has excess eggs and broodstock on an annual basis. In recent years, as a consequence of normal variance in egg survival rates using standard hatchery practices at CBNFH, juvenile Atlantic salmon in excess of the river-specific stocking program targets have been produced. In addition to juvenile salmon in excess of river specific targets, captive reared brood fish are retired from production and become available for release into the wild. Collectively, these fish are referred to as 'bonus fish,' and are surplus to stocking recommendations for their rivers of origin. The conservation stocking program potentially could produce bonus fish on an annual basis.

As a result, the Services and the Maine Atlantic Salmon Commission began to evaluate alternative management options that would allow using these bonus fish in other ways to continue to contribute to Atlantic salmon recovery within the GOM DPS. These options included stocking rivers with remnant wild populations that have sustained low in-river populations over the past several years, utilizing bonus fish for stocking outside the GOM DPS to enhance the Atlantic salmon restoration programs in the Merrimack and Connecticut Rivers, and designating an experimental population. The enhancement of the GOM DPS through the reintroduction of bonus fish could be used to expand the current distribution of wild populations through the reintroduction of bonus fish into suitable historic Atlantic salmon habitat within the DPS. Due to the highly endangered nature of wild Atlantic salmon in the GOM DPS, it is very unlikely that reintroductions could be considered if bonus hatchery production did not exist because there simply would not be enough hatchery stock available to support a reintroduction effort. All hatchery fished produced as a result of the conservation stocking program are used to supplement the remnant wild populations that are persisting at extremely low levels. Given the difficulty of managing and creating adequate hatchery stock for the conservation stocking program (i.e., cost, facility size, availability of parr used for broodstock), it would not be feasible to create a separate conservation stocking program for reintroduction purposes. However, it is also extremely difficult to estimate the exact number of hatchery fish necessary to adequately stock the eight rivers. As a result, it is inevitable that some years result in excess hatchery production and experimental populations offer a way to use these excess fish for recovery purposes. Therefore a reintroduction of Atlantic salmon would only be possible if there are hatchery fish that are excess to the needs of the conservation stocking program.

As previously discussed, there are only remnant populations of wild Atlantic salmon in 8 rivers within coastal Maine. Expansion of the species into vacant historic habitat has the potential to positively and negatively contribute to the viability of the GOM DPS in several different ways. However, to understand the potential contributions that bonus fish could make to recover the GOM DPS, it is fundamental to understand the conservation stocking program, what is defined as bonus, and available vacant habitat. For example, if the Services wanted to use excess fish for research or to test alternative stocking strategies, these activities would be dependent upon the life stage of the excess individuals. If the majority of excess fish are adults, the contribution they could make to species recovery would be different than that of juveniles that are excess to the conservation stocking program. This idea carries over into what habitat is considered for the reintroduction; depending on the life stage and goal of the reintroduction program some rivers would be more appropriate than others.

Definition of Bonus:

The Ad Hoc Stock Enhancement Management Working Group (SEMWG) of the Maine Atlantic Salmon Technical Advisory Committee, of which I was a member, constructed a definition as to what hatchery fish should be considered bonus. The SEMWG determined that hatchery smolt production would never be surplus to the river-specific stocking program because smolts only required a zone of passage into the estuary. It was further recognized that no optimal smolt emigration rates have been observed from any river system. Therefore, bonus river-specific hatchery fish were defined as resident life stages and captive reared broodstock (i.e., juveniles and adults). To determine at what point juveniles and adults were deemed bonus to the river specific stocking program, thresholds were proposed. Juveniles would not become bonus to management needs until:

1) Sub-optimal habitat within the natal river was stocked. For example, in streams too small or inaccessible for canoe stocking, fry could be clumped stocked at available access sites. This would rely on natural dispersal to distribute the fish into productive habitat.

2) Optimal habitat was stocked at densities higher than normal that did not compromise growth and survival.

3) Natural spawning in their natal river exceeded conservation spawning limits and stocking would suppress survival of naturally spawned fish already occupying habitat.

Adults would not become bonus to management needs until:

1) They had been spawned according to CBNFH protocols, and females had produced their lifetime egg contribution target.

2) Natural spawning in their natal river exceeded conservation spawning limits and stocking the progeny of captive reared broodstock would suppress survival of naturally spawned fish already occupying habitat.

Availability of Vacant Habitat:

The SEMWG looked at the quality and availability of habitat both within and outside the GOM DPS to assess what rivers would be available with respect to the three different management options outlined above for the use of bonus fish (i.e. stocking for restoration purposes; enhancement of remnant wild populations; experimental population program). Rivers were evaluated on criteria pertaining to the availability and quality of Atlantic salmon habitat and the ranked list is provided in Table 1. A number of complex issues will need to be resolved before the Service establishes an experimental population of Atlantic salmon. Case studies of previous experimental population designations could help determine how to address some of these difficult issues.

Table 1

Ranked Vacant Habitat in the GOM DPS

Vacant Habitat Within GOM DPS	Priority
Union River	1
Penobscot coastal/estuary tributaries	1
Kennebec coastal/estuary tributaries	2
Tunk Stream	2
Orange River	2
Pennamaquan River	2
Hobart Stream	2
Chandler River	2
Patten Stream	2
Harrington River	2
Indian River	2
Boyden Stream	2
East Stream	2
St George River	2
Medomak River	2

Chapter 3:

Reintroduction Programs: Selected Case Studies

This chapter examines the definition of success with respect to experimental populations and the role that a reintroduction program could play in the recovery of Atlantic salmon. Consideration of previous experimental population designations will assist in this effort. Analysis of previous designations will highlight trends in certain key elements of these reintroductions (e.g., purpose, defined reintroduction site), and facilitate comparisons between this information, information gathered from the predominant literature on reintroduction programs, and data collected from surveys administered to biologists and managers who participated in these programs. There have been approximately 30 experimental population designations completed by the USFWS for a range of species. A number of these designations have been particularly unique. This chapter provides a summary and analysis of each of these controversial and complex designations.

The Delmarva Fox Squirrel: An example of the importance of considering species dispersion.

The Delmarva fox squirrel (*Sciurus niger cinereus*) was one of the first experimental population designations (1984) completed after section 10(j) was amended to the ESA in 1982 (49 FR 3594 September 13, 1984). The experimental population of Delmarva fox squirrel was designated as a nonessential experimental population and was reintroduced in the Assawoman Wildlife Management Area in Sussex County, Delaware. The Secretary completed a 4(d) rule, which outlined what types of incidental take were prohibited under the ESA (49 FR 3594 September 13, 1984). The Assawoman Wildlife Management Area presented a unique situation because prior to the reintroduction, squirrel hunting was permitted (49 FR 3594 September 13, 1984). To sustain public support for the designation and avoid undue regulatory burden on individuals who traditionally used the wildlife management area, it was decided that squirrel hunting should be exempt from the "take" prohibition outlined in the 4(d) rule (49 FR 3594 September 13, 1984). The 4(d) rule did not exempt any other activities that could result in habitat destruction or alteration (49 FR 3594 September 13, 1984). At the time of the listing of the Delmarva fox squirrel the migration and/or movement of the species was thought to be no more than 2-3 miles from the reintroduction area (49 FR 3594 September 13, 1984). However, it was later discovered that the movement of reintroduced individuals was far greater than the range of 2-3 miles. As a result, individuals from the Delmarva fox squirrel population that had been reintroduced were found outside of the Assawoman Wildlife Management Area (49 FR 3594 September 13, 1984).

The expansion of Delmarva fox squirrel individuals outside of the reintroduction area created confusion among adjacent landowners and the general public who assumed that these individuals were still classified as "experimental." The public thus assumed that the prohibition on incidental take did not apply to hunting these animals (in lieu of the previously issued 4(d) rule exempting hunting activities as incidental take) (49 FR 3594 September 13, 1984). This assumption was false, however, because the experimental population designation does not apply beyond the reintroduction area. Instead, according to the USFWS interpretation of the regulations governing experimental populations, individuals that move out of the designated reintroduction area are afforded fully protected status (50 CFR 17.73-17.78). The distinction between protected status within and outside the reintroduction area is important relative to enforcement of prohibitions under the ESA (50 CFR 17.73-17.78). For example, if an individual from an experimental population moved outside of the reintroduction area it would be very difficult if not impossible to distinguish between members of the listed entity fully protected by the ESA and those individuals that are a part of the reintroduction program that enjoy only semi-protected status (50 CFR 17.73-17.78). A similar situation occurred during the reintroduction of gray wolves to Yellowstone National Park. In the case of gray wolves, individuals within the experimental population dispersed outside of the designated reintroduction area.

In the case of the Delmarva fox squirrel, in order to address the confusion created as a result of the dispersion of individuals beyond the reintroduction area, the USFWS created a vigorous public outreach campaign to try and clarify the status of the Delmarva fox squirrel and the associated protections (49 FR 3594 September 13, 1984). While the issues surrounding this designation are currently in the process of being clarified, public misconceptions and confusion may have eroded some public backing which was originally present during the initial reintroduction process. The Delmarva fox squirrel reintroduction program demonstrates the significance of clearly defining the reintroduction site and the problems that can result if certain critical characteristics of the species are ignored, such as dispersion/migratory behavior.

If the Services decide to establish an experimental population of Atlantic salmon in the GOM DPS, consideration of their highly migratory nature and straying rates will be essential. Although straying rates for Atlantic salmon in the GOM DPS are very low and migratory behavior is extremely predictable, providing information on the ESA status of individuals outside the reintroduction area could facilitate public support and understanding if there ever was confusion. Clarifying the status of fully listed individuals and those in the reintroduction program would also facilitate enforcement of certain prohibited acts under the ESA.

Grizzly Bears in the Bitterroot Ecosystem: A demonstration of the importance of public support.

On November 17, 2000, the USFWS published a final rule designating a nonessential experimental population of grizzly bear (*Ursus arctos*) in the Bitterroot ecosystem in East-Central Idaho and adjacent areas in Montana (65 FR 69624 November 17, 2000). The grizzly bear is listed as a threatened species in East-Central Idaho and a portion of Western Montana. Grizzly bears have been extirpated from the majority of the lower forty eight states of the United States; currently they are found only in the Selkirk and Cabinet-Yaak ecosystem, the North Cascades ecosystem, and the Yellowstone ecosystem (65 FR 69624 November 17, 2000). The Bitterroot ecosystem was one of six grizzly bear recovery areas, designated as such in the grizzly bear recovery plan. The Bitterroot ecosystem was considered an ideal recovery area based on biological and ecological characteristics because the ecosystem encompasses several wildlife management areas (65 FR 69624 November 17, 2000). As expected, the proposal to reintroduce grizzly bears into an area where they had been extirpated was highly controversial. The Bitterroot ecosystem is used by the public for both recreational and commercial purposes, therefore major issues that were raised by the public included: safety; predation on livestock; land use restrictions; nuisance bears; and travel corridors (65 FR 69624 November 17, 2000).

The USFWS was sensitive to the concern of the public to these issues and in response formed a 15-member citizen management committee (65 FR 69624 November 17, 2000). The committee had six specific responsibilities including: 1) soliciting technical expertise from wildlife biologists; 2) implementing actions from the Bitterroot section of the recovery plan; 3) establishing a public participation process to review recovery recommendations; 4) developing strategies to emphasize recovery actions; 5) developing grizzly bear guidance for recreational users of the reintroduction area; and 6) developing a response protocol for grizzly bear encounters (65 FR 69624 November 17, 2000). The USFWS also established a website with information on nonessential experimental population designations and developed a public participation and interagency coordination program to identify issues and alternatives to be considered during the NEPA review (65 FR 69624 November 17, 2000). Consideration of public concerns and the reevaluation of recovery actions based upon these concerns effectively reduced some of the public opposition to the experimental population designation (65 FR 69624 November 17, 2000). However, opposition and concerns raised by state agencies, and a lack of resources continued to be ongoing issues that the USFWS was unable to address or resolve (65 FR 69624 November 17, 2000). Finally after failed attempts to build additional support from the public and other government agencies, the USFWS made the decision on June 22, 2001, to remove the experimental population regulations and dispense with implementing that recovery action despite the fact that the final rule to establish an experimental population of grizzly bears in the Bitterroot ecosystem had already been published (66 FR 33619 June 22, 2001). The USFWS pointed to a lack of resources, the need to focus recovery efforts in other areas, and opposition from state agencies as the major factors influencing the change in policy. From June of 2001 to the present there have been no additional plans to pursue grizzly bear reintroduction in the Bitterroot ecosystem.

