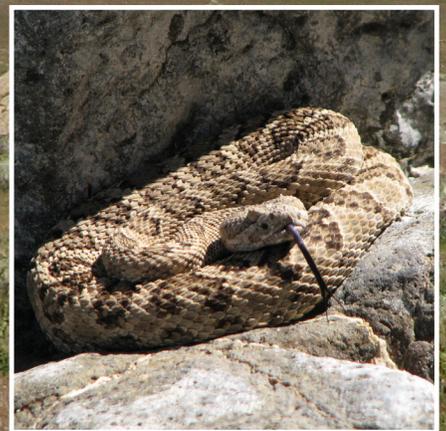
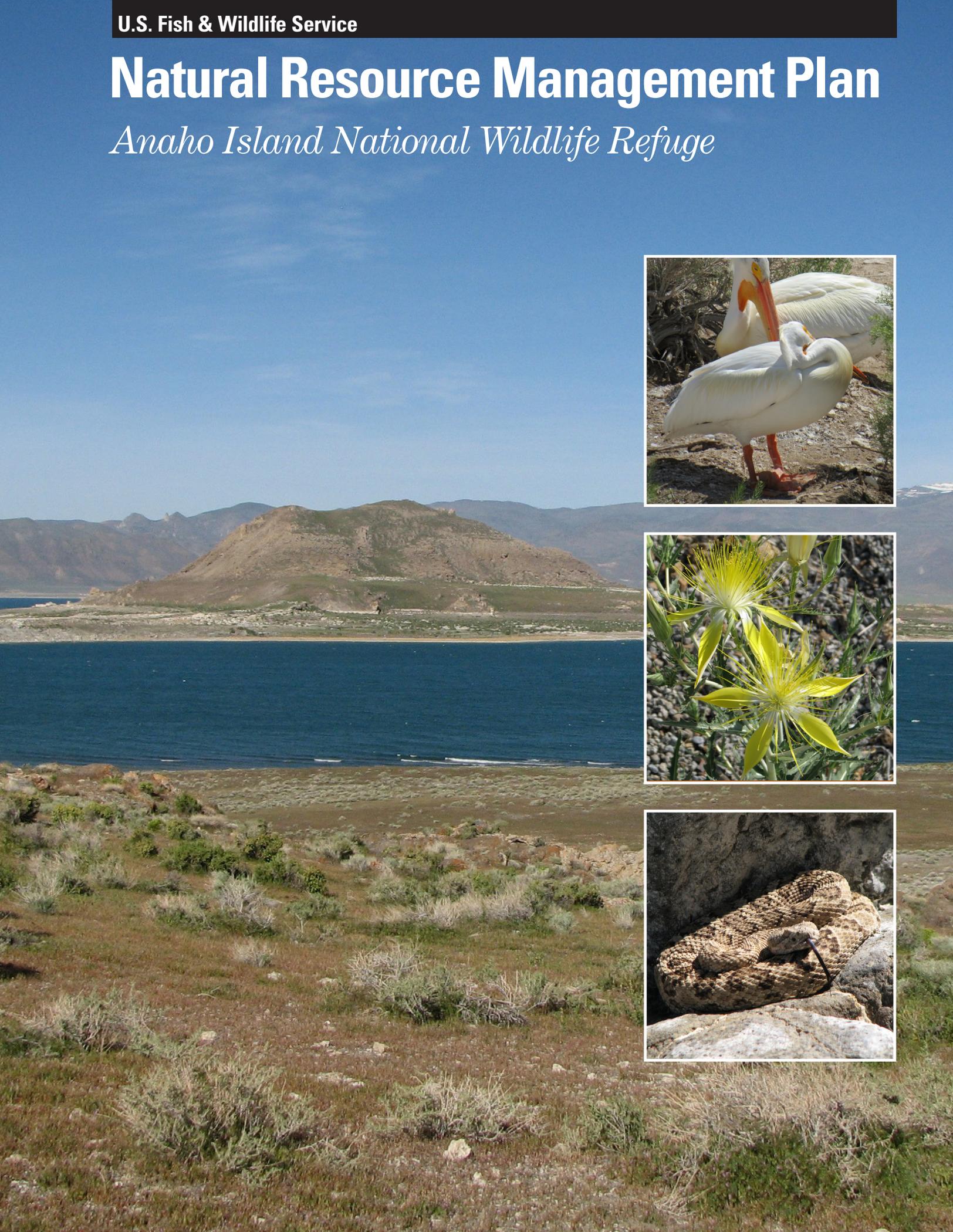


# Natural Resource Management Plan

## *Anaho Island National Wildlife Refuge*



The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.



The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.

*Cover photograph of Pyramid Lake and Anaho Island.*

USFWS

*Cover photographs of American white pelicans, smoothstem blazingstar, and rattlesnake.*

Donna Withers/USFWS

# Natural Resources Management Plan

## *Anaho Island National Wildlife Refuge*

**Nevada**

### **Prepared by**

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Anaho Island National Wildlife Refuge  
Natural Resource Management Plan Review and Approval  
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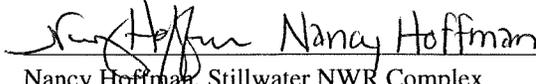
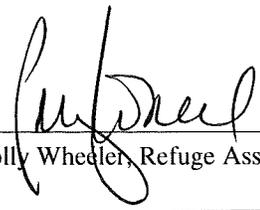
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# Abbreviations

<b>Anaho Island Refuge</b>	Anaho Island National Wildlife Refuge
<b>CCP</b>	comprehensive conservation plan
<b>FY</b>	fiscal year
<b>IMP</b>	inventory and monitoring plan
<b>IWJV</b>	“Intermountain West Joint Venture Implementation Plan”
<b>KEA</b>	key ecological attribute
<b>NRMP</b>	natural resource management plan
<b>Open Standards</b>	Open Standards for the Practice of Conservation
<b>refuge</b>	Anaho Island National Wildlife Refuge
<b>Refuge System</b>	National Wildlife Refuge System
<b>ROC</b>	resource of concern
<b>Service</b>	U.S. Fish and Wildlife Service
<b>Stillwater Refuge Complex</b>	Stillwater National Wildlife Refuge Complex

# Project Summary

Project Name:	Anaho Island National Wildlife Refuge Natural Resource Management Plan
Project Location:	Anaho Island as well as drainage basins and waterbodies within 160 kilometers (99 miles) that are used by Anaho Island biota, particularly colonial nesting waterbirds
Project Vision:	Anaho Island National Wildlife Refuge provides a sanctuary for native birds, especially colonial nesting species and other migratory birds, and maintains its natural biodiversity and cultural values through a cooperative partnership between the U.S. Fish and Wildlife Service and the Pyramid Lake Paiute Tribe.
Contact Name:	Nancy Hoffman, Project Leader, Stillwater National Wildlife Refuge Complex
Address:	U.S. Fish and Wildlife Service, Stillwater National Wildlife Refuge Complex, 1020 New River Parkway, Suite 305, Fallon, Nevada 89406
Project Start Date:	October 1, 2014
Project End Date:	October 1, 2029
Short-Term Project Budget:	\$184,438 (October 2015–October 2017)
Brief Project Description:	<p>Anaho Island National Wildlife Refuge is one of three refuges in the Stillwater National Wildlife Refuge Complex. The refuge is located 0.8 kilometer (0.5 mile) west of the eastern shore of Pyramid Lake in Washoe County, Nevada, within the Pyramid Lake Paiute Tribe Reservation. Established in 1913, the refuge is managed by the U.S. Fish and Wildlife Service for the benefit and protection of colonial nesting birds and other migratory birds.</p> <p>The refuge staff recognized the need for refinement of refuge conservation goals and objectives as well as identification or refinement of critical threats, strategies to address threats, and indicators to measure conservation progress. These needs have been addressed through developing this “Anaho Island National Wildlife Refuge Natural Resource Management Plan” and its companion “Anaho Island National Wildlife Refuge Inventory and Monitoring Plan.” Both of these are stepdown plans from the “Stillwater National Wildlife Refuge Complex Comprehensive Conservation Plan,” which was finalized in 2002. These plans are intended to focus limited refuge resources on activities with the highest likelihood of conservation success.</p>

The natural resource management plan has identified colonial nesting waterbirds, colonial nesting waterbird foraging areas, and the Anaho Island ecosystem as priority resources of conservation concern, which are referred to as “conservation targets” throughout the plan. The status of the refuge’s conservation targets—when assessed as a whole using the Conservation Measures Partnership’s Open Standards for the Practice of Conservation methodology—is considered Fair, indicating a level outside the acceptable range of variation and which requires human intervention. Climate change, water use and management, and invasive species were identified as the most critical threats to the refuge’s conservation targets. Key strategies to address these threats were identified, including (1) developing and implementing a water strategy to perpetuate island isolation and conserve important waterbird foraging areas in the surrounding landscape, (2) developing and implementing an integrated pest management plan to address invasive or nuisance plant and animal species, (3) conducting baseline inventories of island biota, (4) conducting island isolation studies to better understand conditions that would lead to formation of a land bridge between Anaho Island and the mainland, and (5) identifying and implementing actions aimed at restoring island biota such as native plant communities. Inventory, monitoring, and research activities to assess the status and trends of conservation targets (goals) and to assess progress on strategy implementation (objectives) are outlined in this natural resource management plan and detailed in the inventory and monitoring plan.

# Chapter 1—Introduction

Anaho Island National Wildlife Refuge (Anaho Island Refuge or refuge) is one of 562 national wildlife refuges that make up the U.S. Fish and Wildlife Service (Service) National Wildlife Refuge System (Refuge System). Anaho Island Refuge is one of three refuges in the Stillwater National Wildlife Refuge Complex (Stillwater Refuge Complex).

The refuge is located 0.8 kilometers (0.5 mile) west of the eastern shore of Pyramid Lake in Washoe County, Nevada, and lies within the Pyramid Lake Paiute Tribe Reservation (figure 1). Pyramid Lake is approximately 48 kilometers (30 miles) northeast of Reno, Nevada, and about 97 kilometers (60 miles) northwest of Stillwater National Wildlife Refuge. Anaho Island constitutes the extent of the refuge, and its size varies with the water level of Pyramid Lake. Since 1913, Anaho Island has ranged in size from 100 to 301 hectares (247 to 745 acres).

The refuge was established by President Woodrow Wilson by Executive Order 1819 on September 4, 1913 (table 1). The Executive Order recognized Anaho Island as part of the Pyramid Lake Paiute Tribe Reservation and set aside the island as a preserve and breeding ground for native birds. In 1990, Pyramid Lake Paiute Tribal Council Resolution 19–90 and Public Law 101–618 affirmed that Anaho Island is a part of the Pyramid Lake Paiute Tribe Reservation and that it is to be managed and administered under the primary jurisdiction of the Service as a part of the Refuge System for the benefit and protection of colonial nesting bird species and other migratory birds. In 1992, the Pyramid Lake Paiute Tribe and the Service signed a memorandum of understanding to guide management of the refuge. The refuge is closed to the public to protect colonial nesting birds, and boating is prohibited within 305 meters (1,000 feet) of the island.

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<sup>1</sup> The definition of wilderness is in section 2(c) of the Wilderness Act: “A wilderness, in contrast with those areas where man and his works dominate the

## 1.1 Refuge Conservation Planning: Past and Present

The final environmental impact statement for the “Stillwater National Wildlife Refuge Complex Comprehensive Conservation Plan” (CCP; U.S. Fish and Wildlife Service 2002) is the most recent guiding document for the management of Anaho Island Refuge and other refuges in the Stillwater Refuge Complex. The CCP broadly describes the desired future conditions of the refuge and provides long-range guidance and management direction to achieve refuge purposes. Resource management goals and objectives in the CCP are consistent with Anaho Island’s status as a proposed wilderness and its management as *de facto* wilderness<sup>1</sup> (Service Policy 610 FW 1).

Because the CCP’s focus is broad, the refuge staff recognized the need for a more detailed analysis of refuge threats, refinement of refuge goals and objectives, and refinement of management strategies and monitoring to assess conservation progress. These needs have been addressed through development of this natural resource management plan (NRMP) and companion inventory and monitoring plan (IMP; U.S. Fish and Wildlife Service 2014a). A stepdown management plan from the CCP, the NRMP serves as the refuge’s habitat management plan (Service Policy 620 FW 1) and provides specific goals, objectives, and strategies to achieve the refuge’s natural resource conservation vision and purposes given a limited set of resources. The intention of the NRMP is to clearly articulate the optimal set of management strategies and associated inventory, monitoring, and research activities the Service should implement over the next 15

landscape, is hereby recognized as an area where the earth and its community of life are untrammelled by man, where man himself is a visitor who does not remain.”

years while also addressing the potential impacts of climate change expected over the next 50 years. These strategies and associated activities are intended to maximize conservation of priority refuge resources in an adaptive framework. The companion IMP outlines the process used to prioritize and select surveys and provides details on selected surveys. Both the NRMP and IMP are considered dynamic, living plans that should be evaluated and improved over time as we assess conservation progress and increase our knowledge.