The effort to reintroduce grizzly bears into the Bitterroot ecosystem perhaps could have been achieved if public support was not low and opposition from state agencies high. The citizen management committee that the USFWS used to try and increase the involvement of affected parties, provide a forum for open discussion of issues associated with the proposed experimental designation, and disseminate valid information to the public was a sound strategy. The USFWS encouraged the development of similar types of management committees during the consideration of other reintroduction programs. While in the case of grizzly bears the committee was unable to minimize public concern and alleviate some of the fears of State agencies, it should continue to serve as a model for addressing many of the same critical issues that arise when experimental populations are proposed in different areas of the country. Given the risk that grizzly bears pose to public safety, it is perhaps more understandable that in this specific example the committee was unable to resolve all issues of concern.

The Reintroduction of Red Wolves: How public outreach can make a difference.

Prior to the designation of experimental populations, red wolves (*Canis rufus*) only existed in captivity (60 FR 189439 April 13, 1995). Over a span of 4-5 years two different populations of red wolves were reintroduced into two different wildlife management areas (60 FR 189439 April 13, 1995). The first experimental population designation resulted in the reintroduction of a population of red wolves to the Alligator River National Wildlife Refuge in Dare County, North Carolina (60 FR 189439 April 13, 1995). The second experimental population was reintroduced into the Great Smoky Mountain National Park in Hayne and Swain Counties, North Carolina (60 FR 189439 April 13, 1995). Several other counties were added to the reintroduction area described in the experimental population designation in subsequent rules (60 FR 189439 April 13, 1995). This expansion was thought to be necessary given that there was the potential for wolves to disperse into areas adjacent to the reintroduction location (60 FR 189439 April 13, 1995). Both of these experimental population designations were considered nonessential based upon the large captive breeding program that was already well established and were being used to supplement wild populations (60 FR 189439 April 13, 1995). While the creation of self-sustaining populations was the primary reason for the reintroduction, researchers also hoped to gather additional information on other critical issues including the coexistence of sportsman and wolf populations, the influence of public outreach campaigns on the success of the reintroduction, and land use management (60 FR 189439 April 13, 1995). Prior to the release of red wolves, the affected communities voiced much skepticism regarding the potential danger of wolves to public safety and livestock (60 FR 189439 April 13, 1995). However, through an intense public outreach campaign that included running documentaries on PBS, conducting magazine and newspaper interviews, and establishing an information management committee consisting of representatives from state and federal governments, industry groups, and conservation organizations, the public opposition slowly eroded and the effort to reintroduce wolves gained support (60 FR 189439 April 13, 1995).

Gray Wolves in Yellowstone: A national controversy.

The reintroduction of gray wolves (*Canis lupus*) into Yellowstone National Park has perhaps been the most controversial and publicly debated experimental population designation (65 FR 43449 July 13, 2000). The gray wolf was virtually extirpated from North America due to human impacts including the elimination of native ungulates, conversion of wildlands into agricultural land, and predator control efforts by private, state, and federal agencies (65 FR 43449 July 13, 2000). The reintroduction of gray wolves was initially discussed in an early draft of the Gray Wolf

Recovery Plan and it was determined to be a sound recovery strategy that could be combined with other restoration efforts (65 FR 43449 July 13, 2000). In 1990, pursuant to Public Law 101-512, Congress directed the establishment of the Wolf Management Committee comprised of 3 federal, 3 state, and 4 special interest group representatives, to develop a restoration plan for wolves in Yellowstone National Park and some of the surrounding areas (65 FR 43449 July 13, 2000). Experimental populations were considered by the Wolf Management Committee in lieu of a declaration by Congress to evaluate the reintroduction of wolves into the Park (65 FR 43449 July 13, 2000).

In November of 1991, pursuant to Public Law 102-154, Congress directed the USFWS in consultation with the National Park Service and Forest Service, to prepare an Environmental Impact Statement (EIS) to consider wolf reintroduction to the Park (65 FR 43449 July 13, 2000). The USFWS received another directive from Congress in 1992 to complete the EIS by 1994 and proceed with reintroduction (65 FR 43449 July 13, 2000). On November 22, 1994, after extensive public meetings and comment periods the USFWS published a final rule designating a nonessential experimental population of gray wolves in Yellowstone National Park, which is located in portions of Wyoming, Idaho, and Montana (65 FR 43449 July 13, 2000). The reintroduction of wolves into Yellowstone National Park continues to be the subject of much debate and has been at the center of two court cases disputing the status of experimental individuals (65 FR 43449 July 13, 2000). The reintroduction of gray wolves was particularly controversial because ranchers in the area perceived the reintroduction as a program to essentially introduce a predator that could potentially inflict harm on their livestock resulting in economic hardship on ranchers. These fears were further fueled when several of the wolves that were reintroduced dispersed outside of the reintroduction area. This created a lot of confusion among the public regarding the ESA status of the individuals that dispersed beyond the reintroduction area. The public questioned whether these individuals were still considered experimental. One of the wolves that dispersed beyond the reintroduction area was subsequently shot and killed by a citizen. This highlighted the need to address some of the opposition to the reintroduction in general and confusion over the ESA status of individuals that dispersed beyond the reintroduction area.

The Southern Sea Otter Reintroduction Program: The essential experimental population designation.

During the 1700 and 1800's the southern sea otter (*Enhydra lutris nereis*) (also referred to as the California sea otter) was reduced almost to extinction due to the commercial fur trade industry (52 FR 29754 August 11, 1987). Due to legislation banning commercial and recreational hunting of southern sea otters, their population has increased and they have expanded some of their range into areas they historically occupied (52 FR 29754 August 11, 1987). However, the population never rebounded completely and therefore the USFWS listed the species as threatened in 1977 (52 FR 29754 August 11, 1987). The vulnerability of southern sea otters to oil spills was one of the major factors that led to the listing of the species, combined with the discovery that sea otters were also vulnerable to lethal entanglements in large-mesh gill and trammel nets used in the nearshore by the local halibut industry (52 FR 29754 August 11, 1987). In 1987 the USFWS determined that the population was not large enough to encourage range expansion, therefore they proposed reintroducing a population to San Nicholas Island which contained abundant prey resources, kelp, waters relatively free of toxic pollutants, and was sufficiently removed from oil tanker traffic to reduce the potential for sea otters to suffer exposure to oil spills (52 FR 29754 August 11, 1987).

On August 11, 1987, the USFWS designated an essential experimental population of southern sea otters on San Nicholas Island (52 FR 29754 August 11, 1987). From the passage of the experimental population amendment to the ESA to the present, southern sea otters have been the only experimental population designated as essential (as opposed to non-essential)[1]. There are no experimental populations currently designated as essential in the United States). Based upon opposition mainly from the fishing industry that fished the waters in the vicinity of San Nicholas Island, the reintroduction was divided into a management and translocation zone (52 FR 29754 August 11, 1987). The management zone was essentially established to create a buffer around the translocation area and minimize conflicts between the reintroduction program, and commercial fishing and oil industries (52 FR 29754 August 11, 1987). Sea otters found in the management area would be captured and returned either to the translocation area or original habitat (52 FR 29754 August 11, 1987). In addition full

[1] this essential designation was recently amended and the current experimental population of sea otters is designated as non-essential (52 FR 29754 August 11, 1987)

section 7 review was only required for actions occurring in the translocation area (52 FR 29754 August 11, 1987). This reintroduction was highly supported by some sectors of the general public, however it was also vehemently opposed by the commercial fishing and oil industries (52 FR 29754 August 11, 1987). The southern sea otter designation made significant contributions to experimental population management due to the number of issues that arose during and following the implementation of the reintroduction program (52 FR 29754 August 11, 1987). Several of these issues will be discussed later in this thesis.

Other Designations: Unique reintroduction programs.

The Mexican gray wolf (*Canis lupus baileyi*), the California condor (*Gymnogyps californianus*), sixteen species of freshwater mussels, and six different freshwater fish species have been among other experimental population designations that have been carried out for the sole purposes of recovering and expanding the range of a threatened or endangered species (63 FR 631752 January 12, 1993; 59 FR 60266 November 24, 1994; 59 FR 60252 November 24, 1994; 61 FR 54047 October 16, 1996; 66 FR 30853 June 8, 2001; 66 FR 32250 June 14, 2001). Although furthering the conservation of the species is inherent in all of experimental population designations, reintroductions of several other species have served multiple purposes. Black-footed ferret, whooping crane, and Guam rail are species for which experimental populations have been designated to further the conservation of the species, with particular emphasis on scientific research (54 FR 43966 October 30, 1989; 56 FR 41473 August 21, 1991; 58 FR 5647 January 22, 1993; 59 FR 42682 August 18, 1994; 59 FR 42696 August 18, 1994; 61 FR 11320 March 20, 1996; 62 FR 38932 July 21, 1997; 63 FR 52824 October 1, 1998; 65 FR 60879 October 13, 2000).

Crane and Black-footed ferrets: Unique opportunities created by captive breeding programs.

The black-footed ferret (*mustela nigripes*) is the only ferret native to North America and historically it was found over a large geographic area ranging throughout 12 states and the Canadian provinces of Alberta and Saskatchewan (65 FR 60879 October 13, 2000)[2]. Black-footed ferrets prey primarily on prairie dogs and use their burrows for shelter. As the west became more populated and huge portions of prairie were used for agricultural purposes, prairie dog populations declined dramatically (65 FR 60879 October 13, 2000). Prairie dog population decline is attributed to loss of habitat and widespread poisoning of prairie dogs by farmers and ranchers who saw prairie dogs as pests (65 FR 60879 October 13, 2000). At approximately the turn of the century sylvatic plague was introduced into the United States, further decimating prairie dog populations. As a result of the dramatic decline in prairie dog populations, the black-footed ferret was virtually extinct (65 FR 60879 October 13, 2000).

[2] There were several black-footed ferret experimental population designations starting in 1991 and continuing through 2000. Therefore each federal register notice for each designation had information that is discussed throughout the discussion on black-footed ferret experimental populations designations. Rather than sighting each notice in the text repeatedly, the following list provides the other sources that were used in this section: 63 FR 52824 October 1, 1998; 56 FR 41473 August 21, 1991; 59 FR 42682 August 18, 1994; 59 FR 42696 August 18, 1994; 61 FR 11320 March 20, 1996.

On March 11, 1967, the black-footed ferret was determined to be endangered (65 FR 60879 October 13, 2000)[3]. In 1964 a wild population was discovered and studied intensely for the next 10-12 years until the last individual from the population died in captivity in 1979 (65 FR 60879 October 13, 2000). The species was then thought to be extinct until 1981 when a new wild population was discovered in Meeteetse, Wyoming (65 FR 60879 October 13, 2000). In 1986 and 1987 the USFWS captured 18 individuals from this population to serve as the founder population for a captive breeding program that would create populations to reintroduce back into the species' historical range (65 FR 60879 October 13, 2000). Within 6 years the captive population increased from 18 individuals to over 300 individuals (65 FR 60879 October 13, 2000). Several other captive breeding programs were subsequently established and nonessential experimental populations were established in several different areas in the western portion of the United States (e.g. North-Central Montana population, Southwestern South Dakota population) (56 FR 41473 August 21, 1991; 59 FR 42682 August 18, 1994; 59 FR 42696 August 18, 1994; 61 FR 11320 March 20, 1996; 63 FR 52824 October 1, 1998; 65 FR 60879 October 13, 2000). These populations were deemed to be nonessential due to the rapid repopulation of historically occupied habitat as a result of supplementation with captive reared individuals and mitigation of threats to the species throughout their range (65 FR 60879 October 13, 2000).