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## 1.2 Physiographic and Ecological Summary

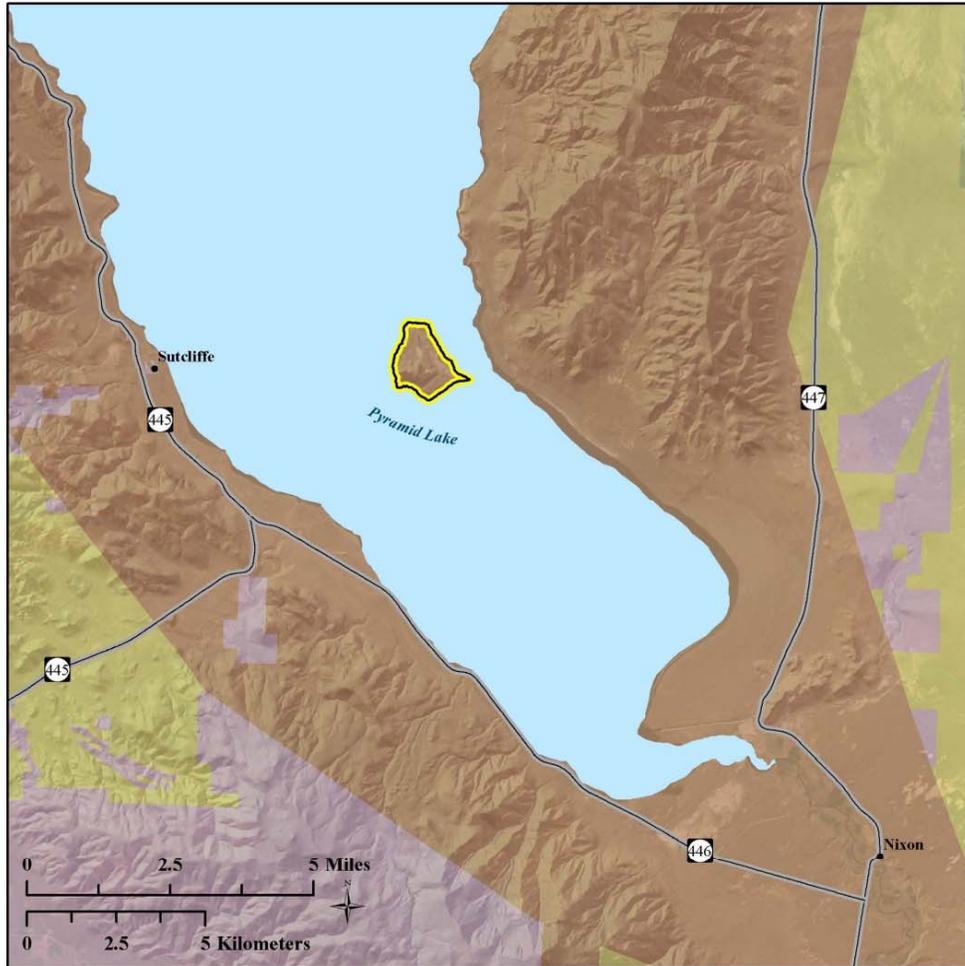
Anaho Island rises from the waters of Pyramid Lake, which is within the Truckee River watershed and Great Basin physiographic region. The Truckee River originates from Lake Tahoe (along the border of California and Nevada) and terminates in Pyramid Lake. This 51-hectare (126-acre) natural saline lake is one of the largest and deepest remnants of ancient pluvial Lake Lahontan.

Landcover of Anaho Island is characterized by gentle slopes near the shoreline and steep, rocky topography toward its 1,334-meter (4377-foot) peak. The surface of the island is predominantly non-vegetated (mainly rock, gravel, and litter), with vegetative cover ranging from 0 to 20 percent at the highest, rockiest elevations to a maximum of about 22 percent at mid-elevation (Kulpa and Leger

2013). Closer to the shoreline, vegetation cover is minimal and consists of desert shrub communities including greasewood (*Sarcobatus vermiculatus*) and winterfat (*Krascheninnikovia lanata*), nonnative annual grass species such as red brome (*Bromus rubens*) and cheatgrass (*Bromus tectorum*), and native bunch grasses and forbs such as desert needlegrass (*Achnatherum speciosum*) and buckwheat (*Eriogonum* spp.) (U.S. Fish and Wildlife Service 2002).

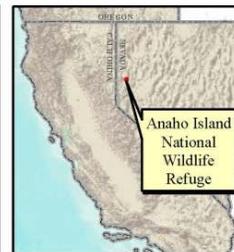
Anaho Island lies along the Pacific Flyway and, along with Pyramid Lake, is designated as a Nevada Important Bird Area by the Audubon Society and a notable waterbird site in the “Intermountain West Waterbird Conservation Plan” (Ivey and Herziger 2006). Anaho Island supports some of the largest breeding concentrations of colonial waterbirds in Nevada, including the second-largest nesting colony of American white pelicans (*Pelecanus erythrorhynchos*) in western North America, averaging over 4,000 nests since 1937 (U.S. Fish and Wildlife Service 2002). In addition to American white pelican, three other colonial nesting waterbird species regularly breed on Anaho Island: double-crested cormorant (*Phalacrocorax auritus*), California gull (*Larus californicus*), and great blue heron (*Ardea herodias*) (U.S. Fish and Wildlife Service 2002). Caspian terns (*Hydroprogne caspia*) breed intermittently at Anaho Island. The island also provides seasonal or year-round habitat for many other native plants, birds, reptiles, small mammals, and invertebrates.

## Anaho Island National Wildlife Refuge - Nearby Land Ownership



### EXPLANATION

- Cities
- Roads
- Anaho Island National Wildlife Refuge
- Pyramid Lake
- Pyramid Lake Paiute Reservation
- Bureau of Land Management
- Private



Map Projection: North American Datum 1983 Universal Transverse Mercator Zone 11; Map Production Date: April 2, 2013. Actual size of island varies with lake level and it is not necessarily as depicted on this map.

**Figure 1. Geographic setting of Anaho Island National Wildlife Refuge.**

**Table 1. Important legislation, Executive Orders, and other documents related to the establishment and management of Anaho Island National Wildlife Refuge.**

<i>Year</i>	<i>Legal document</i>	<i>Regulatory directive behind document</i>
1913	Executive Order 1819	Established the Anaho Island National Wildlife Refuge, identified the refuge purpose as a “preserve and breeding ground for native birds,” and formally recognized Anaho Island as part of the Pyramid Lake Paiute Tribe Reservation.
1974	House Document No. 93-403: Proposed Additions to the National Wilderness Preservation System, Part 29—Anaho Island Wilderness, Nevada	Proposed to add the refuge to the National Wilderness Preservation System.
1990	Public Law 101-618: 210(b)(2)	More narrowly defined the refuge purpose, stating that it was to be managed and administered “for the benefit and protection of colonial nesting species and other migratory birds.”
1990	Public Law 101-618 and Resolution No. 19-90 of the Pyramid Lake Paiute Tribal Council	Recognized that Anaho Island is part of the Pyramid Lake Paiute Tribe Reservation but is to be managed by the U.S. Fish and Wildlife Service as a component of the National Wildlife Refuge System.
1992	Memorandum of understanding between the U.S. Fish and Wildlife Service and the Pyramid Lake Paiute Tribe	Described terms of the Service’s management and administration of the island: “Anaho Island as it exists now and in the future, shall hereafter be managed and administered by and under the primary jurisdiction of the USFWS as an integral component of the NWRS for the benefit and protection of colonial nesting species and other migratory birds.”
2003	Final Environmental Impact Statement for the Stillwater National Wildlife Refuge Complex Comprehensive Conservation Plan	Provided environmental review of the comprehensive conservation plan, which identified refuge goals and management objectives and complied with the National Wildlife Refuge System Administrative Act of 1966, as amended by Refuge Improvement Act of 1997.

Key: NWRS = National Wildlife Refuge System; USFWS or Service = U.S. Fish and Wildlife Service.

Note: Regarding House Document No. 93-403, Congress has never acted on this proposal. Anaho Island retains its essential wilderness character as a roadless island, and in accordance with U.S. Fish and Wildlife Service Policy 610 FW 1, the refuge is managed as if it has been designated.

# Chapter 2—Methods

## 2.1 Project Team

Several individuals worked together to develop the Anaho Island Refuge NRMP (hereafter referred to as the project team; table 2). The draft NRMP was submitted to Service Region 8

leadership, the Pyramid Lake Paiute Tribe, expert advisors, and other stakeholders for their input (appendix A). Stakeholders were individuals, groups, or institutions with a vested interest in the natural resources of Anaho Island or who may be affected by refuge management activities or changes to refuge conditions.

**Table 2. Anaho Island National Wildlife Refuge Natural Resource Management Plan Project Team.**

<i>Name</i>	<i>Organization</i>	<i>Position</i>	<i>Role in project</i>
Carol Damberg	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	Refuge operations chief	Team leader
Giselle Block	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	Inventory and monitoring specialist, Inventory and Monitoring Program	Team leader
Nancy Hoffman	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	Project leader, Stillwater National Wildlife Refuge Complex	Refuge expert
Donna Withers	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	Wildlife refuge specialist, Stillwater National Wildlife Refuge Complex	Refuge expert
Sharon Dulava	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	Refuge wildlife biologist, Inventory and Monitoring Program	Project operations manager, climate change
Arlyne Johnson	Foundations of Success	Open Standards facilitator and trainer	Process facilitator and trainer
Judy Boshoven	Foundations of Success	Open Standards trainer and facilitator	Process facilitator and trainer
Orien Richmond	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	Refuge wildlife biologist, Inventory and Monitoring Program	Resources of concern, birds, inventory and monitoring plan team lead
Kaylene Keller	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	GIS and data manager, Inventory and Monitoring Program	Resources of concern, GIS
Erin Aceituno	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	GIS specialist, Inventory and Monitoring Program	GIS
Rachel Esralew	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	Hydrologist, Inventory and Monitoring Program	Hydrology, climate change
Sallie Hejl	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	Regional biologist	Project assistant

Key: GIS = Geographic Information Systems.

## 2.2 Conservation Planning Approach

The Anaho Island Refuge NRMP was developed using the Conservation Measures Partnership's Open Standards for the Practice of Conservation (referred to as the Open Standards) (Conservation Measures Partnership 2013, Foundations of Success 2009). The Open Standards promote an adaptive management approach for the design and successful implementation of natural resource conservation and encourage conservation practitioners to:

- specify measurable desired results in terms of conservation outcomes, not just actions;
- document our assumptions;
- be explicit about how we believe our actions will lead to desired results;
- implement monitoring to track conservation progress over the short- and long-term;

- adapt strategies based on what we have learned, using data and analyses to promote doing more of what works;
- share results and be transparent about what worked and what didn't to advance conservation at a larger landscape scale.

The steps composing the Open Standards adaptive management cycle are presented in figure 2. This NRMP and companion IMP represent Steps 1 and 2 of the Open Standards process and provide the refuge staff with a framework for practicing adaptive management—a dynamic process for regular review, learning, and adaptation that will require completing several iterations of the five-step Open Standards management cycle over the life of the NRMP.

Common Open Standards terms used throughout this plan are defined below.

- Conservation target: a species, community, or ecosystem that best represents the biodiversity and purpose of the refuge and is



**Figure 2. Conservation Measures Partnership's Open Standards for the Practice of Conservation process (Conservation Measures Partnership 2013).**

the focus of natural resource management; synonymous with “refuge priority resource of concern” or ROC.

- **Key ecological attribute (KEA):** an aspect of a conservation target’s biology or ecology that, if present, defines a healthy conservation target but, if missing or altered, would lead to the outright loss or extreme degradation of that conservation target over time. Examples include population size, reproductive success, community composition or structure, habitat connectivity, hydrological regime, sediment dynamics, and fire regime.
- **Threat:** a human-induced action that stresses—or has the potential to stress—one or more conservation targets. Examples include pollution, invasive species introductions, and human water use for agriculture or other purposes.
- **Stress:** the expression of a threat relative to KEAs. Examples include reduced population size, habitat loss, altered hydrology, and altered fire regime.
- **Conservation goal (goal):** a formal statement detailing a desired outcome of refuge management in terms of conservation targets and associated KEAs.
- **Objective:** a formal statement detailing what a refuge team hopes to achieve for its intermediate results on the way to achieving a refuge goal—in other words, objectives help project teams know if they are making progress toward their conservation target. Objectives are commonly focused on threat abatement (such as invasive species control) or restoration as means of achieving goals.
- **Strategy:** a group of actions with a common focus that work together to reduce one or more threats or to restore natural systems. Strategies are designed to achieve objectives and goals.

Using the Open Standards process, the project team conducted the following activities, as ordered below, to develop this NRMP:

1. Define the project team, stakeholders, and advisors. These are people involved in developing and reviewing the NRMP (“Chapter 2—Methods”).
2. Define the NRMP geographic scope and develop a vision of what the refuge staff hopes to achieve over the next 15 years (“Chapter 3—Scope, Vision and Conservation Targets”).
3. Identify refuge conservation targets (and related KEAs) that are the focus of refuge management and best represent biological diversity and ecological integrity (“Chapter 3—Scope, Vision and Conservation Targets”).
4. Assess the current status, trend, and desired future status of conservation targets in terms of KEAs (“Chapter 4—Viability Assessment”) and develop SMART<sup>2</sup> conservation goals (what success looks like).
5. Identify and rank threats to conservation targets (“Chapter 5—Threat Assessment”).
6. Develop a conceptual model depicting the relationship between conservation targets, priority threats, and opportunities (“Chapter 6—Situation Analysis”).
7. Develop an action plan (“Chapter 7—Action Plan”):
  - a. Identify and describe management strategies aimed at reducing threats to conservation targets.
  - b. Document assumptions about how management strategies are expected to improve the conservation situation.
  - c. Develop SMART results-oriented threat-reduction objectives (interim results of our management strategies along the way to achieving target goals).
  - d. Develop expected near-term (3-year) budget and timeline.
8. Develop measurable indicators for goals and objectives and identify research needs (“Chapter 8—Inventory, Monitoring, and Research”). These indicators informed development of the Anaho Island Refuge IMP, a companion plan to this NRMP.