[3] Despite that the ESA did not exist in 1967, biologists still conducted population assessments to determine the status of the species. In the case of black-footed ferrets they were determined to be endangered in 1967.

In the early stages of recovery, populations were reintroduced to increase the number of individuals in the wild. However, once wild populations were considered to be more stable, black-footed ferret experimental populations were established for other purposes including utilization of excess numbers of individuals in captive breeding programs and study of pre-release and release techniques that could potentially improve the chances of survival of reintroduced individuals (65 FR 60879 October 13, 2000). Reintroductions completed for purposes described above (i.e., utilizing excess propagated individuals and research) other than establishing self-sustaining populations were critical in expanding the types of actions considered in endangered species recovery. The whooping crane (*Grus americana*) reintroduction program was similar to the black-footed program because nonessential experimental populations were primarily established to study release techniques to improve species survival (58 FR 5647 January 22, 1993; 62 FR 38932 July 21, 1997).

The Guam Rail Reintroduction Program: Creating a gene bank for the future.

The Guam rail (*Rallus owstoni*) is a unique example of a nonessential experimental population that has been established (54 FR 43966 October 30, 1989). The Guam rail historically ranged throughout Guam. However, following the introduction of the brown tree snake the Guam rail, along with virtually the entire avifauna of Guam, declined to the point of near extinction (54 FR 43966 October 30, 1989). The continuing presence of the brown tree snake in Guam has rendered Guam rail habitat significantly altered. As a result, the USFWS was forced to look for similar habitat outside the species' historic range (54 FR 43966 October 30, 1989). The nearby Island of Rota had similar habitat and was selected as an appropriate introduction area for excess individuals propagated in the USFWS captive breeding program (54 FR 43966 October 30, 1989). Between 1989 and 1999, 267 Guam rails from the captive breeding program were released on Rota (Brock and Beauprez, 2000). These individuals successfully produced 5 nests with eggs that led to hatchlings (Brock and Beauprez, 2000). Studies show that the Guam rail is particularly susceptible to domestication they become exceedingly tame over time and eventually lose their ability to survive in the wild (54 FR 43966 October 30, 1989). As a result, the USFWS sought to establish a wild population that could serve as a future source of wild Rails for reintroduction to Guam once the invasive brown tree snake is extirpated (54 FR 43966 October 30, 1989). This experimental population essentially created a gene bank that could be used for future recovery actions.

As previously mentioned, one of the main obstacles to Rail reintroduction on Guam was the presence of the brown tree snake. In 1997, the Biological Research Division of the U.S. Geological Survey developed snake barriers and implemented perimeter snake trapping in and around a 60-acre plot located in Guam National Wildlife Refuge (Brock and Beauprez, 2000). This recovery/reintroduction area was renamed Area 50 (Brock and Beauprez, 2000). Portions of Area 50 overlapped with a portion of Andersen Air Force Base, which had specifically been set aside to test habitat management methods, snake control techniques, and species recovery strategies (Brock and Beauprez, 2000). Over the course of nine weeks, the number of snakes trapped declined from approximately 14.9 to 1.5 snakes per 100 trap nights (Brock and Beauprez, 2000). Trapping continued for an additional fifteen weeks, after which a snake barrier was erected around Area 50 and a grid of snake traps was placed evenly around the barrier (Brock and Beauprez, 2000). In 1998, biologists were confident that brown tree snakes within Area 50 were significantly depleted and under control (Brock and Beauprez, 2000). As a result, sixteen captive reared Guam rails were released into Area 50. In 1999, following the reintroduction of several more individuals, nine rails were identified as having made approximately sixteen attempts to nest, resulting in forty-six eggs (Brock and Beauprez, 2000).

This development was extremely encouraging because it demonstrated that Guam rails could be reintroduced into the wild and could successfully breed to produce naturally reared offspring. This effort has reinforced the desire to eradicate the brown tree snake from other areas on Guam with suitable rail habitat and continue the effort to reintroduce individuals to create additional self-sustaining rail populations. It is evident that in the case of Guam rail reintroduction, the ability to create a self-sustaining population certainly has been successful and has contributed to rail recovery.

These case studies have created a set of precedents and pit falls that managers will look to in the future when designating experimental populations. These case studies highlight critical considerations including: 1) the importance of clearly defining the reintroduction area; 2) the need for public outreach and public input during designations; 3) the importance of defining the purpose of the reintroduction;

and 4) the importance of considering ecological as well as political issues during designations.

While experimental populations have been established for a variety of reasons, ultimately the goal of all species reintroductions is to assist species recovery. Whether or not these reintroductions have truly contributed to recovery is still the subject of much debate both in the literature and among wildlife managers. In the following chapter an analysis of the literature will consider the various sides of this debate.

Chapter 4:

Discussion of "success": What constitutes "success" and other important biological baseline data

Thus far, this thesis has reviewed the status of Atlantic salmon in the GOM DPS, the regulatory framework governing the experimental population designation process, and past reintroduction programs that have been implemented in the United States. However, in order to put the above information in context and determine how to define a successful reintroduction program and whether an experimental population could enhance the recovery of Atlantic salmon in the GOM DPS, it is necessary to examine previous studies that have evaluated the effectiveness of reintroduction programs in species recovery.

As seen below there is a somewhat limited body of research that specifically discusses the effectiveness of reintroduction programs in threatened/endangered species recovery. A wider body of research focuses on approaches to conservation and recovery of threatened/endangered species in general. Several reoccurring themes and conclusions are prevalent in these literatures. Reoccurring themes include evaluating "success," predicting conditions for "successful" reintroductions, and effectiveness of experimental populations in enhancing species recovery. The first portion of this following chapter includes a discussion of these critical themes and provides an analysis of the predominant conclusions that have been drawn about these issues.

Predominant Themes of Previous Evaluative Research on Reintroduction Programs:

How Should "Success" Be Defined?

There are many reasons why it is important to define "success." In general, determining whether an individual or organization achieved a specific goal rests upon understanding how success is defined and measured (Maguire et al., 1988; Griffith et al., 1989; Kleiman, 1989; Kleiman, 1990; Konstant, 1990; Phillips, 1990; Reading et al., 2002). For example, if an individual were throwing a party, he might define a successful party by the number of people who attended; he might not feel the party to be a success if only a small number of people attended. This might be completely contrary to another individual who defines a successful party as a party at which the majority of people have a good time. In this case, success is simply defined by whether the people who attend have fun, rather than by the number of people attending. Although the example of evaluating a successful party is a simple and trivial one, it does demonstrate how measuring success is highly dependent on how success has been defined in the first place. Therefore, when implementing a reintroduction program for the purposes of species recovery, it is critical to define the goals of the experimental population program and how success will be measured (Maguire et al., 1988; Griffith et al., 1989; Kleiman, 1989; Kleiman, 1990; Konstant, 1990; Phillips, 1990; Reading et al., 2002).

There is no uniformly accepted definition of what constitutes a "successful" reintroduction. However, there is a predominant view reflected in previous research that is shared among experts regarding the definition of a successful experimental population (Griffith et al., 1989; Kleiman, 1989; Kleiman, 1990; Tate, 1990; Reading et al., 2002). Traditionally, the success of experimental populations has been defined by the ability of the reintroduced individuals to establish self-sustaining populations (Griffith et al., 1989; Griffith et al., 1990; Tate, 1990; Reading et al., 2002). This definition is somewhat embedded in section 10(j) of the ESA ("The likelihood that any such experimental population will become established and survive into the foreseeable future" 50 CFR 17.73-17.78), which was created by Congress to encourage reintroductions as a means to expand the current range of threatened/endangered species without any additional regulatory burden to the public. Section 10(j) of the ESA further supports this limited definition of success because it states that an experimental population should only be established if it is reasonably likely that the species will be able to create a self-sustaining population in the near future (50 CFR 17.73-17.78).

The legislative history demonstrates that this language ("The likelihood that any such experimental population will become established and survive into the foreseeable future" 50 CFR 17.73-17.78) was incorporated to encourage endangered species managers and biologists to carry out viable reintroductions that have some reasonable likelihood of contributing to recovery (H.R. Rep. 97-567, 1982 U.S.C.C.A.N. 2807). However, based upon this traditional view of success, if the majority of experimental populations have not resulted in self-sustaining populations without artificial supplementation of the reintroduced population, then have these reintroduction programs failed? In fact Reading et al. (2002) describe reintroduction as a conservation technique that usually fails based upon the traditional goal of creating self-sustaining populations. Does this mean that experimental populations that are unable to maintain self-sustaining populations have made absolutely no contribution to recovery? To the contrary, it can be argued that such a perception is inherently flawed and overlooks many subtle alternative contributions that reintroduction programs may make to species recovery (Askins, 1987; Griffith et al. 1989; Kleiman, 1989; Phillips, 1990).

Kleiman (1989) presented goal setting as one strategy to highlight subtle contributions of reintroduction programs, and to determine and define the success of the program. There should be a clearly defined link between the stated goals of the program and how success will be measured with respect to these goals. For example, if the goal of the reintroduction program is public education and awareness or preservation of a particular critical habitat area, then simply the presence of the population could be deemed a success and beneficial to the recovery of the species (Maguire et al, 1988; Lewis, 1990; Phillips, 1990).

The reintroduction of red wolves is a good example of a program where goals were carefully defined and measures of success were developed (Phillips, 1990). Biologists developed two specific measures of success: 1) the presence of second-generation wild-born pups in the refuge; and 2) collection of biological information gained through research and monitoring associated with the project (Phillips, 1990). The first measure was developed specifically to provide biologists and managers with a way to measure the project's progress (Phillips, 1990). Although four pairs of released wolves produced pups in the wild, thus demonstrating the ability to transition from reproducing in captivity to natural reproduction, the overall program faced substantial set backs within the first three years (Phillips, 1990). During the first three years fifteen of the twenty-nine released wolves died. This is over a 50% mortality rate, which the public viewed as a significant failure. However, biologists were optimistic due to the nature of the mortality events, all of which were natural or accidental as opposed to violent/malicious wolf-human interactions. The program not only fulfilled the two stated objectives, it also resulted in many indirect net benefits including the following: 1) increased public awareness of wolves and endangered species in general (e.g., 22 magazines, 24 newspapers, five national networks and four regional networks all ran stories on Dare County and the red wolf experimental population designation); 2) increased monetary revenue due to increased publicity for Dare County; 3) heightened public involvement in conservation and restoration activities; and 4) acquisition of additional conservation land by a key non-governmental organization (e.g., the Conservation Fund acquired 45,000 ha of coastal plain habitat to serve as critical red wolf habitat) (Phillips, 1990).

Despite these kinds of benefits, it is important to reevaluate the purpose behind the experimental population provision in the ESA. Are these types of indirect benefits truly appropriate measures to use to define a successful reintroduction program? If indirect benefits, such as those described above, are the primary justifications for implementing a reintroduction program, it is reasonably likely that other reintroductions that have failed to result in self-sustaining populations may have actually contributed to significant indirect benefits to the species. However, it is unclear how some of the aforementioned indirect benefits (e.g., increased public awareness of endangered species conservation) might contribute to species recovery in the long run (Phillips, 1990). Using indirect benefits as a justification for implementing reintroduction programs may perhaps be easier if these factors were determined to positively influence species recovery over the long-term.

The black-footed ferret recovery program in Montana used a slightly different approach when trying to determine the goals of the reintroduction program (Maguire et al., 1988). A decision analysis was used to examine options for promoting ferret recovery in Montana. The decision analysis was specifically applied to develop a strategy for ferret recovery in Montana for 5 years into the future (Maguire et al., 1988). Two objectives for ferret management were developed (i.e., enhancing the survival of any remaining wild ferret populations and promoting successful production of ferrets in captivity for reintroduction into the wild) and two criteria for measuring success were developed (i.e., minimizing the probability of extinction of wild ferrets for the next five years and maximizing the probability that captive breeding will provide surplus ferrets for reintroductions within the next 5 years) (Maguire et al., 1988). The analysis preformed used decision trees that graphically displayed the major elements of decisions under uncertainty (Maguire et al., 1988). For example, this method was used to analyze the ferret habitat management in Montana. This analysis showed that protecting and managing ferret habitat for future reintroductions could reduce the probability of extinction from about .95 to about .93, with the expected benefits of habitat protection depending critically on the availability of captive-reared ferrets for reintroduction (Maguire et al., 1988). There are obvious limitations to decision analysis given that it largely relies on subjective information (Maguire et al., 1988). However, this is one potential approach to that can be used to organize and capture subjective information (e.g., expert opinion etc.) in a quantitative form and uses it to make informed management decisions that can be reviewed by other managers and the public (Maguire et al., 1988).

Given that experimental population programs are a high-risk recovery technique, it may be necessary in each situation to determine what other additional contributions a population may make to recovery if a self-sustaining population is not successfully established (Griffith et al., 1989; Kleiman, 1989; Griffith et al., 1990). Although the assessment conducted by biologists and managers who participated in the red wolf reintroduction seems like a logical and beneficial exercise, it seems to be a unique approach as compared with other experimental populations that were established.

Endangered-species managers should incorporate similar assessments and goal setting strategies as standard practice when implementing reintroduction programs for species recovery (Griffith et al., 1989; Kleiman, 1989; Griffith et al., 1990). Implementing goal setting strategies and conducting assessments on the ability of the program to attain set goals could result in the expansion of the traditional definition of what constitutes a successful experimental population program. Expansion of the traditional definition of a successful experimental population program could be positive provided that set goals are not trivial, thus compromising the contribution that a reintroduction program makes to the recovery of the species. By expanding the accepted definition (i.e., creation of self-sustaining populations), negative perceptions toward the role of experimental populations reflected in past research may be dispelled. Thus, there may be less reluctance by endangered species managers and biologists to implement these programs based upon the potential indirect contributions they may make to species recovery in conjunction with direct contributions (i.e., natural reproduction in the wild).

One difficulty with expanding the traditional definition of a successful experimental population is the danger of trivializing the purpose and contributions that an experimental population program may make to species recovery. Diversifying the definition of success should not encourage reintroductions as a politically acceptable means of essentially disposing of individuals surplus to captive rearing programs. In other words, experimental population designations should not be implemented as a means to simply "get rid of" individuals surplus to a captive propagation program. The experimental population provision in the ESA specifically states that experimental populations must be likely to survive into the foreseeable future, therefore, the conditions under which individuals are reintroduced should be sound. Kleiman (1990) describes certain factors that should be considered to facilitate success regardless of the set objectives of the program including: 1) utilizing a genetically diverse, self-sustaining, captive population for donor individuals; 2) suitable habitat; 3) adequate release site; 4) elimination of factors leading to species decline; and 5) adequate knowledge of species' biological needs. These factors should be considered when determining if the appropriate conditions exist for a reintroduction, after consideration of these factors, goals for the experimental population program should be set separately such as the creation of a self-sustaining population or collection of new scientific research.

With respect to creating optimal reintroduction conditions, Templeton (1990) further defines additional genetic criteria that are essential for consideration in reintroduction and captive breeding programs. Maintenance of genetic diversity, preservation of distinct genotypes, and avoidance of adaptation to captivity are critical areas that should be considered. Unfortunately, maintaining genetic diversity or preserving distinct genotypes can be very difficult to achieve depending on the health of the founder population, selective forces of a captive breeding program, or the ability to determine the level of genetic diversity that will contribute to recovery. For example, in collared lizards there is very little genetic diversity within a locally adapted population, diversity is instead critical between multiple locally adapted populations. Therefore, a collared lizard reintroduction program that uses a captive breeding program and has created a high level of diversity within the captive bred population could potentially have a negative effect on species recovery (Templeton, 1990). Over the past several decades science has made incredible headway in understanding genetics and the impact of genetic health on populations. However, the genetic diversity of many species is still not understood well, which presents certain challenges for species recovery.

Defining success in relation to reintroduction programs requires managers and biologists to walk a fine line between being overly liberal or conservative with respect to defining measures of success. Overly liberal definitions of success run the risk of trivializing the core purpose of the provision, which is to recover a species by increasing the species range and numbers in the wild. However, a conservative interpretation of the definition of success could hinder the willingness of biologists and managers to implement these programs if self-sustaining populations are the only acceptable criteria (Griffith et al., 1989; Kleiman, 1989; Kleiman, 1990; Tate, 1990; Reading et al., 2002).

Designing Reintroduction Programs: Considering Critical Issues:

The second theme that previous studies have addressed is the need for the management community to diversify the types of issues it considers when designing an experimental population program (May, 1986; Booth, 1988; Clark, 1989; Kleiman, 1989; Kleiman, 1990; Lewis, 1990; Reading and Kellert, 1993; Brock and Beauprez, 2000; Reading et al., 2002). Most experimental population programs focus on the biological and ecological demands of the species to determine whether a reintroduction has the potential to be successful. As previously discussed, primary biological and ecological characteristics that should be considered include: vacant habitat; quality of habitat; behavioral traits; origin and health of the donor population;

and mitigation and/or minimization of threats responsible for the species decline (May, 1986; Booth, 1988; Clark, 1989; Kleiman, 1989; Kleiman, 1990; Lewis, 1990; Reading and Kellert, 1993; Brock and Beauprez, 2000; Reading et al., 2002).

Comparisons involving the introduction of game species in certain areas suggest that, in general, threatened and endangered species have a lower probability of establishing a self-sustaining population in the reintroduction area than do game species (e.g., American Bison) that are reintroduced (Kleiman, 1989; Griffith et al., 1990; Kleiman, 1990). This is mainly attributed to the precarious state of endangered/threatened species that is often due in large part to habitat destruction and fragmentation. Therefore, if the reintroduction area is highly fragmented and the quality of the habitat has been marginalized, the probability of natural reproduction is minimized. Unfortunately, even when these factors are considered critical, information is often unavailable or difficult to evaluate.

For example, in the southern sea otter experimental population program, the available behavioral data did not indicate that sea otters would react negatively toward translocation due to a strong inherent homing instinct. Therefore, biologists and managers were unable to anticipate that translocated sea otters would disperse from the reintroduction site to return to their home range (Booth, 1988). Given that the reintroduction site was a significant distance from their home range, many of the translocated sea otters died when they attempted to return to their home range (Booth, 1988). As a result, even in situations where there are available data, it is often difficult to fully anticipate all of the variables that have the potential to influence the ability of an organism to successfully adapt to a new environment.

However, endangered species management is not solely focused on biological issues, quite the opposite. Instead, endangered species recovery programs are often dominated by socio-economic issues, power and authority struggles among different agencies, and organizational conflict among recovery teams (Askins, 1987; Booth, 1988; Clark and Westrum, 1989; Kleiman, 1989; Kleiman, 1990; Reading and Kellert, 1993; Reading et al., 2002). Despite the fact that these elements are considered when developing recovery strategies in general, some past reintroductions have neglected to address these factors (e.g., black footed ferret and California condor reintroduction programs). While it seems misplaced that socio-economic issues or power struggles should be considered when dealing with a species that is perhaps facing extinction, the reality is that lack of acknowledgement of these issues could lead to failure of the program (Booth, 1988; Clark and Westrum, 1989; Reading and Kellert, 1993; Reading et al., 2002). Reading et al. (2002) outlined four specific areas for analysis: 1) biotechnical aspects; 2) authority and power aspects; 3) organizational aspects; and 4) socio-economic aspects.

Bio-technical issues refer to the biological and ecological factors that were previously discussed and usually take a front seat when managers and biologists strategize and predict the potential success of an experimental population designation. Power and authority issues often exist between different organizations that are charged with management authority for a particular species. If two agencies have difficulty communicating and agreeing on specific management approaches, it is highly likely that the poor partnership will have a negative effect on the reintroduction program. Organizational issues are in some sense an extension of power/authority struggles. Organizational issues include building key partnerships, but this also refers to the importance of understanding the culture and structure of the different agencies involved. A highly motivated, dynamic reintroduction team that includes individuals with a high level of expertise and training that can work in a high stress environment and confront significant political pressures will likely have the greatest potential for successfully establishing an experimental population (Clark and Westrum, 1989; Reading and Kellert, 1993; Reading et al., 2002).

Finally, perhaps the most critical element is consideration of socio-economic factors. Socio-economic issues include the public's perception of endangered species, the public's willingness to support conservation programs, and the potential effect that experimental population designation will have on the public. Without fully understanding public perceptions and attitudes, it is hard to predict if there will be opposition and, if so, how to address negative attitudes (Askins, 1987; Booth, 1988; Phillips, 1990; Reading et al., 2002).

The reintroduction of southern sea otters is a good example of how public education about potential social and economic impacts may have avoided animosity from key industry groups whose support was necessary to ensure the success of the experimental population program (Booth, 1988). In contrast the red wolf and black-footed ferret reintroduction programs have demonstrated the importance of understanding public perceptions and utilizing that information to make decisions regarding the experimental population designation. In the case of black-footed ferrets, researchers employed a variety of methods (e.g. public meetings, informal interviews, and surveys) to collect information on public perceptions of the designation of an experimental population of black-footed ferrets (May, 1986; Phillips, 1990; Reading et al., 2002). This information was invaluable because it revealed that most individuals opposed the reintroduction program because of the additional protections that would be extended to prairie dog colonies. Black-footed ferret and prairie dog communities are interdependent because as noted previously prairie dogs provide a source of food for ferrets, while ferrets help naturally control overpopulation in prairie dog communities. Although there was little managers could do to change attitudes towards prairie dogs, at the very least they became aware that opposition was not aimed directly at ferrets (Reading et al., 2002).

Establishing experimental populations is a contentious issue due to skepticism regarding: the ability of reintroduced species to establish self-sustaining populations; the contributions that experimental populations make to species recovery; and the types of issues that should be considered prior to implementation of a recovery program that may utilize experimental populations. Previous studies clearly indicate that there is a need to reevaluate the methods used to define success of experimental population programs in relation to species recovery (Griffith et al., 1989; Kleiman, 1989; Kleiman, 1990; Tate, 1990; Reading et al., 2002).

Experimental populations can potentially make significant contributions to species recovery beyond simply establishing self-sustaining populations; however, existing research does not present data that demonstrate this. None of the studies previously cited presents data that compare reintroductions across taxa and that have been collected from individuals who have directly participated in these programs. Analysis of data collected in a survey that was administered to key endangered species managers and biologists to collect information on the characteristics of previous reintroduction programs and potential contributions that experimental populations have made in endangered species recovery will help clarify the controversies surrounding reintroductions. Survey data will also be used to evaluate evidence as to the potential role establishing an experimental population of Atlantic salmon may play in the species recovery.

This thesis poses several questions regarding the contributions that an experimental population of Atlantic salmon may make to the health and genetic integrity of existing runs. To evaluate the potential genetic contributions existing data on the biological status and health of remnant populations of endangered Atlantic salmon in the GOM DPS must be analyzed. Therefore, the second portion of this chapter presents existing biological research on Atlantic salmon in relation to "straying" and "hatchery effect."

Biological Information on Atlantic salmon Critical for Consideration:

To evaluate the potential role that establishing an experimental population of Atlantic salmon could play in recovering the GOM DPS, past reintroduction programs will be examined along with associated research. This information will also be used to draw conclusions and conduct an analysis of the results of the survey. However, this thesis also seeks to examine several additional questions with regard to the specific contribution an Atlantic salmon reintroduction program may make to the health and genetic integrity of existing runs. Questions posed in this thesis that specifically relate to a reintroduction of Atlantic salmon include: 1) could an experimental population of Atlantic salmon contribute to the genetic integrity of existing runs through "straying" and reduce the incidence of "hatchery effect"?; and 2) would establishing an experimental population of Atlantic salmon be successful in expanding the range of persistent populations into unused portions of their historic range and avoid extinction due to a catastrophic event? While these questions are very complex, review and analysis of existing biological data may facilitate answering these questions in conjunction with the results of the survey discussed later in this thesis.