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<sup>2</sup> SMART stands for specific, measureable, achievable, relevant, and time-bound.

We used Miradi<sup>3</sup> adaptive management software to record and facilitate the development of the Anaho Island Refuge NRMP. Miradi will also provide the refuge staff with a platform to document progress, learn from conservation actions, and adapt NRMP strategies, goals, and objectives over time.

NRMP and are central to the work of the Refuge System. The process used for identifying ROCs is described in “Region 8 Methodology for Identifying Priority Resources of Concern to Guide Management on National Wildlife Refuges” (U.S. Fish and Wildlife Service 2014b). The Region 8 methodology is based in part on “Identifying Refuge Resources of Concern and Management Priorities: A Handbook” (Paveglio and Taylor 2010). A summary of the ROC process is presented in table 3. Priority ROCs—which are primarily referred to as conservation targets in this document—were then used to develop refuge conservation goals.

## 2.3 Selection of Priority Resources of Concern (Conservation Targets)

Synonymous with conservation targets, priority ROCs<sup>4</sup> are the focus of the Anaho Island Refuge

**Table 3. Summary of the steps used to identify Anaho Island National Wildlife Refuge priority resources of conservation concern (conservation targets).**

<i>Step</i>	<i>Description</i>
Step 1—Identify the refuge’s purposes	Identify the species, species groups, communities, or ecosystems identified in refuge establishing legislation and administrative documents.
Step 2—Identify refuge system resources of concern	Identify Refuge System resources of concern by reviewing the Service’s Policy on National Wildlife Refuge System Mission and Goals and Refuge Purposes (601 FW 1). Refuge System resources of concern include migratory birds, inter-jurisdictional and anadromous fish, threatened and endangered species, and marine mammals for which the Service has responsibility.
Step 3—Address biological integrity, diversity, and environmental health	Consider elements of biodiversity on the refuge (for example, native fish, animals, plants, and communities) according to the Service’s Policy on Biological Integrity, Diversity and Environmental Health (601 FW 3.3). Consider the importance and contribution of the refuge to larger landscape conservation (for example, review of larger landscape conservation plans).
Step 4—Compile comprehensive list of refuge resources of concern	Compile a list of species, communities, and ecosystems that have been reported to occur on the refuge by consulting the comprehensive conservation plan and other refuge plans, reports of pertinent biological surveys, refuge staff members, and online databases.
Step 5—Identify priority refuge resources of concern	Rank the comprehensive list of species, communities, and ecosystems from Step 4 and select the final resources of concern that will be a focus of the natural resource management plan. A set of filters and criteria is used to rank resources of concern (for example, listing status or contribution of the refuge to regional or global populations).

Key: Refuge System = National Wildlife Refuge System; Service = U.S. Fish and Wildlife Service.

<sup>3</sup> More information about Miradi can be found at [www.miradi.org](http://www.miradi.org).

<sup>4</sup> Priority ROCs are all plant and animal species, species groups, or communities specifically identified in a refuge’s purpose(s), or relevant international, national, regional, State, or ecosystem conservation

plans or acts. For example, waterfowl and shorebirds are a resource of concern on a refuge whose purpose is to protect “migrating waterfowl and shorebirds.” Federal or State threatened and endangered species on that same refuge are also a ROC under the terms of the respective endangered species acts (620 FW 1).

# Chapter 3—Scope, Vision, and Conservation Targets

## 3.1 Scope

The geographic scope—hereafter referred to as the NRMP scope—of the Anaho Island Refuge NRMP is the exposed land mass of Anaho Island and surrounding drainage basins and waterbodies (within about 160 kilometers [99 miles]) important to Anaho Island biota, particularly colonial nesting waterbirds (figure 3). Drainage basins and waterbodies of critical importance are those that (1) provide water to Pyramid Lake and are essential to maintaining aquatic isolation of Anaho Island; (2) contain foraging habitats used by colonial nesting waterbirds; or (3) are a current or potential source of invasive<sup>5</sup> species, contaminants, and other threats that may adversely affect Anaho Island biodiversity.

We recognize that the Service has primary management jurisdiction over Anaho Island, not its surroundings. However, the scope of the NRMP was expanded to recognize the importance of natural resources in the larger landscape in conserving Anaho Island natural resources. For example, telemetry studies by Seegar and Fuller (1997) showed that American white pelicans breeding at Anaho Island regularly fly from several to more than 100 kilometers (62 miles) per day between feeding, roosting, and breeding sites. Their studies supported a long-held assumption that the extensive wetland area from Pyramid Lake through the Lahontan Basin and south are necessary to sustain the Anaho Island pelican population. In addition, the Service expends resources to manage other Service lands (for example, Stillwater National Wildlife Refuge) or works with partners to conserve natural resources in the larger area surrounding the refuge.

<sup>5</sup> Executive Order 13112 defines an invasive species as “an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.”

## 3.2 Vision<sup>6</sup>

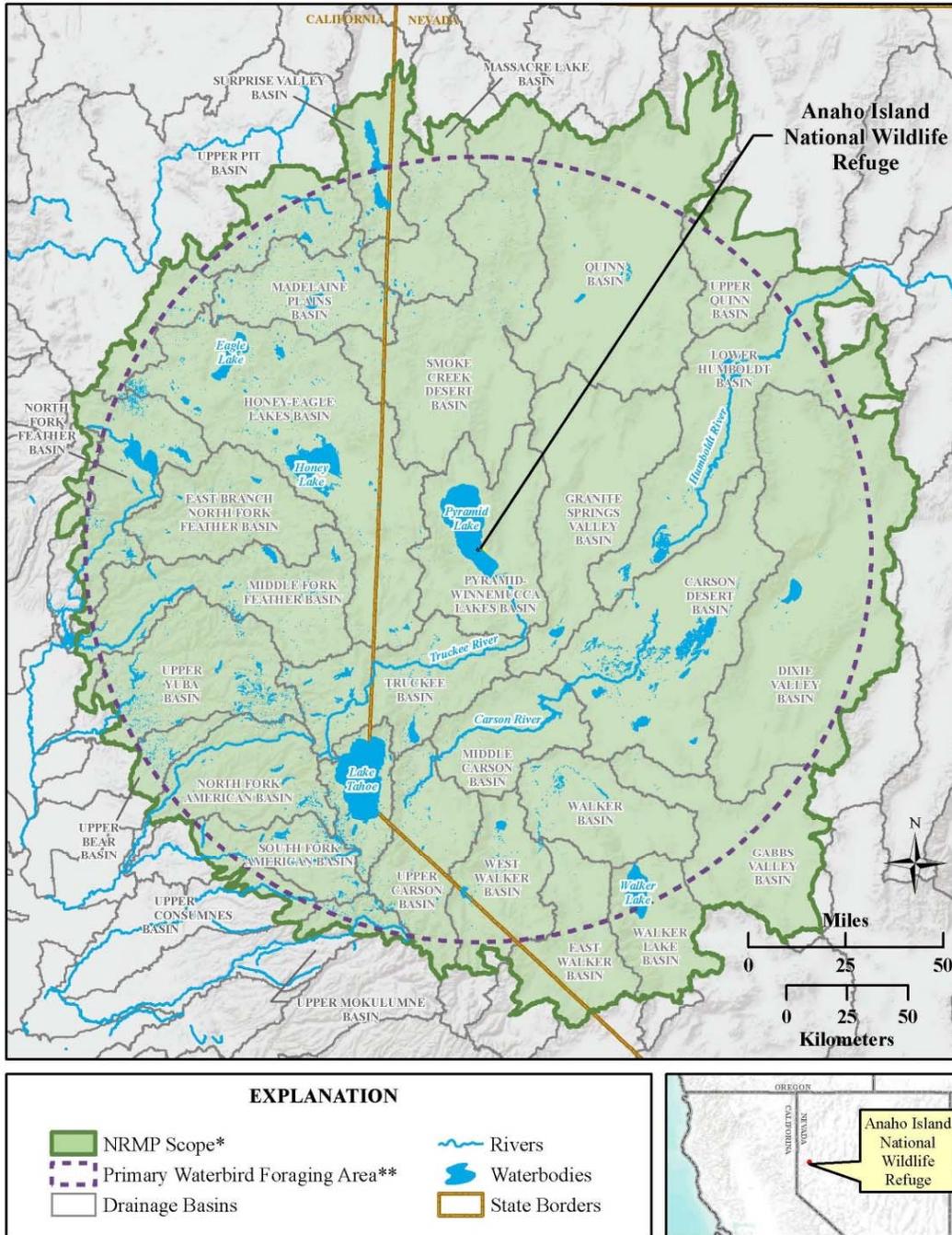
*Rising out of the waters of Pyramid Lake, the rugged and arid landscape of Anaho Island National Wildlife Refuge will provide secure and sustained refuge for migratory, colonial nesting birds and other naturally occurring insular species. This vision will be achieved by restoring and conserving the island’s natural biodiversity, promoting species resilience, and preserving its unrestrained wilderness character. Outreach to surrounding communities and close cooperation with Pyramid Lake Paiute Tribe will foster an appreciation for Anaho Island’s significance in the conservation landscape and cultivate natural resource and cultural stewardship by future generations.*

## 3.3 Priority Resources of Concern (Conservation Targets)

The biodiversity of Anaho Island is a complex combination of species and communities. Although conserving this entire complex system is ideal, the refuge lacks the resources to explicitly focus on every element of biodiversity. For this reason, we selected three conservation targets we believe best represent biodiversity at Anaho Island:

<sup>6</sup> A vision is a general summary of the desired state or ultimate condition of the project area or scope that a project is working to achieve (Conservation Measures Partnership 2013).

## Geographic Scope of the Anaho Island National Wildlife Refuge Natural Resource Management Plan



**Figure 3. Spatial scope of the “Anaho Island National Wildlife Refuge Natural Resource Management Plan” and extent of primary waterbird foraging area.**

**Table 4. Summary of species and ecological community types identified in Anaho Island National Wildlife Refuge’s purpose or establishing legislation.**

<i>Species, species group, community, or ecosystem identified in establishing legislation or administrative order</i>	<i>Supporting ecological factors</i>	<i>Life history requirements provided</i>	<i>Establishing legislation or administrative order</i>
Native birds	Island vegetation, island biodiversity, proximity to lacustrine and riverine systems, isolation from mainland, and protection from human disturbance	Nesting, spring and fall migration, and/or wintering	Executive Order 1819
Colonial waterbirds	Landcover (for example, open substrate for American white pelicans or tall greasewood for great blue herons and cormorants), proximity to lacustrine and riverine systems for foraging, cobble or fine gravel and vegetation-free beaches, isolation from mainland, and protection from human disturbance	Nesting, spring and fall migration, and wintering for select species	Public Law 101–618: 210(b)(2)
Other migratory birds	Island vegetation, island biodiversity, proximity to lacustrine and riverine systems, isolation from mainland, and protection from human disturbance	Nesting, spring and fall migration, and/or wintering	Public Law 101–618: 210(b)(2)
Other wildlife	Island vegetation, island biodiversity, isolation from mainland, and protection from human disturbance	Year-round life requirements for non-migratory reptiles, mammals, and insects	Public Law 101–618: 210(b)(2)

- colonial nesting waterbirds
- colonial nesting waterbird foraging areas
- Anaho Island ecosystem

These targets represent island biodiversity as well as natural resources in the larger landscape needed to maintain the health and persistence of the island ecosystem and colonial nesting waterbirds. These targets also address conservation priorities identified in Anaho Island Refuge’s purpose or establishing legislation and administrative orders (table 4). A detailed account of the Anaho Island ROC process is presented in “Anaho Island Resources of Concern” (U.S. Fish and Wildlife Service 2014c).

### **3.3.1 Conservation Target 1—Colonial Nesting Waterbirds**

The colonial nesting waterbird conservation target includes five colonial nesting waterbird

species that regularly breed at Anaho Island Refuge (table 5). The first account of waterbirds was provided by Robert Ridgway, who visited Pyramid Lake and Anaho Island in 1867–1868 as part of a geological exploration led by Clarence King (Ridgway 1877). Ridgway refers to Anaho Island not by its current name but only as the “main island” of Pyramid Lake. Ridgway noted a colony of great blue herons nesting on top of “remarkably large grease-wood bushes” along the island’s southern beach; hundreds of American white pelicans nesting at the northern end of the island and thousands of pelicans floating on the lake; an immense California gull colony also at the northern end of the island but separate from the pelicans; and an abundance of double-crested cormorants. Ridgway’s work was the first of many efforts over more than a century to document the status and trends of Anaho Island Refuge waterbirds.

**Table 5. Waterbird species nested under the Anaho Island National Wildlife Refuge colonial nesting waterbird target.**

<i>Common name</i>	<i>Scientific name</i>	<i>Foraging guild</i>
American white pelican	<i>Pelecanus erythrorhynchos</i>	Cooperative surface feeders
Double-crested cormorant	<i>Phalacrocorax auritus</i>	Shallow-water divers
California gull	<i>Larus californicus</i>	Shallow-water generalists
Caspian tern	<i>Hydroprogne caspia</i>	Shallow-water plunge-divers
Great blue heron	<i>Ardea herodias</i>	Stalking ardeids

Notes: A nested target is defined as an ecosystem, species, or ecological process that may also be conserved if the broader target within which it is found is conserved.

Foraging guilds follow Liordos (2010).