The Role Of "Straying" In An Atlantic Salmon Reintroduction Program:

One of the critical characteristics of the life cycle of salmonids is their unique homing behavior. Homing is the behavioral instinct that allows salmonids to return to the same stream in which they hatched after undertaking significant migrations into the marine environment (NRC, 1996; Baum, 1997). Salmonids mainly return to the same stream, however, a small percentage of individuals sometimes return to a different stream (NRC, 1996). These individuals are referred to as strays and the action of returning to a stream other than their natal stream is referred to as straying. Straying can result in repopulating a nearby stream that has gone locally extinct due to a major environmental disruption (NRC, 1996). Straying is also responsible for the exchange of genetic material between two different runs (NRC, 1996). Generally straying usually occurs between populations that are geographically close to one another and therefore the stream habitat is very similar (Quinn et al., 1991; Pascal and Quinn, 1994). Straying is influenced by a number of factors including genetics, random events, and environmental differences (Quinn et al., 1991). There is limited data on differences in straying rates between hatchery and wild populations; however, Waples (1991) and Quinn (1993) have both indicated that straying rates might be slightly higher for hatchery fish.

Straying rates vary from one region to another, for example straying rates observed among salmonids on the West Coast of the United States are slightly higher than straying rates observed in Atlantic salmon in Maine. Further comparisons have been made of straying rates between Atlantic salmon in the Northwest Atlantic Ocean and populations in the Northeast Atlantic Ocean. For example, straying rates observed for Atlantic salmon in Norway are approximately 5- 8% while U.S. Atlantic salmon populations in Maine display straying rates of approximately 2-3% (Baum, 1997). Baum assessed homing of 1.2 million carlin-tagged Atlantic salmon stocked as smolts from 1966-1987 in 5 coastal rivers in Maine (Baum, 1997); only 2% of the tags recovered were from individuals that did not home to their natal river (Baum, 1997). Furthermore, some of the individuals among the 2% of the non-natal tag recoveries eventually did end up returning to their natal river even though they initially returned to a non-natal stream (Baum, 1997). Baum (1997), therefore, concluded that straying rates for Atlantic salmon populations in Maine are extremely low in comparison with other salmonids and also determined that straying occurs in a very limited geographic area, which contributes to highly distinct populations within Maine coastal rivers (NRC, 2003).

Despite low straying rates within the GOM DPS, the National Research Council (NRC) of the National Academies attributes a lack of inbreeding depression in Atlantic salmon populations in Maine to natural straying (NRC). The NRC states that natural straying occurs at a rate that is adequate to provide enough gene flow between populations within the GOM DPS without disrupting local adaptations (NRC, 2003). There is little evidence to demonstrate with certainty that natural straying in the GOM DPS has resulted in the repopulation of rivers that have been extirpated. However, with the removal of the Edwards Dam on the lower Kennebec, some recolonization of the upper mainstem has been observed. Studies by Baum (1997) and Beland (1986) document the presence of strays from other river systems in the Kennebec River. The NRC has urged the Services to allow the Kennebec River to rebound naturally without hatchery augmentation.

Based upon the data on straying, there is the potential for an experimental population of Atlantic salmon in the GOM DPS (established in vacant habitat) to contribute to repopulating an adjacent river that also has vacant habitat or to improve the genetic integrity of an adjacent remnant population through the exchange of genetic material. Given that river recolonization has not been observed in the GOM DPS, it is unclear if and how long an experimental population would contribute to restoring historically occupied habitat. However, it is clear that any amount of straying from a reintroduced population will result in the positive exchange of genetic material between adjacent runs, thus enhancing the genetic diversity of both populations. This conclusion has been drawn independent of the survey results presented later in this thesis given that it was only necessary to consider the existing scientific data.

Reversing The Effects Of Hatcheries:

For decades hatcheries have propped up natural reproduction and survival in the wild salmonid populations on both the east and west coasts of the United States. Hatcheries were once thought to have little if any negative effects on the recovery and restoration of salmonid populations. However, after prolonged periods of artificial stocking and poor hatchery practices, researchers began to notice a significant difference between hatchery-reared populations and wild populations. In the early years of artificial propagation non-local stocks were widely used to supplement runs, artificially selected mating altered the transfer of important alleles, and in general a lack of knowledge regarding genetic diversity contributed to a decline in the genetic integrity of hatchery populations thereby negatively affecting wild populations (Hindar et al. 1991; Kapuscinski, 1991; Simon, 1991; Busack and Currens, 1995; Tessier, 1997). Throughout the past several decades as scientific knowledge regarding artificial selection, adaptation, and the importance of genetic integrity has increased, improved hatchery practices have resulted. Unfortunately, some aspects of artificial propagation are difficult to alter without completely abandoning the practice altogether and returning to a system that relies on natural reproduction in conjunction with minimizing/ mitigating threats.

Busack and Currens (1995) outline four major types of genetic risks that are posed by artificial propagation programs: 1) genetic inbreeding; 2) loss of genetic variation between populations; 3) loss of genetic variation within a population; and 4) domestication selection. Factors 1, 2, and 3 typically result when poor mating practices have been implemented, causing artificial selection for certain genetic alleles. Geneticists have found that when certain genes are selected for over generations there are serious deleterious effects that result from the loss of genes that are selected against well as genes that were undetected (Allendorf and Leary, 1988). These deleterious effects have resulted in vertebral deformities and missing fins (Allendorf and Leary, 1988). Ineffective population sizes combined with artificial mating also lead to inbreeding depression and thus reduced genetic variation. While this loss in fitness does not necessarily inhibit the survival of hatchery fish in the hatchery facility, poor fitness does inhibit the survival of propagated fish in the wild. Furthermore, propagated fish that do survive in the wild and successfully mate with wild fish have the potential to reduce the genetic fitness of their offspring by perpetuating the transfer of inferior genes. Some of these hatchery issues have been addressed by improved genetic knowledge and technology that has allowed scientists to improve artificially selected mating and improve the diversity of hatchery populations.

Domestication selection is the final issue that is perhaps the most difficult to address because it can only fully be abolished by doing away with artificial propagation altogether. The term "hatchery effect" in large part refers to domestication selection where hatchery fish become genetically adapted to the hatchery environment. Domestication or hatchery effect occurs in two major ways: 1) non-random collection of hatchery broodstock over the duration of a spawning run; and 2) altered selection pressures due to differences between the natural environment and the artificial hatchery environment (Steward and Bjorn, 1990). The second process is the most difficult to alter because the natural environment would have to be recreated in an artificial setting in order to reduce this factor. Hatchery fish are not subjected to natural selective pressures such as diversity of temperature and flow regimes, exposure to predators and prey, diversity in cover and substrate, habitat structure, and ability to exercise sexual selection. Some of these pressures could be artificially created like variation in substrate and cover or even exposure to artificial predators. However, others such as sexual selection are more elusive. When any organism selects its mate, evolution is essentially in motion because all organisms select that mate based upon key characteristics that are sometimes evident or sometimes hidden. By removing the ability for salmonids to select their own mates, scientists are only able to make predictions about what individuals would likely mate naturally in the wild. Although progressive genetic knowledge is implemented in making these predictions, it is virtually impossible for artificial selections to determine in all cases which spawners are best suited to mate with one another. Given that selective pressures combined with adaptations influence the genetic integrity of organisms, it is difficult to argue that artificial propagation is an equivalent substitute for natural reproduction.

As previously discussed, existing research demonstrates that hatchery fish are not as robust as wild fish and therefore are not as likely to survive as long in the natural environment. Hatcheries are definitely a mixed blessing in terms of costs and benefits and in some situations the costs of hatcheries may be found to outweigh any benefits. So why not completely abandon hatcheries altogether? While this aggressive approach may be possible for populations that are not in severe decline, for Atlantic salmon in the GOM DPS abandoning hatchery supplementation altogether may very well push the GOM DPS to extinction. With only eight remnant populations in the GOM DPS all of which experience low returns, it would be virtually impossible for these populations to survive on their own without hatchery supplementation.

Chapter 5:

Perspectives from the Field: Results of survey on the role of experimental populations in species recovery

Existing studies on reintroduction programs do not indicate that researchers have conducted a review of experimental population designations across taxa based upon data collected from biologists and wildlife managers in the field responsible for implementing these programs. Many past studies have relied upon existing research combined with assessment techniques developed by researchers to evaluate the success of individual reintroduction programs. While these methods are extremely important and have resulted in important findings, conclusions can also be drawn from data obtained directly from individuals involved with implementing reintroduction programs. Therefore, to address the void that exists in the literature and determine whether feedback from individuals in the field across the United States supports the general conclusions reflected in the aforementioned studies, 38 wildlife managers and biologists were administered surveys. Out of the 38 individuals administered surveys 14 completed surveys were submitted.

The following discussion includes a description of the survey and how it was administered as well as an explanation of the intended purpose of the survey. Without the collection of raw data from field personnel it would be difficult to prove or disprove if past research on reintroductions is consistent with the approach taken on the ground with respect to implementing and evaluating experimental population programs. Given that this study seeks to draw conclusions as to the potential role of an experimental population in recovery of endangered Atlantic salmon in the GOM DPS, comparisons between results of past research and raw data collected from the field are important.

Survey Methodology:

A survey on the role of experimental populations in recovery was administered to 38 wildlife managers and biologists involved in implementing reintroduction programs across taxa. The survey was administered by e-mail. In 15 cases an initial phone call had been completed to establish the willingness of the individual to participate in the study. A phone call to initially establish contact was not completed in all cases because most individuals contacted by phone volunteered to forward the survey to other colleagues who may have wanted to participate. In those cases, the contact information which would have allowed initial phone contact to be made was not available. As a result, in 23 out of the 38 individuals administered the survey, e-mail contact was the only contact that was established. The inability to establish personal contact with all respondents may have resulted in a greater non-response bias than originally anticipated.

In general participants were given approximately 6 weeks to complete the survey. All individuals contacted by phone, with the exception of one, voiced interest in participating in the research and agreed to take the survey via e-mail. Often, reintroductions are implemented and evaluated by a team of individuals who represent different areas of expertise. The ability to devise a contact list was limited by the availability of public information and thus it was not possible to compile a list of all participants on various reintroduction teams. The original contact list devised consisted of at least one contact from each experimental population designation that had been completed in the United States.

Survey Response Rate:

Very few experimental population programs have been implemented in the United States as compared with other types of recovery initiatives including, for example, habitat protection and restoration or artificial enhancement of existing populations in the wild. Reintroduction is a very dynamic recovery technique that still lacks widespread support among biologists, fish and wildlife managers, the general public, industry, and non-governmental organizations. Therefore, given the small number of experimental populations programs that have been implemented in the United States, it was difficult to identify a substantial number of individuals to survey who had been involved in reintroduction programs.

The contact list that was originally drafted consisted of names gathered from the final Federal Register notice designating an experimental population. This method created three key problems including outdated names, duplication, and misidentified expertise. Experimental population designations date back to the early 1980's, which in some cases resulted in contacts that were outdated as individuals had either retired or moved into a new position. There was also some duplication of contact names because in some cases, such as with the black-footed ferret, there were several experimental populations that were established for that species and for every designation the black footed ferret recovery coordinator was named as the appropriate contact. This limited the number of respondents that were identified via the Federal Register. Instead, to try and solicit additional feedback, I had to either rely on either individuals forwarding the survey on to colleagues or contact other individuals based upon recommendations. In the case where individuals simply forwarded the survey to their colleagues, I was unable to establish initial phone contact prior to sending out the survey.