Refuge natural resource monitoring has been primarily focused on American white pelicans. Consistent long-term data on other waterbirds are limited to species richness and number of nests. A summary of Anaho Island Refuge waterbird ecology is presented below. In cases where waterbird data were lacking, we used available information from the scientific literature to describe waterbird ecology and large scale population trends. Unless otherwise mentioned, information sources that were used to prepare the waterbird summaries included:

- Birds of North America Online (Cuthbert and Wires 1999, Hatch and Weseloh 1999, Knopf and Evans 2004, Vennesland and Butler 2011, Winkler 1996)
- “Intermountain West Joint Venture Implementation Plan” (Intermountain West Joint Venture 2013)
- “Nevada Partners in Flight Bird Conservation Plan” (Nevada Partners in Flight 1999)
- “A Status Assessment of the Double-Crested Cormorant (*Phalacrocorax auritus*) in Western North America: 1998–2009” (Adkins and Roby 2010)

## American White Pelican

The American white pelican is identified as a Conservation Priority Species by the Nevada Department of Wildlife (Nevada Department of Wildlife 2012), a Globally Vulnerable and State Imperiled species in Nevada by NatureServe, a

species of high concern in the “Intermountain West Waterbird Conservation Plan” (Ivey and Herziger 2006), and a focal waterbird in the “Intermountain West Joint Venture Implementation Plan” (Intermountain West Joint Venture 2013).

American white pelicans winter along the Pacific coast from central California and southern Arizona south to Baja California, western Mexico, and Nicaragua, as well as from Florida, the Gulf states, and southern Texas through central plateau of Mexico and to the northern Yucatan Peninsula (Knopf et al. 2004). They breed in central British Columbia, Canada, and in the north central and northwestern United States (Knopf et al. 2004). The Nevada American white pelican breeding population is almost entirely represented by a single large colony located on Pyramid Lake’s Anaho Island. This is 1 of the 10 largest colonies in North America (King and Anderson 2005) and, depending on annual fluctuations, the second largest breeding colony in the West after Gunnison Island Wildlife Management Area in Utah (Pacific Flyway Council 2012). Because of Anaho Island’s contribution to American white pelican populations in the West, the refuge has long served as a site for monitoring American white pelican population and reproduction. Although refuge data on Anaho Island American white pelicans date back to 1868, consistent annual monitoring of abundance and reproductive success did not begin until the late 1970s. Since 1977, the annual number of

American white pelican<sup>7</sup> breeding adults and active nests on the refuge show a high level of fluctuation (figure 4) and is assumed to be influenced by the abundance of waterbodies and related food availability in the NRMP scope. Of recent concern is the declining trend in number of young fledged and fledging rates that, since 2010, have reached some of their lowest values recorded since 1977. A comprehensive analysis of American white pelican legacy data is needed to quantify trends through time in relation to water availability, food supply, population size of California gulls (a predator of eggs and nestlings) on the island, and other environmental factors. This information will inform revision or development of new management strategies.

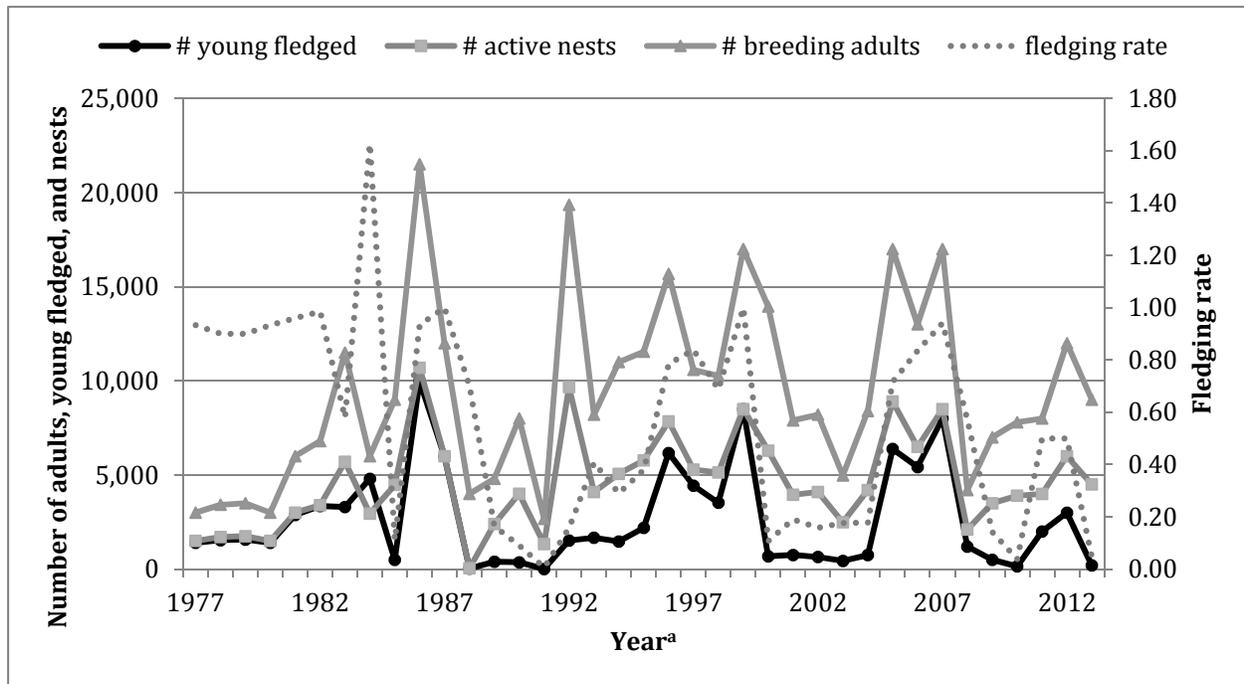
American white pelicans breed asynchronously from mid-March to early September on sparsely vegetated islands. American white pelicans at Anaho Island Refuge typically nest on flat or slightly sloping ground with a good view of the surrounding terrain and seem to prefer nesting in the vicinity of rocks and shrubs such as saltbush (*Atriplex confertifolia*) and greasewood.

Anaho Island Refuge American white pelicans feed primarily on Asiatic or common carp (*Cyprinus carpio*), Lahontan Tui chub (*Gila bicolor*), cui-ui (*Chasmistes cujus*), and to some extent Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) (Knopf and Kennedy 1980, Wiemeyer and Saake 2007). Lahontan cutthroat trout are federally listed as threatened and cui-ui are federally listed as endangered. American white pelicans at Anaho Island Refuge generally forage in surrounding wetlands within a 160-kilometer (99-mile) radius (Donna Withers, wildlife refuge specialist, Stillwater Refuge Complex, personal communication). Telemetry studies by Seegar and Fuller (1997) showed American white pelicans breeding at the refuge regularly fly from several to more than 100 kilometers (62 miles) per day between feeding, roosting, and breeding sites. Their studies supported a long-held assumption that the extensive wetland area from Pyramid Lake through the Lahontan Basin and south are necessary to sustain the local pelican population.

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<sup>7</sup> Anaho Island waterbird data were not collected on a regular basis at the refuge prior to 1977. This

information is preliminary. There is a need to verify the waterbird data and evaluate inconsistencies in how the data were collected and originally reported.



<sup>a</sup> Although American white pelican monitoring data date back to 1868, the longest period of consistent annual measures spans 1977–2013.

**Figure 4. Trends in annual American white pelican population and reproductive measures, 1977–2013.**

## Double-Crested Cormorant

Double-crested cormorant is identified as a priority breeding waterbird in the “Intermountain West Joint Venture Implementation Plan” (Intermountain West Joint Venture 2013). Adkins and Roby (2010) defined the western population of double-crested cormorant as birds breeding in states west of the Continental Divide and southern British Columbia. In 2009, they estimated this breeding population at 29,240 breeding pairs. Double-crested cormorant nests at Anaho Island Refuge are composed primarily of dried alkali weed stems (*Bassia hyssopifolia*) and cormorant and pelican feathers (Woodbury 1966). The first record of nesting by double-crested cormorant on Anaho Island Refuge was in 1940 (Bond 1940). During his visits in 1867 and 1868, Ridgway (1877) described cormorants nesting in cottonwood snags around the Truckee River but did not mention nesting on any of the islands in Pyramid Lake. Refuge data show that the annual number of double-crested cormorant nests at Anaho Island Refuge has fluctuated

with a high of 2,500 nests in 1986 and a low of 150 nests in 2008. The mean annual number of nests from 1978 to 2010 was 870.

Double-crested cormorants are generalist piscivores and are known to prey on more than 250 species of freshwater and marine fishes ranging in length from 3 to 40 centimeters (1.2 to 15.7 inches), with the most common prey size less than 15 centimeters (5.9 inches). Double-crested cormorants at Anaho Island Refuge tend to fish close to nesting sites and forage on fish such as Lahontan Tui chub (Woodbury 1966).

## California Gull

The California gull is identified as a species of moderate concern in the “Intermountain West Waterbird Conservation Plan” (Ivey and Herziger 2006) and a focal waterbird in the “Intermountain West Joint Venture Implementation Plan” (Intermountain West Joint Venture 2013). California gulls have an estimated breeding population of 4,200 in Nevada and 414,000 in North America (Ivey and Herziger 2006). The annual number of California

gull nests at Anaho Island Refuge has fluctuated, with a high of 3,300 nests in 1988 and a low of 1,000 nests in 1964. The mean number of nests from 1950 to 1990 was 2,000. California gull nesting colonies at Anaho Island Refuge have been documented on a long, curved sandy beach on the south side of the island (Woodbury 1966), but in recent years they primarily nest on the east side of the island. Ridgeway (1877) described the California gull colony site, when the island was much smaller, as being on more rocky elevated ground on the northern shore. Birds first return to Anaho Island Refuge colony sites around late March. Nests consist of depressions on bare sand or of sticks and feathers in salt grass. Egg-laying begins in mid-to late April and continues through May (Woodbury 1966).

California gulls forage opportunistically in farmlands, marshes, meadows, garbage dumps, parks, streams, and rivers for small mammals, fish, birds, nestlings, consumable human refuse, and a variety of invertebrates. At Anaho Island, California gulls will depredate eggs from unattended pelican nests (Hall 1925; Donna Withers, wildlife refuge specialist, Stillwater Refuge Complex, personal communication). They will also eat fish regurgitated on the island, carrion along roadways, and small fish on the surface waters of Pyramid Lake (Woodbury 1966).

## Great Blue Heron

The great blue heron is identified as a species of moderate concern in the “Intermountain West Waterbird Conservation Plan” (Ivey and Herziger 2006) and a focal waterbird in the “Intermountain West Joint Venture Implementation Plan” (Intermountain West Joint Venture 2013). Great blue herons have an estimated breeding population of 600 in Nevada and 83,000 in North America (Ivey and Herziger 2006). Refuge data show the annual number of great blue heron nests at Anaho Island Refuge has fluctuated with a high of 140 nests in 1984 and a low of 2 nests in 1955. The mean number of nests from 1950 to 1994 was 41. Great blue heron nesting sites at Anaho Island Refuge have varied from heavy growths of saltbush and dried alkali weed to the tops of large greasewoods (Ridgeway 1877, Woodbury 1966).

Great blue herons forage along the shorelines of oceans, marshes, lakes, and rivers and in upland areas for fish, amphibians, reptiles, small mammals, insects, and other birds. Nesting great blue herons at Anaho Island Refuge primarily forage for fish in shallow waters around the island (Woodbury 1966).

## Caspian Tern

The Caspian tern is identified as vulnerable to imperiled by NatureServe in Nevada, is included on the Service’s Birds of Conservation Concern list (U.S. Fish and Wildlife Service 2008), and is identified as a priority breeding waterbird in the “Intermountain West Joint Venture Implementation Plan” (Intermountain West Joint Venture 2013). Caspian terns have an estimated breeding population of 236 in Nevada and 68,000 in North America (Ivey and Herziger 2006). Refuge data show the annual number of Caspian tern nests at Anaho Island Refuge has fluctuated with a high of 125 nests in 1962 and several years of no documented nesting. The average annual number of nests from 1950 to 1994 was 29. The first record of Caspian terns nesting on Anaho Island Refuge was in 1950 (Woodbury 1966). Caspian terns at the refuge have nested within the California gull colony on the sandy beach at the south end of the island (Woodbury 1966), but in recent years they have nested among the California gulls on the east side of the island (Donna Withers, wildlife refuge specialist, Stillwater Refuge Complex, personal communication). Caspian terns live almost entirely on fish, capturing them in shallow surface waters near breeding sites.

## Conflicts with Sensitive Fish Species

Conflicts created by predation of piscivorous birds (for example, American white pelicans, double-crested cormorants, Caspian terns) on imperiled and sport fish populations (for example, federally listed as endangered cui-ui and threatened Lahontan cutthroat trout) occur in the NRMP scope, but the long-term impact of waterbird predation on imperiled and sport fish populations is uncertain. Conflicts between American white pelican and the cui-ui and Lahontan cutthroat trout of Pyramid Lake have been well documented. Declines in the Pyramid

Lake trout population in the early 1920s prompted sportsmen and others to request an investigation (by the U.S. Department of Agriculture) of the impact of American white pelican on the trout fishery of Pyramid Lake. A 1924 study of the food habits of adult and juvenile pelicans at Anaho Island revealed that pelicans were not detrimental to the Pyramid Lake trout fishing industry but that the trout population decline was attributed to multiple human-related factors, primarily the diversion of water out of the Truckee River (Hall 1925). In 1940, residents of the Pyramid Lake region were still convinced that the pelicans had caused the decline in the populations of Lahontan cutthroat trout and also cui-ui, but another study of the food habits of the Anaho Island Refuge pelicans again revealed the birds primarily consumed other fish species (Bond 1940). Additional studies showed similar results (Alcorn 1943, Anderson 1987, Marshall and Giles 1953, Woodbury 1966). More recent analysis of fish tags recovered from the colonial waterbird nesting areas on Anaho Island Refuge indicates that American white pelican and double-crested cormorant predation on spawning cui-ui and hatchery-reared Lahontan cutthroat trout may be substantial in certain years (Mark Fabes, U.S. Geological Survey Western Fisheries Research Center–Reno Field Station, personal communication; Scopettone et al. 2006). Recovered fish tag data suggest that American white pelicans were the primary source of mortality among cui-ui tagged from 1989 to 1996, and it was presumed that most were taken during wetter years (1993–2000) when American white pelicans were more abundant (Scopettone et al. 2014). These conflicting results suggest a need to better understand the predator-prey relationship between pelicans and cui-ui, especially as factors like water supply, water quantity, and trout stocking practices continue to change.

### 3.3.2 Conservation Target 2— Colonial Nesting Waterbird Foraging Areas

Colonial nesting waterbird foraging areas encompass waterbodies and associated wetlands within approximately 160 kilometers (99 miles)

of Anaho Island (figure 3). Waterbodies and wetlands surrounding Anaho Island provide aquatic food resources like fish and invertebrates that are critical to the survival of waterbirds. Although all Anaho Island Refuge waterbirds use aquatic food resources to some degree, the extent of foraging areas included in the NRMP scope was influenced primarily by American white pelicans because (1) they depend primarily on aquatic food resources, (2) they will travel long distances to acquire food during the breeding season, and (3) data on foraging distances are available for American white pelican in the region (for example, Wiemeyer and Saake 2007; Scopettone et al. 2006, 2014). Waterbodies known to be important to Anaho Island Refuge waterbirds include:

- Nevada: Pyramid Lake, Truckee River and associated reservoirs, Carson River and associated reservoirs (Lahontan), Stillwater National Wildlife Refuge wetlands, Fallon National Wildlife Refuge wetlands, Carson Lake, private wetland areas in the Lahontan Valley, irrigation storage reservoirs, irrigation water delivery ditches and canals, private agriculture lands, Walker Lake, Walker River and associated reservoirs (Webber), lower Humboldt River and associated reservoirs (Rye Patch), and Humboldt Wildlife Management Area wetlands
- California: Truckee River, Carson River, Honey Lake, Eagle Lake, and Davis Lake

Waterbird foraging areas occur on private, tribal, State, and Federal lands and are managed for a variety of purposes including agriculture and waterfowl conservation (for example, Stillwater Refuge Complex). Waterbird use varies both spatially and temporally in response to factors such as water depth and food availability (for example, fisheries). Annual water supply to waterbodies in the NRMP scope originates primarily from mountain snow accumulation, most notably from the Sierra Nevada. Reduced water supply or increased human demand can lead to degradation or loss of waterbird foraging areas. Should a shallow wetland dry up in a year, fish and other aquatic organisms it supports are lost. If and when water supplies are renewed, there is often a lag time of 1 year or more for re-establishment of

fish and other aquatic organisms. Low water supply can lead to poor fish spawning conditions, reduced fish production, and reduced waterbird food availability. Aquatic food availability (for example, fish) within the NRMP scope is considered the primary driver of American white pelican reproductive success at Anaho Island Refuge (see “Chapter 4—Viability Assessment”).

Management of water within the NRMP scope is complex. Historical and continued changes in water use, ownership, and management are believed to have a strong influence on availability of waterbird aquatic food resources. Today, several State and Federal laws, decrees, plans, and agreements influence water supply and management within the NRMP scope to ensure water rights are served while preserving the rights of American Indian tribes and minimizing impacts on natural ecosystems and listed species. Additional details about water rights and management in the NRMP scope are provided in appendix B.

### 3.3.3 Conservation Target 3— Anaho Island Ecosystem

The Anaho Island ecosystem is a unique biological community of interacting organisms and their physical environment. Over time, the island’s natural resources have been greatly influenced by Pyramid Lake and humans. The importance of maintaining Anaho Island’s aquatic isolation from the mainland and preventing impacts from humans and nonnative animal species like coyotes has been recognized since the late 1800s and continues today (Chapman 1908; Evermann 1923; Hall 1924, 1925; Henshaw 1879; Marshall and Giles 1953; Thompson 1932).

#### Anaho Island Biota

The majority of biological data available for Anaho Island pertains to colonial nesting waterbirds. As noted above, the first account of waterbirds was provided by Robert Ridgway, who visited Pyramid Lake and Anaho Island in 1867–1868 as part of a geological exploration led by Clarence King (Ridgway 1877). Since then, others have added to the knowledge of the avifauna of the island but have made only

incidental mention of the other island biota. Beginning in 1950, annual monitoring of colonial waterbirds (primarily American white pelicans) was conducted by the refuge, but still little work was focused on documenting the other aspects of the island’s biodiversity. Woodbury (1966) conducted the first ecological study of Anaho Island biota between 1962 and 1965, resulting in a documented species list: 45 plants, 7 lichens, 2 mosses, 5 colonial nesting bird species, 43 other bird species, numerous invertebrates and arachnids (genus level), 5 lizard species, 4 snake species, and 1 rodent species. Woodbury noted bats foraging over the island at dusk but did not locate a roost on the island. Woodbury (1966) noted that his investigations did not provide a comprehensive inventory of the flora and fauna of Anaho Island Refuge because of the difficulty in accessing Anaho Island.

#### Reptiles

The presence of rattlesnakes on Anaho Island has long been recognized. Chapman (1908) remarked on the abundance of venomous snakes during his visit to the island in 1903. The Anaho Island Refuge population of Great Basin rattlesnakes (*Crotalus viridis lutosus*) is one of three extant island populations of western rattlesnake (*Crotalus viridis*) (Ashton 2000). Ashton (2000) determined the Great Basin rattlesnakes on Anaho Island Refuge are substantially smaller than those on the surrounding mainland and remarked that the future of this unique population depends on the continued isolation of Anaho Island. Gienger and Tracy (2008) confirmed the presence of eight lizard species and five snake species on Anaho Island. Keehn et al. (2013) analyzed available reptile specimens from Anaho Island Refuge and identified significant differences in the size and other physical attributes of some reptile species between Anaho Island Refuge and mainland populations.

#### Mammals

Peacock (2005) and Kuhn et al. (2007) confirmed the presence of one rodent species on Anaho Island, deer mice (*Peromyscus maniculatus*). Kuhn et al. (2007) determined that the density of this species was lower on the island than on the mainland but individuals had significantly longer bodies and shorter tails. In December 1965,

Woodbury observed tracks and feces of a coyote on the island.

### *Vegetation*

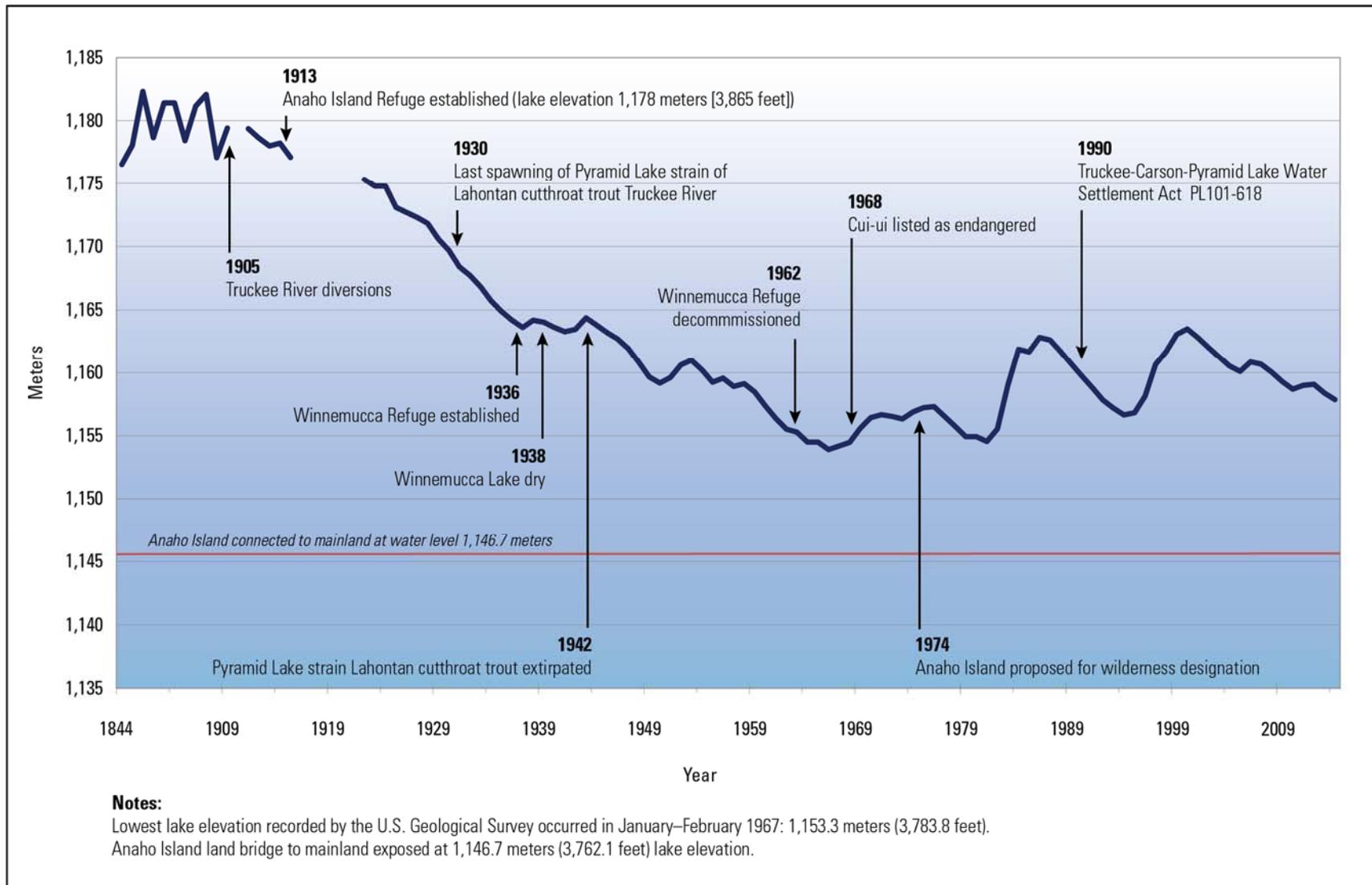
Recent (2009–2011) vegetation sampling at Anaho Island expanded the number of documented plant species from 45 (in 1966) to 68 (50 native species and 18 nonnative species) (Kulpa and Leger 2013, Phillips 2011). As with previous efforts, a comprehensive plant inventory was impeded by terrain, presence of nesting waterbird species, and weather conditions. Several nonnative plant species, especially nonnative annual grasses such as cheatgrass and red brome, are now widespread on the refuge and have the potential to harm native vegetation through competition for resources and increased fire risk (Kulpa and Leger 2013, Svejcar and Tausch 1991, Tausch et al. 1992, Woodbury 1966). If a wildfire were to occur, the current extent of nonnative annual grasses increases the likelihood of losing native vegetation species because such species are not fire-adapted (Svejcar and Tausch 1991). The only documented wildfire on Anaho Island occurred on May 15, 1950 (Marshall and Giles 1953).

## **Pyramid Lake**

Pyramid Lake is one of only two permanent lakes remaining of the once vast Lake Lahontan that covered most of northern Nevada during the Pleistocene (Russell 1885). A review of information provided in Adams et al. (2008) suggests that Anaho Island, with elevation of its highest peak at 1,334 meters (4,377 feet), was submerged by Lake Lahontan approximately 15,000 years ago when the lake had a maximum water surface elevation of approximately 1,340 meters (4,396 feet) above sea level. U.S. Geological Survey (USGS) has monitored Pyramid Lake water elevation since 1867 (U.S. Geological Survey n.d.). USGS records show a high of 1,182 meters (3,878 feet) in January 1862, a minimum of 1,153 meters (3,783 feet) in January and February 1967, and 1,158 meters (3,799 feet) in March 2014 (figure 5). In 1913, when Anaho Island was established as a national wildlife refuge, Pyramid Lake water elevation was 1,178 meters (3,864 feet).

The primary source of water for Pyramid Lake is the Truckee River, which originates from Lake Tahoe in the Sierra Nevada. Russell (1885) noted that by 1881, the Truckee River was largely used for irrigation by settlers in the Reno area and by the Pyramid Lake Paiute Tribe Reservation. In 1905, the Newlands Reclamation Project began diverting a significant portion of Truckee River water to the Lahontan Reservoir. These human-induced changes to hydrology have contributed to (1) the extirpation of the Pyramid Lake strain of Lahontan cutthroat trout, (2) Federal listing of the cui-ui, and (3) a 24-meter (79-foot) decline in the lake's water level (figure 5). The decline in Pyramid Lake water levels also prompted concern that a peninsula (land bridge) would be created between Anaho Island and the mainland, eliminating its status as an island and a predator-free breeding ground for nesting birds (Woodbury 1966). The Truckee-Carson-Pyramid Lake Water Rights Settlement Act of 1990 and its provisions provide the best available framework for minimizing further declines in Pyramid Lake water levels and related impacts on the Anaho Island ecosystem.

Additionally, to the east of Pyramid Lake, Winnemucca Lake was once an important breeding area for American white pelicans. The lake was established as a national wildlife refuge in 1936 but was decommissioned in 1938 because the lake went dry (figure 5).