The last complication that was encountered while compiling the contact list was misidentified expertise. The Federal Register has only limited space for all necessary information that must be conveyed to the public. Therefore, Federal Register notices for experimental population designations usually include only one or two individuals as appropriate contacts for additional information regarding that particular designation. In some cases the individuals listed as contacts have had very little involvement in the development and implementation of the experimental population program and instead these individuals are upper management personnel who may perhaps be better equipped to deal with public relations issues as opposed to technical inquires about the specific reintroduction program. Furthermore, it would be impractical to include a lengthy list of all of the individuals with scientific and policy expertise that implemented the reintroduction program.

The three aforementioned key areas, combined with a low number of experimental population programs overall, reduced the number of individuals that were originally going to be surveyed regarding the role of experimental populations in species recovery. As with all surveys that are voluntary, it was anticipated that there would be a certain level of non-response. However, due to an inability to contact all individuals that were targeted as potential participants in this research via phone prior to administering the survey via e-mail, it is likely that there was more non-response bias than what had been originally anticipated. Closer to 20-25 surveys were expected to be returned out of the 38 surveys distributed.

In total 14 surveys were returned. Not all questions were completed on all of the surveys due to the unique nature of each reintroduction and thus the non-applicable nature of some questions. For example, in the case of grizzly bears and Atlantic salmon, experimental populations have been contemplated, however, they have yet to be designated. As a result, some respondents were unable to answer fundamental questions that were posed and this contributed to an even lower response rate with respect to some questions.

Information Solicited in the Survey:

The survey was intended to collect information on three key components by posing questions that solicited both objective and subjective responses. The three key components include: 1) defining success by the creation of self-sustaining populations, versus other measures of success; 2) reintroduction as an effective recovery strategy;

and 3) factors other than biology in evaluating reintroduction programs. Collecting data on these three components will test whether previous studies are consistent with data collected from the field and allow this study to draw certain conclusions about reintroduction programs in comparison to the predominant themes in the literature.

Data collected on the first key component evaluates whether the traditional approach reflected in past studies on evaluating success is actually implemented in the field. This component was evaluated by asking two direct questions and other indirect questions, all of which will allow certain inferences to be made upon their completion. For example, respondents were asked a series of questions including what factors were used to measure success, if a self-sustaining population had been established, and if the reintroduction program had been successful. Assessing success through a series of related questions results in a more rigorous and dynamic evaluation of whether personnel in the field are actually using self-sustaining populations as the ultimate measure of success. Posing related questions as described above, assesses whether other measures of success were devised either independently of or in conjunction with establishing a self-sustaining population.

The second key component asks a very basic question to solicit the opinion of respondents on recovery effectiveness. Finally the third key component evaluates other factors that were considered outside of purely biological characteristics. This component is evaluated indirectly by inquiring about the factors that influenced selection of the reintroduction area and whether education/ outreach was part of implementation of the reintroduction program. The advantage of asking the question in an indirect manner is that it does not lead the respondent to answering in a particular manner and it encourages respondents to provide a higher level of detail.

As previously discussed survey results are used to compare and contrast predominant themes in the literature with new survey data, and then draw new conclusions about the role of experimental population programs in species recovery. Conclusions drawn from comparisons between survey data and past research are utilized to discuss the potential role of reintroduction in the recovery of Atlantic salmon in the GOM DPS.

Results of Survey on the Role of Experimental Populations in Species Recovery:

As previously discussed, the "success" of reintroduction programs has been defined by their ability to establish self-sustaining populations in the wild. Reading et al. (2002) stated that, based upon the traditional definition of success, reintroduction programs are typically a conservation technique that usually fails.

The Question of "Success:"

In an effort to clarify the traditional view reflected in the current research over what constitutes a successful experimental population program, I surveyed biologists and managers directly involved in planning and implementing an experimental population program. Based upon the case studies that I had read and the diversity of species that have been reintroduced, I expected to receive diverse feedback on the measure of success used in the field. These individuals responded to the following question posed in the survey regarding success:

1. How has "success" in relation to the goals of the experimental population programs been defined? (i.e., self-sustaining, research)

The response rate on this question was affected by two different factors: 1) one respondent failed to answer the question correctly; and 2) three other respondents were unable to comment because experimental population designations had not been carried out. Therefore a total of 10 responses were tallied with respect to the question presented above. In 7 out of 10 responses received, success is defined by the ability of the individuals to reproduce naturally and establish a self-sustaining population in the wild. With respect to these 7 designations where success was defined by self-sustaining populations, 3 respondents stated that self-sustaining populations had been established. Of these 3 individuals only 2 stated that the program was truly successful, the other respondent stated that the program was not successful because they had not reached the target they had set for the number of individuals they would have liked to see in the wild as a product of natural reproduction. The other respondent that provided feedback on 4 different experimental population designations was unable to determine whether the experimental populations had resulted in self-sustaining populations because they were only recently reintroduced.

The other 3 designations varied in the way in which the program staff surveyed defined success in these reintroductions. With respect to 2 of the designations, respondents stated that success was defined by the information gathered on release methods, causes of mortality, and increased public awareness. These respondents stated that the ultimate goal would be to see the reintroduction program result in a self-sustaining population in the wild; however, this was not the main measure of success of the reintroduction program. Lastly, in one designation success was defined in relation to the observation of certain behavioral traits that indicated that captive individuals were adapting and thriving in the wild without human assistance. In this particular reintroduction of the Mexican gray wolf, the formation of wolf packs was the observed behavior that indicated that introduced wolves were dispersing, engaging in natural reproduction, and captive-raised wolves were surviving in the wild without the assistance of wildlife managers. For all three of these designations respondents indicated that offspring were produced as a result of natural reproduction and in all cases that program was considered successful. Table 2 on the following page summarizes these data.

Table 2

Defining Success

Question 1: How has "success" in relation to the goals of the experimental population been defined? (i.e., self-sustaining, research)	
a. Success = ability of the individuals to reproduce naturally and establish a self-sustaining population in the wild	70% (7 out of 10)
Respondents using success definition (a.) who stated that self-sustaining populations had been established	42% (3 out of 7)
Respondents using success definition (a.) who stated that the program was truly successful	66% (2 out of 3)
b. Success = information gathered on release methods, causes of mortality, and increased public awareness	20% (2 out of 10)
c. Success = observation of behavioral traits that indicated that captive individuals were adapting and thriving in the wild without human assistance	10% (1 out of 10)
Respondents using success definitions (b. & c.) who stated that offspring were produced as a result of natural reproduction	100% (1 out of 1)
Respondents using success definitions (b. & c.) who stated that the program was truly successful	100% (1 out of 1)

Summary of the "Success" Question:

These data correspond to the traditional view among experts in the field over how to define success with respect to reintroduction programs. It seems that there is a trend for biologists and managers in the field to also apply the traditional definition of success. In all 7 cases where success was defined by self-sustaining populations, respondents answered affirmatively when asked if they felt the program was successful based upon this definition. Even in the three cases of the designations that did not define success strictly in terms of self-sustaining populations, all respondents stated that natural reproduction in the wild was observed. This raises the question as to whether a different outcome, perhaps a high mortality rate, would have influenced these respondents to answer differently when asked if they believed the program was successful despite the fact that success was not defined in relation to the traditional definition.

The Question of Recovery:

Recovery is defined by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service as:

> The process by which the decline of an endangered or threatened species is arrested or reversed, and threats removed or reduced so that the species survival in the wild can be ensured. The goal of the ESA is recovery of listed species to levels where protection under the ESA is no longer necessary (16 U.S.C. 1531 et seq.).

There are many different approaches to endangered/threatened species recovery including Safe Harbor agreements which provide regulatory assurances to non-Federal landowners who voluntarily implement measures that contribute to the conservation of listed species on their land; grants to states, territories and private landowners who engage in conservation and recovery activities; and reintroduction programs (16 U.S.C. 1531 et seq.). Two questions were posed to biologists and managers directly involved with planning and implementing experimental population programs to solicit feedback on their assessment of the role that reintroductions play in recovery. These individuals responded to the following questions regarding recovery that were posed in the survey:

1. (G) Do you think that experimental populations are an effective recovery strategy?
2. (S) Do you think that in this specific case [of the species reintroduction that respondent is involved with] designation of an experimental population facilitated recovery? Please explain.

These two questions ranged from the general to the specific and are noted as such with a (G) and (S). The response rate with respect to the general question (G) was high, all individuals providing feedback on 14 designations responded to this question. 12 out of 14 designations analyzed by this survey identified experimental populations as an effective recovery strategy. The two respondents that did not identify reintroductions as an effective recovery strategy both grounded their assessment in their own experience with a specific reintroduction program. However, their responses generally reflected the shared perception that there were other flexible measures to enhance recovery such as Safe Harbor agreements and/or other types of negotiations to facilitate recovery and that there is a low probability for reintroductions to lead to expansion of a species into their historic range.

The specific question (S) had a slightly lower response rate, because in two cases experimental populations were not established, which therefore prohibited two individuals from responding. With respect to 10 out of the 12 responses received, respondents stated that in those specific cases experimental populations facilitated recovery. One interesting aspect of the recovery question that emerged was the emphasis that many respondents placed on the importance of the regulatory flexibility that experimental populations provide for recovery implementation. In 6 out of the 10 responses received, it was stated that the effectiveness of experimental populations in recovery was directly attributable to the increased regulatory flexibility experimental population programs allow. Managers and biologists are able to implement experimental population programs to try and achieve diverse recovery goals that would otherwise be difficult to achieve due to restrictive regulatory aspect of the ESA with respect to managing endangered/threatened species.

The two respondents that did not think the experimental population designation facilitated recovery of the particular species they were working with stated slightly different reasons for their positions. For one respondent, experimental populations were not seen as a valid recovery strategy for the species because the experimental population would have to be designated as an essential experimental population. As a result, the respondent stated that the essential experimental population designation was not a beneficial recovery tool and instead other recovery tools were being implemented.

The other respondent that did not think the experimental population benefited the species recovery stated that the designation instead limited the range of expansion of the species. These limitations were mainly due to certain restrictions that the US Fish and Wildlife Service decided to implement with respect to managing the species within the reintroduction area in order to avoid conflicts with other user groups. Table 3 on the following page summarizes these data.

Table 3

Effectiveness of Experimental Populations in Species Recovery

Question 2a: Do you think that experimental populations are an effective recovery strategy? (G)	
a. Experimental populations were identified as an effective recovery strategy	85% (12 out of 14)
Question 2b: Do you think that in this specific case, designation of an experimental population facilitated recovery? (S) Please explain.	
b. Experimental populations facilitated recovery in those specific cases	83% (10 out of 12)
Respondents that stated (b.) stated effectiveness of experimental populations in recovery was directly attributed to the increased regulatory flexibility under the ESA	60% (6 out of 10)

Summary of the Recovery Question:

The role of experimental populations in species recovery is mainly considered in the reintroduction literature in conjunction with the likelihood of the reintroduction to result in a self-sustaining population in the wild. Given that the literature reflects a significant degree of skepticism with respect to the ability to create self-sustaining populations, these programs are largely perceived as a risky and unreliable recovery tool. However, this does not seem to be the view shared by field biologists and managers involved in planning and implementing reintroduction programs. Instead the perception of experimental populations as a significant recovery tool seems positive. Sixty percent of respondents that felt reintroduction programs were an effective recovery strategy for that specific species attributed the effectiveness of experimental populations in species recovery to regulatory flexibility. In summary, the results of the survey demonstrate that there is some consensus among field biologists and managers that experimental population programs can be an effective tool for species recovery. This data is significant in comparison with the predominant literature on reintroductions, which does not seem to indicate that these programs are an effective recovery tool.

Evaluating Factors Other than Biology in Implementing Reintroduction Programs:

There is a consensus among experts that consideration of factors other than simply species ecology is critical to the success of the reintroduction program. As previously discussed, in this context the definition of success is the creation of self-sustaining populations in the wild. The literature reflects the perception that many experts share that most experimental population programs do not conduct comprehensive analyses of issues that could potentially influence the success of the program.