**Figure 5. Pyramid Lake water surface elevations and related events, 1844–2014 (Harris 1970, U.S. Geological Survey 2013).**



# Chapter 4—Viability Assessment

The project team conducted a viability assessment of Anaho Island Refuge priority conservation targets to identify and describe (1) what “healthy” targets look like in terms of their KEAs, (2) the current status of targets, and (3) the expected future (15 years) state of targets as a result of refuge management. KEAs and related indicators were developed for each target as a means of assessing target health and status over time and set the foundation for developing SMART conservation goals (“Chapter 7—Action Plan”).

We used the best available information, including refuge data and reports, scientific literature, and expert opinion to inform the viability assessment. The status of Anaho Island Refuge conservation targets, in terms of KEAs and related indicators, were categorized as Poor, Fair, Good, or Very Good:

- Very Good: ecologically desirable status; requires little intervention for maintenance
- Good: indicator within acceptable range of variation; some intervention required for maintenance
- Fair: outside acceptable range of variation; requires human intervention
- Poor: restoration increasingly difficult; may result in extirpation of target

Sections 4.1–4.3 below contain the viability assessment for the six KEAs (and related indicators) of our three priority conservation targets. Additional information about KEA indicators and measures is presented in “Chapter 8—Inventory, Monitoring, and Research” and the companion Anaho Island Refuge IMP. The viability scale and indicators will be refined as new information becomes available.

## 4.1 Conservation Target 1—Colonial Nesting Waterbirds

### 4.1.1 Key Ecological Attribute 1.1—Colonial Nesting Waterbird Diversity

Colonial nesting waterbird diversity is indicated by annual species richness and abundance at Anaho Island Refuge. Refuge staff members currently monitor waterbird species richness and expect to incorporate waterbird abundance into a diversity index in the future. Current waterbird diversity is considered Good (5–7 species; table 6). The waterbird species richness viability scale was developed using refuge legacy data and staff knowledge. Five waterbird species were present at Anaho Island Refuge in 2013: American white pelican, double-crested cormorant, California gull, Caspian tern, and great blue heron. These five species consistently breed at Anaho Island. Black-crowned night heron and snowy egret have been documented on the refuge but are considered uncommon.

#### Additional Work Needed to Improve KEA Indicator and Viability Scale

A comprehensive analysis of refuge legacy waterbird data is needed and may result in refinements to the viability scale and target goals.

### 4.1.2 Key Ecological Attribute 1.2—Colonial Nesting Waterbird Reproductive Success

Colonial nesting waterbird reproductive success is indicated by annual fledging success of American white pelicans at Anaho Island. Although the refuge staff would like to assess

reproductive success of all Anaho Island Refuge waterbird species, it is infeasible at this time due to limited refuge resources. We decided to focus the viability assessment on American white pelicans because of their conservation importance, contribution to Intermountain West populations, and availability of refuge data.

Annual fledging success is defined as the number of pelican fledglings divided by the number of active nests in a given year. Fledglings are defined as juvenile pelicans present in subcolonies on the island prior to dispersal from the subcolony and prior to becoming flight-capable and leaving the island (which usually occurs between July and September). Active nests are defined as pelican nests that contain at least one pelican egg or fledgling or with at least one adult in direct attendance, either incubating or standing directly on a nest.

Refuge data from 1977 to 2013 show that average fledging success is 0.55 (range = 0.01–1.63) for American white pelican. We used this long-term average and the observed long-term variability in fledging success to develop the viability scale (figure 4, table 6). Current colonial nesting waterbird fledging success is considered Poor (fledging rate <0.1; figure 4, table 6). Since 1977, American white pelican fledging success has reached Poor status (fledging rate <0.1) during 3 years: 1991, 2010, and 2013 (figure 4). The refuge staff believes the decline in fledging success is primarily related to food availability in the NRMP scope.

### **Additional Work Needed to Improve KEA Indicator and Viability Scale**

Additional work is needed to refine the refuge waterbird database, analyze waterbird legacy data, and report on long-term status and trends of American white pelican reproductive success in relation to environmental variables such as water supply, precipitation, snowpack, and food availability. These results will be used to refine the viability scale and target goals.

## **4.2 Conservation Target 2—Colonial Nesting Waterbird Foraging Areas**

### **4.2.1 Key Ecological Attribute 2.1—Aquatic Food Availability**

Anaho Island’s colonial nesting waterbird species are dependent upon aquatic food resources (for example, fish and invertebrates) during the breeding season. This is especially true for American white pelicans, double-crested cormorants, and Caspian terns. Aquatic food resources are found in Pyramid Lake and surrounding waterbodies of the NRMP scope (figure 3). Due to the complexities and feasibility of measuring aquatic food availability, waterbody surface area (in hectares) will be used as an index of aquatic food availability. The status of waterbody surface area in the NRMP scope is unknown but estimated to be Fair based on the low level of American white pelican reproductive success in 2013 (table 6).

### **Additional Work Needed to Improve KEA Indicator and Viability Scale**

The aquatic food availability indicator and viability scale is based on two main assumptions: (1) waterbird reproductive success is positively correlated with aquatic food availability and (2) aquatic food availability is positively correlated to waterbody surface area in the NRMP scope. Work is needed to:

- develop feasible methods to estimate waterbody surface area (hectares) in the NRMP scope;
- assess past trends in waterbody surface area within the NRMP scope;
- test our assumption about the relationship between waterbody surface area and aquatic food production;
- test our assumption about the relationship between aquatic food availability and waterbird reproductive success.

Information from this work will be used to improve the aquatic food availability indicator and viability scale.

## 4.3 Conservation Target 3— Anaho Island Ecosystem

### 4.3.1 Key Ecological Attribute 3.1—Landcover Diversity

Landcover diversity at Anaho Island is indicated by the proportion of the island that is vegetated and its native plant composition (percent cover). The amount and composition of vegetation cover is assumed to have a strong influence on the biodiversity of Anaho Island. Recent vegetation surveys (2009–2011) suggest 20 percent of the island is vegetated and 50 percent of the vegetative cover comprises native species (Kulpa and Leger 2013). The status of landcover on Anaho Island Refuge is considered Fair (island is  $\leq 20$  percent vegetated and 25–50 percent of vegetation is composed of native plant species; table 6). The landcover diversity scale was based primarily upon a recent report on Anaho Island Refuge vegetation by Kulpa and Leger (2013) where they compared recent vegetation data with data collected in the 1960s (Woodbury 1966). Kulpa and Leger (2013) note that cover of invasive annuals is increasing on Anaho Island, especially in lower elevation areas. Both Woodbury (1966) and Tausch et al. (1992) have noted a decrease in native shrub cover and other native species on Anaho Island Refuge since the 1960s.

#### Additional Work Needed to Improve KEA Indicator and Viability Scale

Evaluation of legacy imagery to evaluate changes in vegetative cover at Anaho Island Refuge over time may help refine the landcover diversity scale.

### 4.3.2 Key Ecological Attribute 3.2—Biodiversity

Biodiversity or biological diversity is defined as the variety of life and its processes, including the variety of living organisms, the genetic differences among them, and communities and ecosystems in which they occur (Service Policy 601 FW 3). Anaho Island biodiversity encompasses several taxa, including

invertebrates, plants, birds, mammals, and reptiles. Refuge biodiversity will initially be indicated by bird species richness. Birds were chosen because:

- they are responsive to environmental changes (locally and at larger landscape scales);
- they can be feasibly measured;
- bird data are available from local and larger landscape scales, like from the Avian Knowledge Network;
- birds are commonly used to indicate changes in environmental health at larger landscape scales such as changes associated with climate change.

Species richness (the number of species in a given area) represents a single but important metric that is valuable as a common indicator of biodiversity. In the future, bird species richness will be integrated with other metrics to more fully capture refuge biodiversity (for example, abundance and richness of other taxa, genetic variability, distribution). The status of bird species richness at Anaho Island Refuge is currently unknown but is estimated as Good based on knowledge of refuge staff (table 6).

#### Additional Work Needed to Improve KEA Indicator and Viability Scale

The refuge staff intends to conduct biotic inventories at Anaho Island, beginning with birds, to establish a baseline for assessing biodiversity of the island ecosystem. An analysis of future inventories of other taxa will then be used to select an appropriate metric or metrics that best represents biodiversity at Anaho Island.

### 4.3.3 Key Ecological Attribute 3.3—Anaho Island Isolation

Continued aquatic isolation of Anaho Island is critical for preserving its biological diversity. The unique biological community of interacting organisms at Anaho Island has been shaped in large part by its aquatic isolation and associated lack of mammalian predators (for example, coyotes and badgers) and other novel nuisance species (for example, cattle, horses, and dogs). In addition, aquatic isolation reduces the

likelihood of unauthorized refuge access and impacts by humans. Island isolation is indicated by the surface elevation of Pyramid Lake. We assume the risk of negative impacts on island biodiversity increases as Pyramid Lake water elevation decreases. The water elevation at which a land bridge would form between Anaho Island and the mainland is estimated at 1,147 meters (Harris 1970). Pyramid Lake elevation was 1,158 meters in 2013 (U.S. Geological Survey 2013) and is considered Fair along the viability scale. At this elevation, the aquatic distance between Anaho Island and the mainland is approximately 853 meters (2,799 feet; Google Earth 2013). A study of urban coyotes along the east coast suggests a coyote crossed a 1-kilometer-wide (0.6-mile-wide) canal (Way 2002); however, to date there have been no documented crossings by terrestrial predators to Anaho Island.

## **Additional Work Needed for Improvement**

The relationship between Pyramid Lake surface elevation and water depth is not well understood. Work is needed to model the relationship of these factors and project trends in response to climate change. This information will be used to refine the viability scale and will help the refuge staff identify thresholds for management action (for example, very high risk of access by mammalian predators, other nuisance species, or humans).

**Table 6. Viability assessment of Anaho Island National Wildlife Refuge conservation targets.**

<i>Conservation target (○), Key Ecological Attribute (🔑) and Indicator (▲)</i>	<i>Current Status (2013)</i>	<i>Poor</i>	<i>Fair</i>	<i>Good</i>	<i>Very Good</i>	<i>Source</i>
○ 1. Colonial Nesting Waterbirds	Fair					
🔑 1.1 Colonial nesting waterbird diversity	Good					
▲ 1.1.1. Colonial nesting waterbird species richness and abundance	Good	1–2 species	3–4 species	5–7 species	>7 species	Refuge data; expert knowledge
🔑 1.2 Colonial nesting waterbird reproductive success	Poor					
▲ 1.2.1 American white pelican fledging success	Poor	<0.1 chicks fledged per nest	0.1–0.3 chicks fledged per nest	>0.3–0.5 chicks fledged per nest	>0.5 chicks fledged per nest	Refuge data; expert knowledge
○ 2. Colonial Nesting Waterbird Foraging Areas	Fair					
🔑 2.1 Aquatic food availability	Fair					
▲ 2.1.1. Surface hectares of waterbodies within NRMP scope	Fair		Waterbody surface hectares in 2013	Waterbody surface hectares when American white pelican nesting success was Good or Very Good	Estimation	by refuge staff members

Conservation target (○), Key Ecological Attribute (🔑) and Indicator (▲)	Current Status (2013)	Poor	Fair	Good	Very Good	Source
○ 3. Anaho Island Ecosystem	Fair					
🔑 3.1 Landcover diversity	Fair					
▲ 3.1.1 Vegetation cover and composition	Fair	Island is >20% vegetated and <25% of vegetation is composed of native plant species	Island is ≤20% vegetated and 25–50% of vegetation is composed of native plant species	Island is ≤20% vegetated and >50–75% of vegetation is composed of native plant species	Island is ≤20% vegetated and >75% of vegetation is composed of native plant species	Kulpa and Leger 2013
🔑 3.2 Biodiversity	Good					
▲ 3.2.1 Native bird species richness	Good	<60% of species persist <sup>1</sup>	60–75% of species persist	>75–80% of species persist	>80–100% species persist	Estimation by refuge staff members
🔑 3.3 Island isolation	Fair					
▲ 3.3.1 Pyramid Lake water surface elevation	Fair	<1,158 meters (<3,799 feet)	1,158– <1,166 meters (3,799– <3,825 feet)	>1,166– <1,173 meters (>3,825– <3,848 feet)	>1,173 meters (>3,848 feet)	U.S. Geological Survey 2013, Google Earth 2013

Note: The viability scale requires establishment of a baseline for comparison. Regarding native bird species richness (3.2.1), a bird inventory at Anaho Island Refuge is expected within the life of this plan and will be used, in combination with legacy data (for example, Woodbury 1966), to establish a baseline and refine this viability scale.

# Chapter 5—Threat Assessment

## 5.1 Threat Ranking

The core project team identified and prioritized direct threats and related stresses to conservation targets. Direct threats are human actions that affect, or have the potential to affect, one or more conservation targets (in terms of KEAs) over the next 15 years. Stresses are altered attributes of a target's ecology (KEA) that are impaired by one or more direct threats. For example, invasive species are introduced by human activities and can ultimately degrade native plant composition. Here, invasive species are the threat, and the stress is altered native plant composition. This threat assessment helps the refuge focus its limited resources on threats of greatest conservation concern.

We prioritized threats<sup>8</sup> using three criteria:

- the spatial scope of the target area (for ecosystems) or proportion of population affected by a threat (for species);
- the severity of the threat based on the level of damage it would cause to a target;
- the irreversibility of a threat or degree to which the effects of a threat could be undone if the threat were to cease.

When ranking threats, we considered scope, severity, and irreversibility over the next 15 years. In the case of climate change, we expanded the period to 50 years because the severity of this threat is expected to increase over the long term and may require actions in the near term to ameliorate future stress—a proactive approach.

We identified 19 current or potential threats to one or more Anaho Island Refuge conservation targets (Threats T01–T19, table 7). Threat ratings were estimated for individual

targets and across targets (summary rating). For additional information on how summary threat ratings were calculated, see appendix B of “Conceptualizing and Planning Conservation Projects and Programs” (Foundations of Success 2009). Greenhouse gas emissions (which lead to climate change) had a summary rating of High, while water use and invasive or nuisance animal species each had a summary rating of Medium. Although the summary rating for invasive or nuisance plant species was Low, it was a Medium threat for the island ecosystem. Invasive plant distribution and abundance on Anaho Island Refuge has expanded over the last several decades (Kulpa and Leger 2013) and this trend is likely to continue. Terrestrial pathogens and renewable energy both had a summary rating of Low but ranked Medium for colonial nesting waterbirds. Unlike invasive plants, the refuge does not expect these threats to increase significantly over the next 15 years.

As summarized in table 7, threat assessment results suggest the most critical threats to Anaho Island Refuge conservation targets are:

- climate change (Threat T01);
- water use and management (Threats T02–T04);
- invasive species (Threats T05 and T06).

Our results also suggest colonial nesting waterbirds and the island ecosystem are highly threatened. Below is a brief summary of the critical threats and stresses to Anaho Island Refuge conservation targets. Details about each threat and related stress to refuge conservation targets are presented in appendix C.

<sup>8</sup> Threats were ranked using a stress-based threat ranking approach. This is a two-step process that includes rating the scope and severity of each stress

on its target and then the contribution that each relevant direct threat makes to the stress and its irreversibility.

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## 5.2 Threat Summary by Conservation Target

### 5.2.1 Threats to Conservation Target 1—Colonial Nesting Waterbirds

Current and projected threats of greatest concern to Anaho Island Refuge waterbirds are (1) climate change, (2) water use and management, and (3) invasive animal species (table 7). Climate change and resulting declines in precipitation and snowpack are expected to exacerbate existing water supply and distribution threats in the NRMP scope, resulting in decreased aquatic food production (for example, fisheries). Aquatic food availability is considered the main driver of waterbird reproductive success. Although renewable energy posed a Medium threat to waterbirds, the refuge staff believes the scope and severity of this threat over the next 15 years is low. In addition, the refuge staff has no control over renewable energy development in the NRMP scope.

The potential for introduction of novel mammalian predators and nuisance species is a critical concern for Anaho Island Refuge waterbirds. Such introductions could negatively impact waterbird species richness, abundance, and reproductive success at Anaho Island. If Pyramid Lake water levels continue to fall, a land bridge will eventually form between the island and the eastern shoreline, resulting in invasive animal introductions. Such introductions would likely increase waterbird mortality rates across all species and life stages (that is, eggs, chicks, and adults) and result in reproductive failure or loss of waterbird species. For example, a subcolony of American white pelicans at Chase Lake abandoned 7,000 nests after being disturbed by coyotes in 2004 (Sovada et al. 2008). Subcolonies of California gulls at Mono Lake, California, experienced near-complete reproductive failure in 1989 when coyotes gained access to Negit Island and Pancake Islet after a significant drop in lake water levels (Dierks 1991).

### 5.2.2 Threats to Conservation Target 2—Colonial Nesting Waterbird Foraging Areas

Current and projected threats of greatest concern to waterbird foraging areas are (1) climate change and (2) water use and management (table 7). Declining water supply as a result of human use (agriculture, domestic, public) and climate change can negatively impact the abundance, distribution, and characteristics (for example, depth and food web) of wetlands and waterbodies in the NRMP scope. For the purposes of this NRMP, we assume surface hectares of waterbodies and wetlands in the NRMP scope are positively correlated with aquatic food availability (for colonial nesting waterbirds). Reduced aquatic food availability, in turn, can result in lowered waterbird reproductive success, especially among fish-dependent species (American white pelican, double-crested cormorant, and Caspian tern). Climate change and resulting declines in precipitation and snowpack are expected to exacerbate the threat of water supply and distribution in the NRMP scope.

### 5.2.3 Threats to Conservation Target 3—Anaho Island Ecosystem

Current and projected threats of greatest concern to the Anaho Island ecosystem are (1) climate change, (2) water use and management, and (3) invasive animal and plant species. Increasing demand for water within the NRMP scope, exacerbated by climate change, could further reduce Pyramid Lake water levels and increase the likelihood of invasive animal introductions. Such changes could significantly alter the Anaho Island ecosystem through increased mortality or loss of colonial nesting bird populations and other native animal and plant species. Invasive plants continue to be a moderate threat to the Anaho Island ecosystem, especially invasive annual grass species. Invasive annual grasses increase fire susceptibility and intensity, compete with native species, and can ultimately result in ecosystem shifts (for example, vegetation type conversions) (Brooks et al. 2004; Great Basin Bird Observatory 2010).

**Table 7. Direct threats to and threat ratings (High, Medium, and Low) for Anaho Island National Wildlife Refuge conservation targets.**

<i>Threat category</i>	<i>Direct threat</i>	<i>Conservation Target 1—Colonial nesting waterbirds</i>	<i>Conservation Target 2—Colonial nesting waterbird foraging areas</i>	<i>Conservation Target 3—Anaho Island ecosystem</i>	<i>Summary threat rating</i>
Climate change	T01—Greenhouse gas emissions	High	Medium	High	High
Water use and management	T02—Water use for conservation areas	Medium	Low	High	Medium
	T03—Water use for residential and commercial development	Medium	Low	Medium	Medium
	T04—Water use for agriculture	Medium	Medium	High	Medium
Invasive and other problematic species	T05—Invasive or nuisance animal species	Medium	Low	High	Medium
	T06—Invasive or nuisance plant species	Low	Low	Medium	Low
	T07—Pathogens: aquatic biota		Low		Low
	T08—Pathogens: terrestrial biota	Medium		Low	Low
Energy production and mining	T09—Renewable energy	Medium	Low		Low
Biological resource use	T10—Fishing and harvesting aquatic resources	Low		Low	Low
	T11—Gathering terrestrial plants	Low		Low	Low
	T12—Hunting and collecting terrestrial animals	Low		Low	Low
	T13—Biotic/abiotic monitoring and other conservation work	Low		Low	Low
	T14—Recreational activities	Low		Low	Low

<i>Threat category</i>	<i>Direct threat</i>	<i>Conservation Target 1—Colonial nesting waterbirds</i>	<i>Conservation Target 2—Colonial nesting waterbird foraging areas</i>	<i>Conservation Target 3—Anaho Island ecosystem</i>	<i>Summary threat rating</i>
Pollution	T15—Agricultural and forestry effluents	Low	Low	Low	Low
	T16—Industrial and military effluents	Low	Low	Low	Low
	T17—Household sewage and urban waste water	Low	Low		Low
Transportation and Service corridors	T18—Flight paths	Low		Low	Low
Fire and fire suppression	T19—Altered fire regime	Low		Low	Low
	Summary target ratings	High	Medium	High	High

Notes: Ratings are based on threat scope, severity, and irreversibility. Available refuge data, scientific literature, expert opinion, or refuge knowledge were used to inform threat ratings.

Threat categories are based on Salafsky et al. (2008).

A blank box indicates that the threat does not stress a target and is not expected to cause stress over the next 15 years.

# Chapter 6—Situation Analysis

A situation analysis involves an analysis and visualization of the key factors affecting Anaho Island Refuge conservation targets, including direct threats, indirect threats,<sup>9</sup> and opportunities.<sup>10</sup> The purpose of conducting a situation analysis is to come to collective agreement about the different forces influencing Anaho Island Refuge conservation targets within the NRMP scope. Often project team members believe they have a shared understanding of their project’s context, main threats, opportunities, and the relationships among factors and conservation targets. However, by working through a formal process to gather information about the site and using it to document underlying assumptions about the project’s context, project team members often find they have somewhat different perceptions of the same situation.

The project team discussed and identified relationships among refuge conservation targets, direct threats that impact the conservation targets, and the indirect threats that drive them (conceptual model; figure 6). We also identified human wellbeing targets that may be affected by the status of conservation targets; these were environmental observation and education, fishing income, and Paiute

culture. Although we identified 19 threats to Anaho Island Refuge conservation targets (“Chapter 5—Threat Assessment”), we focused our conceptual model on threats of greatest conservation concern: climate change, water use and management, and invasive animals and plants. The conceptual model illustrates how Anaho Island Refuge conservation targets are impacted by multiple factors, and thus their status is affected by the interaction and summation of cumulative impacts across priority threats within the NRMP scope.

The left-most portion of the model highlights indirect threats (orange boxes) that lead to direct threats (pink boxes); for example, lowered Pyramid Lake water levels, an indirect threat, ultimately leads to invasive animals, a direct threat. As you move closer to the targets (green ovals), the relationships among indirect threats, direct threats, and the conservation targets become more direct. The project team identified natural resource management strategies (yellow hexagons), which are the collection of actions aimed at reducing threats and ultimately conserving targets. Strategies and their associated actions are detailed in “Chapter 7—Action Plan.”

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<sup>9</sup> Also called a root cause or underlying cause, an indirect threat is a factor that drives a direct threat and is often an entry point for conservation actions.

<sup>10</sup> An opportunity is a factor that potentially has a positive effect on one or more targets—either directly or indirectly—and is often an entry point for conservation actions.



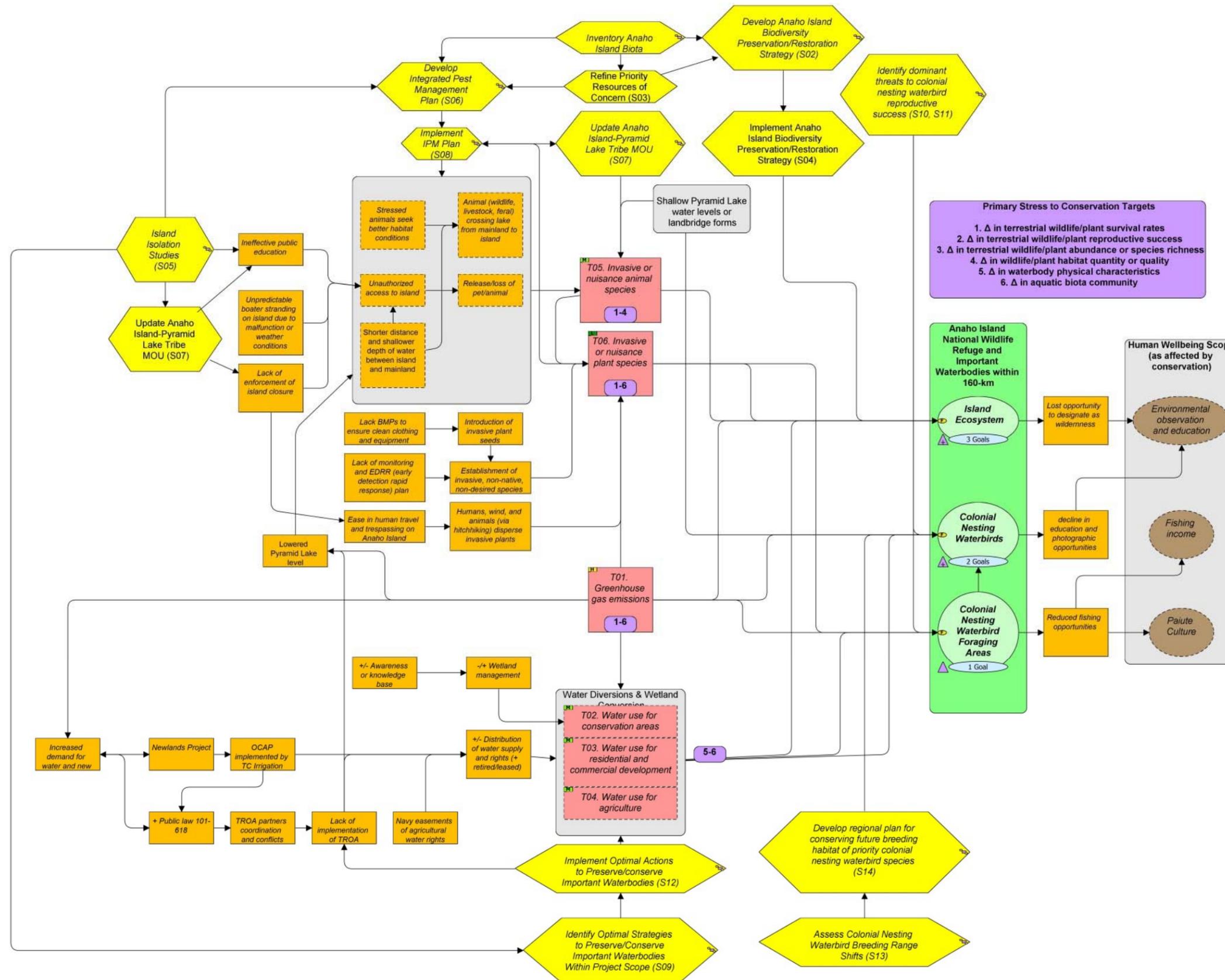


Figure 6. Anaho Island National Wildlife Refuge conceptual model (indirect threat = orange box; direct threat = pink box; conservation target = green oval; strategy = yellow hexagon; human wellbeing target = brown oval; stress = purple box).