To assess whether areas other than simple species ecology were evaluated to predict success, a series of questions was posed to field biologists and managers to evaluate what criteria were considered with the implementation of the program. The data that I obtained were inconclusive and did not indicate a trend as to whether field biologists and managers conducted a comprehensive evaluation of issues within the four areas discussed above. This lack of data is attributed to poor question structure in the survey. It is difficult to discern from the way in which the questions were posed whether individuals evaluated certain factors in order to determine if an experimental population was likely to be effective and successful or if certain factors were evaluated after the decision to establish an experimental population was already determined. In other words, were the four critical areas evaluated as part of a systematic decision structure used to determine whether to move forward with a reintroduction program or after the decision had already been determined independent of any decision process? This may seem like a highly bureaucratic question; however, it is a fundamental issue in trying to establish a method and consensus in the field for procedures on determining how to effectively assess experimental population programs.

Summary of Conclusions Drawn from Survey Data:

The results of the data correspond to the traditional view among experts in the literature over how to define success with respect to reintroduction programs. Field biologists and managers surveyed use the traditional definition of success (i.e., the creation of self-sustaining populations in the wild) to evaluate experimental population programs.

There is a great deal of skepticism in the literature regarding the effectiveness of reintroduction programs in species recovery. However, in the case of recovery, the data collected in the survey reflects a different perception among field biologists and managers. The perception of experimental populations as a significant recovery tool is positive. Therefore, among the individuals surveyed, there is consensus that an experimental population program is an effective tool for species recovery.

Chapter 6:

So What Does This Mean For Atlantic Salmon?

Conclusion and Recommendations for Future Areas of Research

Since the 1980's experimental populations have been established for a variety of species. The previous chapters outline fundamental information about these designations and conclusions that have been drawn based upon analysis in the literature, the review of Federal Register notices, and primary data collected with the use of a survey. Through a review of Federal Register notices outlining these designations and survey data collected from program staff involved in planning and implementing reintroduction programs, it is clear that in the majority of cases the primary goal of the program is to expand the species range into historically occupied habitat and create self-sustaining populations.

Survey data and the predominant literature on reintroduction programs reflected consensus that the success of experimental populations should be defined by the establishment of self-sustaining populations. The literature also reflected consensus over the need to evaluate factors other than species ecology in making a determination as to whether an experimental population would facilitate recovery. Survey data collected to evaluate this perception were inconclusive. The flexible nature of experimental populations with respect to regulatory oversight by the federal government has made species reintroduction an appealing recovery tool. Section 10(j) of the ESA that authorizes experimental population designations allows the Secretary of Commerce or Interior to make special provisions exempting experimental populations from protections that would normally be afforded to them as endangered/threatened species under the ESA. Exempting certain protections results in the relaxation of certain regulatory provisions that would otherwise limit the activities of the general public, federal agencies, or other private entities. Survey data reflected a strong consensus among managers and field biologists on the effectiveness of experimental populations in species recovery.

In this chapter consideration of this information will be used to discuss the potential role that an experimental population of endangered Atlantic salmon could play in the recovery of the GOM DPS. This information will also be used to answer questions posed in this thesis that relate to the potential contribution that an experimental population may make specifically to Atlantic salmon in light of some of the unique challenges this species faces.

In this chapter the three key research questions posed in this study will be addressed in light of all of the information collected via surveys, Federal Register notices, and the literature are:

1. How do we attempt to evaluate the success of an experimental population program?
2. How should we define success of an Atlantic salmon experimental population program?
3. What implications are there for attempting to reintroduce a population of endangered Atlantic salmon in the GOM DPS?

In answering these questions, the factors that should be considered will be clarified and conclusions will be stated regarding the potential role that an experimental population of Atlantic salmon will play in the species recovery.

Evaluating Success:

Experts in the literature and field biologists and managers implementing reintroduction programs both define successful experimental population programs by the ability of reintroduced individuals to create self-sustaining populations in the wild. Given the consensus over the definition of success, experimental population programs should continue to be evaluated based upon their ability to create self-sustaining populations in the wild. Therefore, with respect to the first key question posed, defining a successful experimental population program should include the self-sustaining standard.

Implications of an Atlantic Salmon Reintroduction Program and Potential Contributions to Recovery: "straying," "hatchery effect," avoidance of extinction, and scientific research

The other two key research questions posed in this study evaluate the direct contribution that an experimental population of Atlantic salmon could make to the recovery of the GOM DPS. Specifically four sub-questions must be addressed in light of survey data, the literature on reintroductions, and Federal Register notices, to construct viable recommendations for the future implementation of an Atlantic salmon reintroduction program. The four sub-questions listed below seek to address the following key research question posed in this thesis: What implications are there for attempting to reintroduce a population of endangered Atlantic salmon in the GOM distinct population segment DPS?

Sub-Questions:

1. Could a reintroduction of Atlantic salmon into vacant historic habitat facilitate recovery?
2. Could an experimental population of Atlantic salmon contribute to the genetic integrity of existing runs through "straying" and reduce the incidence of "hatchery effect"?
3. Would establishing an experimental population of Atlantic salmon be successful in expanding the range of persistent populations into unused portions of their historic range and avoid extinction due to a catastrophic event?
4. Could an experimental population of Atlantic salmon enhance recovery through the collection of additional scientific information?

Vacant Habitat and Genetic Contributions: "Straying" and "Hatchery Effect":

Establishing an experimental population of Atlantic salmon is possible given that vacant habitat is available and bonus Atlantic salmon are likely to continue to be produced on an annual basis due to the difficulty in predicting stocking targets. Based upon the data on straying, there is the potential for an experimental population of

Atlantic salmon in the GOM DPS that has been established in vacant habitat to contribute to repopulating an adjacent river that also has vacant habitat or improve the genetic integrity of an adjacent remnant population through the exchange of genetic material. Given that river recolonization has not been observed in the GOM DPS, it is unclear if and how long an experimental population would contribute to restoring historically occupied habitat. However, it is clear that any amount of straying from a reintroduced population will result in the positive exchange of genetic material between adjacent runs, thus enhancing the genetic diversity of both populations.

Could an experimental population of Atlantic salmon contribute to the genetic integrity of existing runs by reducing the incidence of "hatchery effect"? As discussed in Chapter 4, "hatchery effect" is defined as domestication selection where hatchery fish become genetically adapted to the hatchery environment. For a reintroduction program to reduce the incidence of "hatchery effect" there would have to be some level of natural reproduction to create an additional broodstock source that would diversify the existing broodstock sources from the 8 remnant populations. There are low levels of natural reproduction in the 8 other river systems that support remnant populations. From year to year, reproduction varies and in some particularly poor years observed indications of natural reproduction have ceased altogether. All of these remnant populations are supported by CBNFH's conservation stocking program. It is important to note as well that many of the populations that used to be present in vacant habitat were driven locally extinct several decades ago. Furthermore, many of the threats that resulted in these local extinctions have since been minimized, or eliminated altogether. As a result, it is likely that if bonus Atlantic salmon were reintroduced into vacant habitat some level of natural reproduction could be observed and contribute to the reduction of hatchery effect through the availability of an additional source for the collection of broodstock. However, low levels of natural reproduction would most likely have to be supplemented annually for some time with additional bonus individuals. Therefore, it is unclear if and when a reintroduction program would result in the creation of a self-sustaining population that could be used as an additional source for broodstock, thus reducing the incidence of hatchery effect.

Expanding the Range of Atlantic Salmon and Avoiding Catastrophic Effects:

An experimental population of Atlantic salmon has the potential to expand the range of the species into historically occupied habitat. Recolonization of vacant habitat can occur naturally through straying; however, due to low straying rates recolonization is not likely to occur rapidly. Although there is little known about the estimated time it takes Maine Atlantic salmon to naturally recolonize a river, it is likely that recolonization would require sustained straying over a significant time period. The National Research Council is currently conducting ongoing monitoring in the Kennebec River to determine estimated time frames of natural recolonization (NRC, 2003).

Reintroducing bonus Atlantic salmon into vacant habitat would essentially help accelerate any natural recolonization that would otherwise occur. However, it is hard to predict whether an experimental population would result in a self-sustaining population thereby expanding the range of the species into historic habitat. Currently, adult returns within the eight remnant wild populations are exceedingly low. Many threats within these river systems have been identified and are being addressed by local, state, and federal agencies. However, Atlantic salmon have a very complex life history and there is little known about the level or causes of mortality in the marine environment. It is hypothesized that declining adult returns may have more to do with ocean mortality than other threats facing Atlantic salmon in the freshwater environment. An experimental population could lead to the creation of a self-sustaining population of Atlantic salmon, however, based upon trends in the current conditions of stocks it is likely that this process would occur over a significant period of time.

Although an Atlantic salmon reintroduction program would likely take a significant amount of time to establish a self-sustaining population, there are other immediate contributions that an experimental population could make to enhancing the recovery of the GOM DPS. Establishing an experimental population of Atlantic salmon could provide additional protection from extinction due to a potential catastrophic effect that could occur at CBNFH. CBNFH currently is the only hatchery facility where all GOM DPS wild broodstock are maintained. If there were a catastrophic event such as a sustained power failure, disease outbreak, or fire, it is possible that all of the river specific populations used to supplement and support remnant populations within the GOM DPS could be destroyed. Therefore, the more "genetic material" that is located in other areas, the better off the GOM DPS would be as a whole if something did destroy or reduce the supply of wild broodstock held at CBNFH.

Enhancing Scientific Research:

One final area in which an experimental population of Atlantic salmon has the potential to make contributions is scientific research. As discovered from survey data, an analysis of the literature, and Federal Register notices, scientific research in some cases has been used in part as a justification for reintroduction programs. In some cases where it was not necessarily the main reason for designation, it was at least noted as a beneficial byproduct of the experimental population designation. In the case of Atlantic salmon, there are still many areas that would benefit from additional research. Specific issues that managers and biologists are currently struggling with include: abundance and survival of Atlantic salmon at key freshwater life stages; impacts of contaminants (e.g., river acidification, pesticides); predation on wild and hatchery-reared river-specific populations; and habitat restoration techniques. Establishing an experimental population of Atlantic salmon with the use of bonus fish would allow researchers greater flexibility in how they are able to explore and analyze these critical issues without jeopardizing the eight wild populations of Atlantic salmon left in the United States. However, biologists and managers must carefully compare the contributions from additional research due to the establishment of an experimental population with other recovery strategies that may enhance the number of individuals in the wild population.

Defining Success for an Atlantic salmon Reintroduction Program:

The final question posed in this thesis focuses on defining success of experimental populations, specifically in relation to Atlantic salmon. The following discussion considers survey results and conclusions drawn in the literature in conjunction with the current status of Atlantic salmon to define success specifically for an Atlantic salmon reintroduction program. As discussed earlier, both survey data and the literature on reintroductions define the success of an experimental population program in terms of the creation of self-sustaining populations. As a result, this measure should be used to define the purpose and success of an Atlantic salmon reintroduction program. However, this should not be the only criterion used, given that the creation of a self-sustaining population of Atlantic salmon would not be likely until far into the future. Therefore, if this were the only criterion used, it is likely that for quite a ways into the future the experimental population program would be deemed a failure. If an experimental population of Atlantic salmon could make contributions in the interim and in addition to the ultimate goal of creating a self-sustaining population, then perhaps other criteria could be incorporated as additional measures of success.

In the case of scientific research, it is uncertain whether the knowledge gained would benefit the entire GOM DPS, thereby enhancing the recovery and survival of eight populations. Some individuals may argue that definitions are simply semantics or a policy paper exercise. However, it is quite the opposite in the case of experimental populations. If an Atlantic salmon reintroduction program were defined only by the self-sustaining population criterion, failure may be likely. Reintroduction programs require a significant commitment of resources on the part of State and Federal agencies and if the program is perceived as a failure based upon the defined success criterion, program funding and support could be reduced. The worst-case scenario could be discontinuing of the project. This could be extremely detrimental if the reintroduction program was making significant contributions in the interim in other areas outlined above. Perhaps the soundest approach would be to rank the success criteria so that each component is weighted relative to the likely contribution it may make to the recovery of the GOM DPS.

Future Areas of Research:

There are several areas of future research that were either not considered in this thesis or that could be enhanced through the incorporation of additional information. The following list outlines the main areas that could be enhanced by the collection of additional data:

1. The survey response rate was low and could be improved by additional time and use of different techniques. New techniques that could be used include the creation of a contact list that consists of all members on reintroduction teams. This list could be compiled by contacting appropriate personnel from the Services via phone. Once a more complete list of reintroduction program participants is compiled, phone contact could be established with each

individual. Although this may be time and cost intensive, it would greatly improve the response rate, thereby improving the quality of the data gathered.

2. The length of the survey could be abbreviated.
3. A direct question regarding the criteria used to evaluate whether an experimental population should be designated should be posed to field biologists and managers to determine if the four areas outlined by Reading et al. (2002) were considered.

The following list outlines areas that were not considered in this thesis but could be explored in future analyses of experimental population programs:

1. Reintroduction programs could be analyzed on a worldwide basis to determine if there are worldwide trends in reintroduction programs.
2. State reintroduction programs should be explored and compared with federal reintroduction programs implemented under section 10(j) of the ESA.

Appendix A

Survey on Role of Experimental Populations in Recovery

The purpose of this survey is to evaluate the role that experimental populations have played in recovery of endangered species.

Questionnaire:

- E-mail survey questionnaire
- Endangered species managers/ biologists that have participated in reintroduction programs
- Sample will consist of all managers/ biologists from federal and state natural resource agencies

Professional Title (e.g. fishery biologist, recovery coordinator, wildlife biologist):

Species Information:
For the following survey, when answering multiple choice questions, please just list all the letters that apply. For questions that only require a Yes or No answer, please just indicate in the parentheses either (Y) or (N).

1. Species:

2. What were the major listing factors that necessitated listing this species as threatened/ endangered?

   ☐ the present or threatened destruction, modification, or curtailment of its habitat or range
   ☐ overutilization for commercial, recreational, scientific, or educational purposes
   ☐ disease or predation
   ☐ the inadequacy of existing regulatory mechanisms

   ☐ other natural or manmade factors affecting its continued existence

   ☐ other (please list below):

3. What year was this species listed as endangered?

Experimental Population Designation:

4. Was reintroduction/ experimental population designation identified as an element of the Recovery strategy in the species Recovery Plan?

5. Was there major political opposition to the reintroduction? Yes ☐ No ☐

6. Did the Services establish an experimental population for this species?
   - ☐ Yes
   - ☐ No (please answer only the following questions on this survey- 26, 29, 31)

7. If no, have the Services contemplated experimental population designation as a recovery strategy for this species? Yes ☐ No ☐
8. What year was the experimental population designated?

9. Was the experimental population designated as:
   - ☐ Nonessential or
   - ☐ Essential

10. What were the main reasons for designating an experimental population for this species?

    - ☐ Expansion of species range into historically occupied habitat necessary for recovery
    - ☐ Scientific research purposes (i.e. test different release techniques, test different stocking techniques)
    - ☐ Create additional breeding population to encourage infusion of new genetic material
    - ☐ Excess individuals available from a captive breeding program
    - ☐ Other:

11. Was a public outreach campaign implemented to educate the public about the reintroduction program? Yes ☐ No ☐

12. If yes, what types of education/ outreach techniques were used?
    - ☐ Passive techniques (i.e. posters, information displays, pamphlets)
    - ☐ Active techniques (organized presentations to community groups, mailings)
    - ☐ Experiential (i.e. community participation in reintroduction process)

13. What groups opposed designation of the experimental population? (Circle all the relevant groups that apply)

- [ ] Non-governmental Organizations (NGO's)
- [ ] Industry groups
- [ ] State Government
- [ ] Private Citizens
- [ ] Other

14. Which category(s) would you say best describes the leading reason(s) for opposition to the experimental population designation?
    - [ ] Opposition to additional regulatory oversight by the Federal Government
    - [ ] Opposition to the expansion of the species into its historical range
    - [ ] Opposition to utilizing experimental population designation as a tool for recovery
    - [ ] Opposition to nonessential designation instead of essential designation

15. Please list the main reasons the experimental population was designated as either essential or nonessential?

16. What individuals were used for the reintroduction?
    - [ ] Captive bred
    - [ ] Transplanted individuals from wild populations

17. How many individuals were released to establish the experimental population(s)?

18. Were the number of individuals released determined by:
    - [ ] Habitat carrying capacity
    - [ ] Public support/ opposition
    - [ ] Number of individuals available
    - [ ] Genetic integrity of existing population

19. Please describe the reintroduction site:

20. What criteria were used to determine the reintroduction site?

21. Have there been any offspring that have been produced as a result of natural reproduction in the experimental population? Yes ☐ No ☐

22. If yes, are enough offspring being produced to establish a self-sustaining population that does not have to be supplemented artificially? Yes ☐ No ☐

23. If no, is the experimental population being supplemented artificially with captive raised individuals or transplanted individuals from a wild population?
    Yes ☐ No ☐

24. Would you say that this reintroduction program has been successful?

25. How has "success" in relation to the goals of the experimental population programs been defined? (i.e.self-sustaining, research)

26. Has any monitoring been conducted to try and determine if objectives have been met?
    Yes ☐ No ☐

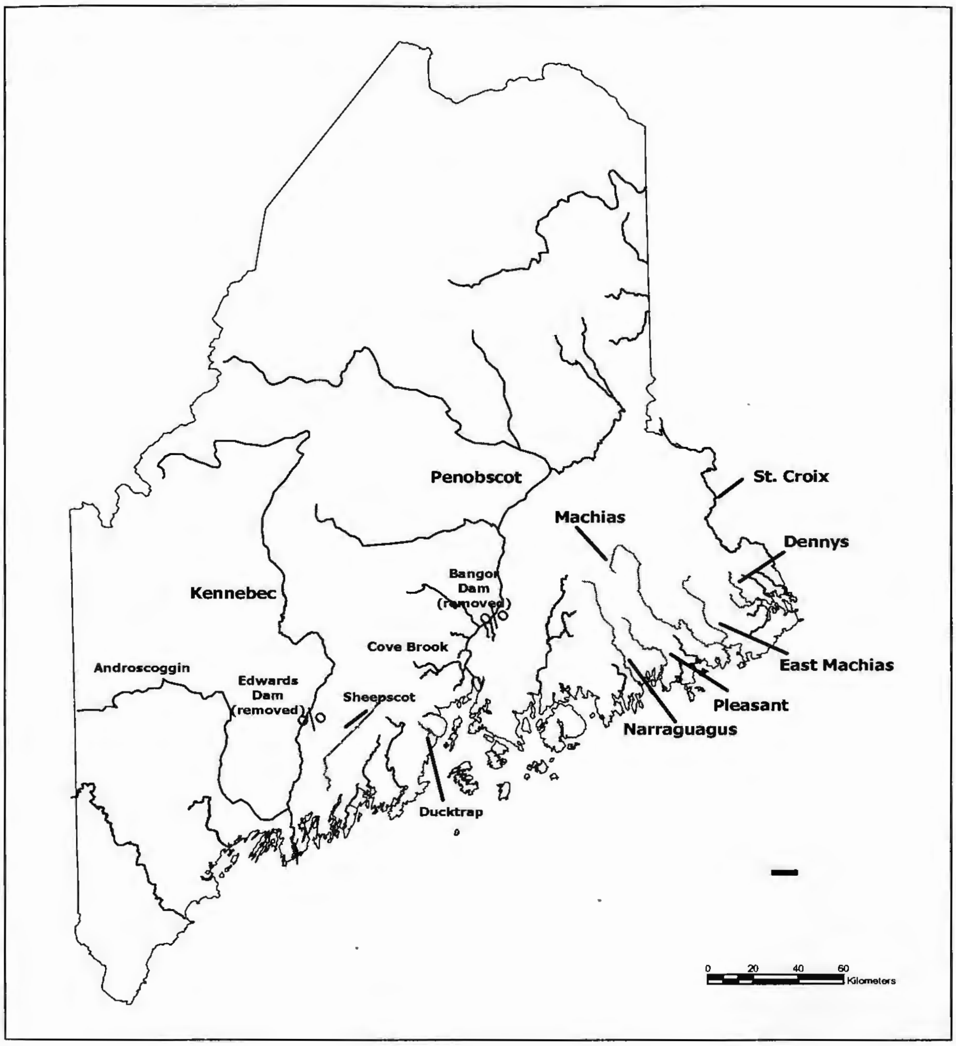
27. If yes, please describe the type of monitoring that has been conducted:

28. Do you think that experimental populations are an effective recovery strategy?

29. Do you think that in this specific case, designation of an experimental population facilitated recovery? Please explain:

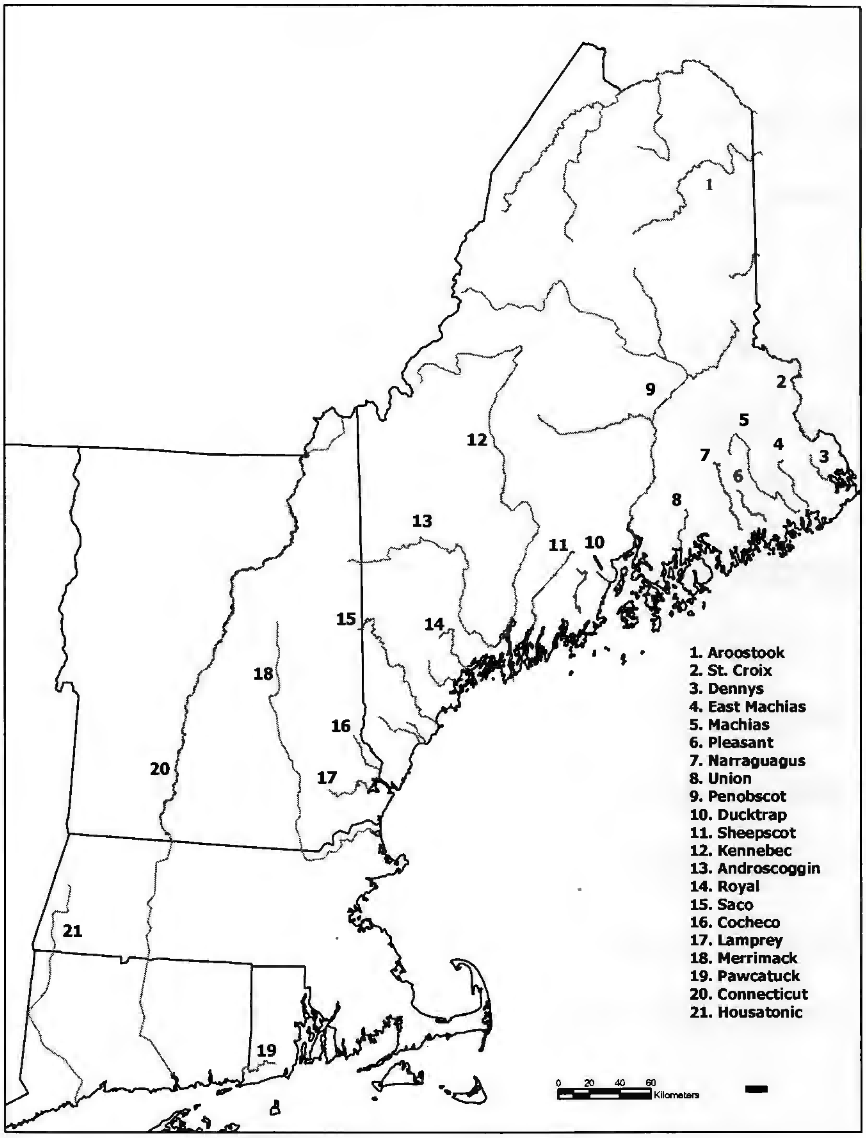
30. Do you think there is consensus among managers and biologist as to the effectiveness of experimental populations in recovery?

Appendix B



Gulf of Maine Distinct Population Segment of Atlantic Salmon

Appendix C



Major Historic Atlantic Salmon Rivers of New England

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