# Chapter 7—Action Plan

The action plan provides the framework for achieving the refuge vision. The action plan integrates information from the previous steps of this NRMP to formulate specific goals, objectives, strategies, and monitoring needed to assess conservation progress. Lastly, the action plan indicates who will be doing what and when to develop or implement conservation strategies. Our action plan includes the following components:

- SMART goals for each of our conservation targets
- strategies to directly address conservation targets (for example, restoration) or to address threats or opportunities affecting targets
- activities we will need to undertake for each strategy to achieve the desired results
- theories of change (results chains) that lay out our assumptions about how each strategy we undertake will help us reduce threats or restore targets and ultimately achieve target goals
- SMART objectives for reducing threats or restoring targets (specifies interim results of implementing strategies)

## 7.1 Conservation Goals

A goal specifies the desired state of refuge conservation targets over the next 15 years. The goals are derived from the viability assessment:

<sup>11</sup> Fledging success is the total number chicks fledged divided by the total number of active nests within a single breeding season.

<sup>12</sup> In combination with the scientific literature and expert opinion, comprehensive analysis of legacy refuge data on the American white pelican population and reproductive trends will be used to refine this goal in the future.

<sup>13</sup> American white pelicans showed poor reproductive success in 2013, and this is assumed to be driven by lack of food sources such as fish and invertebrates in

they are written in terms of KEA indicators and take into account the current status of a target and the future status that can realistically be attained over the next 15 years. Refuge goals will be reviewed annually and refined as needed as new information becomes available.

### 7.1.1 Conservation Target 1—Colonial Nesting Waterbirds

**Goal 1.1.** Over the next 15 years, Anaho Island Refuge continues to support breeding populations of at least five colonial nesting waterbird species annually. Waterbird abundance will be incorporated into this goal in the future following development of methods to estimate waterbird abundance.

**Goal 1.2.** Over the next 15 years, annual American white pelican fledging success<sup>11</sup> at Anaho Island Refuge is  $\geq 0.3$  pelicans fledged per active nest.<sup>12</sup>

### 7.1.2 Conservation Target 2—Colonial Nesting Waterbird Foraging Areas

**Goal 2.1.** Over the next 30 years, waterbody surface area (hectares) within the NRMP scope is greater than 2013 levels (to be quantified; Strategy S05) to sustain Anaho Island Refuge colonial nesting waterbird populations.<sup>13</sup>

surrounding wetlands and waterbodies (figure 3). Furthermore, food availability is assumed to be positively correlated with waterbody surface area within the NRMP scope. Waterbodies include lakes, wetlands, and rivers. Goal 2.1 will be refined following analysis of American white pelican reproductive data, in combination with environmental data (for example, waterbody surface hectares), to determine the relationship among water supply, food availability, and American white pelican fledging success (see section 4.1).

## 7.1.3 Conservation Target 3— Anaho Island Ecosystem

**Goal 3.1.** Over the next 15 years, Anaho Island Refuge vegetation cover is maintained at  $\leq 20$  percent, and  $> 50$  percent of the vegetation is composed of native plant species.

**Goal 3.2.** Over the next 30 years,  $> 80$  percent of native bird and plant species documented on Anaho Island Refuge (since first records in the late 1800s) continue to persist.<sup>14</sup>

**Goal 3.3.** Over the next 30 years, the water surface elevation of Pyramid Lake is  $\geq 1,166$  meters in order to maintain island isolation and preserve island biodiversity.<sup>15</sup>

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## 7.2 Threat Reduction Objectives

Objectives define the changes needed in critical threats (or other factors) to ultimately achieve refuge goals. Another words, they help refuge staff members know if they are making progress toward securing their conservation target. Refuge objectives will be reviewed annually, and refined as needed, as new information becomes available.

### 7.2.1 Direct Threats—Water Use and Climate Change<sup>16</sup>

**Objective 01.** By fiscal year (FY) 2016, the Service identifies priority waterbody preservation and conservation actions within the Truckee River Basin and Carson River Basin

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<sup>14</sup> Refuge legacy data (for example, Woodbury 1966) and new biotic inventories will be used to refine the viability scale and Goal 3.2.

<sup>15</sup> Goal 3.3 will be refined following the development of a model relating Pyramid Lake water surface elevation, water depth, and aquatic distance between Anaho Island and the mainland. The refuge staff wants to maintain the aquatic distance between Anaho Island and the mainland above 956 meters (0.6 mile).

<sup>16</sup> Because stresses resulting from climate change are expected to exacerbate the threats of water use and

waterbird foraging areas. Priority actions are feasible<sup>17</sup> actions with a high likelihood of improving colonial nesting waterbird foraging areas. Objectives and indicators will be refined once specific preservation and conservation actions have been identified (Strategy S09).

**Objective 02.** By FY2016, the Service identifies priority waterbody preservation and conservation actions within the Humboldt River drainage basin. Priority actions are feasible actions with a high likelihood of improving colonial nesting waterbird foraging areas. Objectives and indicators will be refined once waterbody preservation and conservation actions have been identified (Strategy S09).

**Objective 03.** By FY2017, the Service identifies priority waterbody preservation and conservation actions within the Walker River drainage basin. Priority actions are feasible actions with a high likelihood of improving colonial nesting waterbird foraging areas. Objectives and indicators will be refined once waterbody preservation and conservation actions have been identified (Strategy S09).

**Objective 04.** By FY2018, the Service identifies priority waterbody preservation and conservation actions within the California portion of the Anaho Island NRMP scope. Priority actions are feasible actions with a high likelihood of improving colonial nesting waterbird foraging areas. Objectives and indicators will be refined once waterbody preservation and conservation actions have been identified (Strategy S09).

**Objective 05.** By 2018, Stillwater Refuge Complex staff are coordinating water use and management (on lands next to the complex) with at least two of the following partners: Fallon

invasive species, the objectives focused on these threats also address the climate change-related stresses. This plan includes specific actions that are expected to reduce the threats that are exacerbated by climate changes and to build resiliency of targets under anticipated climate changes.

<sup>17</sup> Feasible here and throughout the remaining objectives means economically and technically feasible under anticipated climate change stresses such as drought or increased average temperatures.

Paiute Shoshone Tribe, Canvasback Club, Naval Air Station Fallon, and the City of Fallon.

**Objective 06.** Over the next 50 years, Pyramid Lake is at or above a surface water elevation that prevents the formation of a land bridge between Anaho Island and the mainland or that prevents access by priority invasive animal species. Water elevation thresholds will be informed by Anaho Island isolation studies (Strategy S05). Priority invasive animal species and related thresholds for island access will be identified during development of the refuge’s integrated pest management plan (Strategy S06). This information will be used to refine this objective.

**Objective 07.** Over the next 30 years, waterbody surface area (hectares) within the NRMP scope is greater than 2013 levels in order to sustain Anaho Island Refuge colonial nesting waterbird populations. American white pelicans showed poor reproductive success in 2013, presumably related to a reduction in waterbody surface area and associated reductions in food availability (for example, fisheries). Waterbodies include lakes, wetlands, and rivers. Information gained from analysis of waterbird legacy data may lead to refinements of this objective (Strategy S10).

## 7.2.2 Direct Threats—Invasive Species and Climate Change

**Objective 08.** By FY2018, the Service identifies priority invasive animal and plant threats to Anaho Island biodiversity and develops optimal strategies to prevent, eradicate, or mitigate their impacts. Priority invasive species are species that pose the greatest threat to Anaho Island Refuge natural resources and will be identified in the refuge’s integrated pest management plan (Strategy S06). Prioritization of invasive threats will take into account potential exacerbation by drought and other aspects of climate change.

**Objective 09.** By FY2018, spatially referenced data on the distribution and abundance of priority invasive or nuisance plant species on Anaho Island Refuge are collected, summarized, and shared with the Pyramid Lake Paiute Tribe. Priority invasive and nuisance species are

species that pose the greatest threat to Anaho Island biodiversity and are identified in the refuge’s integrated pest management plan (Strategy S06).

**Objective 10.** Over the next 15 years, the Pyramid Lake Paiute Tribe continues to monitor human activity within the Anaho Island buffer zone. The buffer zone was established by the Pyramid Lake Paiute Tribe and encompasses waters within 305 meters (1,000 feet) of the shoreline of Anaho Island (Strategy S07).

**Objective 11.** Over the next 15 years, new priority invasive plant species are not on Anaho Island Refuge. “Established” here means that a species that grows and reproduces on Anaho Island. A baseline invasive plant inventory is needed to provide a baseline for future comparison. Priority invasive and nuisance species are species that pose the greatest threat to Anaho Island biodiversity and are identified in the refuge’s integrated pest management plan (Strategy S06).

**Objective 12.** Over the next 15 years, the abundance of priority invasive plants on Anaho Island Refuge does not increase above 2009–2010 levels (abundance categories; Kulpa and Leger 2013). Priority invasive and nuisance species are species that pose the greatest threat to Anaho Island biodiversity and are identified in the refuge’s integrated pest management plan (Strategy S06). Inventory of priority invasive plant species will inform refinement of this objective (for example, to create species-specific objectives).

**Objective 13.** Over the next 15 years, priority invasive animal species are not established on Anaho Island Refuge. Anaho Island legacy data, biotic inventories (Strategy S01), and the integrated pest management plan (Strategy S06) will inform refinement of this objective (for example, to create species-specific objectives). “Established” here means that the species persists on Anaho Island Refuge for >1 year, even if only seasonally. Current priorities include medium-sized mammals such as coyotes that are known to disturb, kill, or otherwise impact colonial nesting waterbirds.

## 7.2.3 Direct Threats—Water Use, Invasive Species, and Climate Change

**Objective 14.** By FY2020, priority natural resource preservation and restoration needs at Anaho Island Refuge have been identified and documented (Strategy S02). Priority preservation and restoration needs will be informed by biotic inventories (Strategy S01), evaluation of legacy data, larger landscape conservation priorities, and anticipated stresses resulting from climate change.

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## 7.3 Management Strategies to Achieve Goals and Objectives

### 7.3.1 Strategy Summary

Strategies are a group of actions with a common focus that work together to reduce threats, capitalize on opportunities, or restore natural systems. Strategies are designed to achieve Anaho Island Refuge goals and objectives. The project team used the conceptual model (situation analysis) to identify opportunities where refuge staff members could intervene (for

example, to reduce a threat or restore a target) and then brainstormed management strategies. We identified 14 potential strategies (S01–S14; table 8). Because it may not be technically or financially feasible to implement all 14 strategies, we prioritized the strategies using the following criteria:

- **Potential impact:** if implemented, will the strategy lead to desired changes in the situation at the project site? (Very High=4, High=3, Medium=2, Low=1)
- **Feasibility:** would the refuge be able to implement the strategy within the likely constraints including time, financial, staffing, ethical, and others? (Very High=4, High=3, Medium=2, Low=1)

We averaged the impact and feasibility scores to generate an overall strategy score (table 8). A higher score reflects a higher priority strategy. As expected, implementation strategies ranked higher than development strategies; for example, integrated pest management plan implementation ranked higher than integrated pest management plan development. Due to limited refuge resources, we decided not to focus on S13 and S14, the two lowest rated strategies. The refuge staff will continue to consider these strategies as additional resources or as partners become available and intends to focus its management resources on the remaining 12 strategies over the next 15 years.

**Table 8. Anaho Island National Wildlife Refuge Natural Resource Management Plan conservation strategies and associated impact and feasibility scores.**

<i>Strategy number</i>	<i>Strategy name</i>	<i>Impact</i>	<i>Feasibility</i>	<i>Summary rating</i>
S04	Implement Anaho Island Refuge biodiversity preservation and restoration strategy	4	3	3.5
S06	Develop Anaho Island Refuge integrated pest management plan	4	3	3.5
S07	Update Anaho Island Refuge–Pyramid Lake Paiute Tribe memorandum of understanding	3	4	3.5
S08	Implement Anaho Island Refuge integrated pest management plan	4	3	3.5
S12	Implement optimal actions to preserve and conserve waterbodies important to waterbirds within the NRMP scope	4	3	3.5
S01	Inventory Anaho Island biota	3	3	3
S03	Refine Anaho Island Refuge priority resources of concern (conservation targets)	3	3	3
S05	Conduct Anaho Island Refuge isolation studies	3	3	3
S09	Identify optimal strategies to preserve and conserve waterbodies important to waterbirds in the NRMP scope	3	3	3
S11 <sup>1</sup>	Identify threats to water quantity and quality of key waterbird foraging areas throughout the NRMP scope	3	3	3
S02	Develop Anaho Island Refuge biodiversity preservation and restoration strategy	3	2	2.5
S10	Identify dominant threats to colonial nesting waterbird reproductive success	3	2	2.5
S13	Assess colonial nesting waterbird breeding range shifts (research)	2	3	2.5
S14	Develop regional plan for conserving future breeding habitat of priority colonial nesting waterbird species	2	3	2.5

Notes: Strategy S11 was combined with Strategy S10 and is no longer considered a stand-alone strategy.  
 Potential impact: if implemented, will the strategy lead to desired changes in the situation at the project site? (Very High=4, High=3, Medium=2, Low=1).  
 Feasibility: would the refuge be able to implement the strategy within likely constraints including time, financial, staffing, ethical, and others? (Very High=4, High=3, Medium=2, Low=1).

## 7.3.2 Strategies and Related Objectives

### Strategy S01—Inventory Anaho Island Biota

#### *Description*

Conduct biotic inventories to document species occurring at Anaho Island Refuge (table 9). Taxa include birds, plants, mammals,

amphibians, reptiles, and invertebrates. Information from this strategy will be used to develop biodiversity measures, assess trends in biodiversity, and inform future conservation strategies (Strategy S02).

#### *Priority Threats Addressed*

Invasive species, water use and management, and climate change

*Assumptions Linking This Strategy to Conservation Targets (figure 7)*

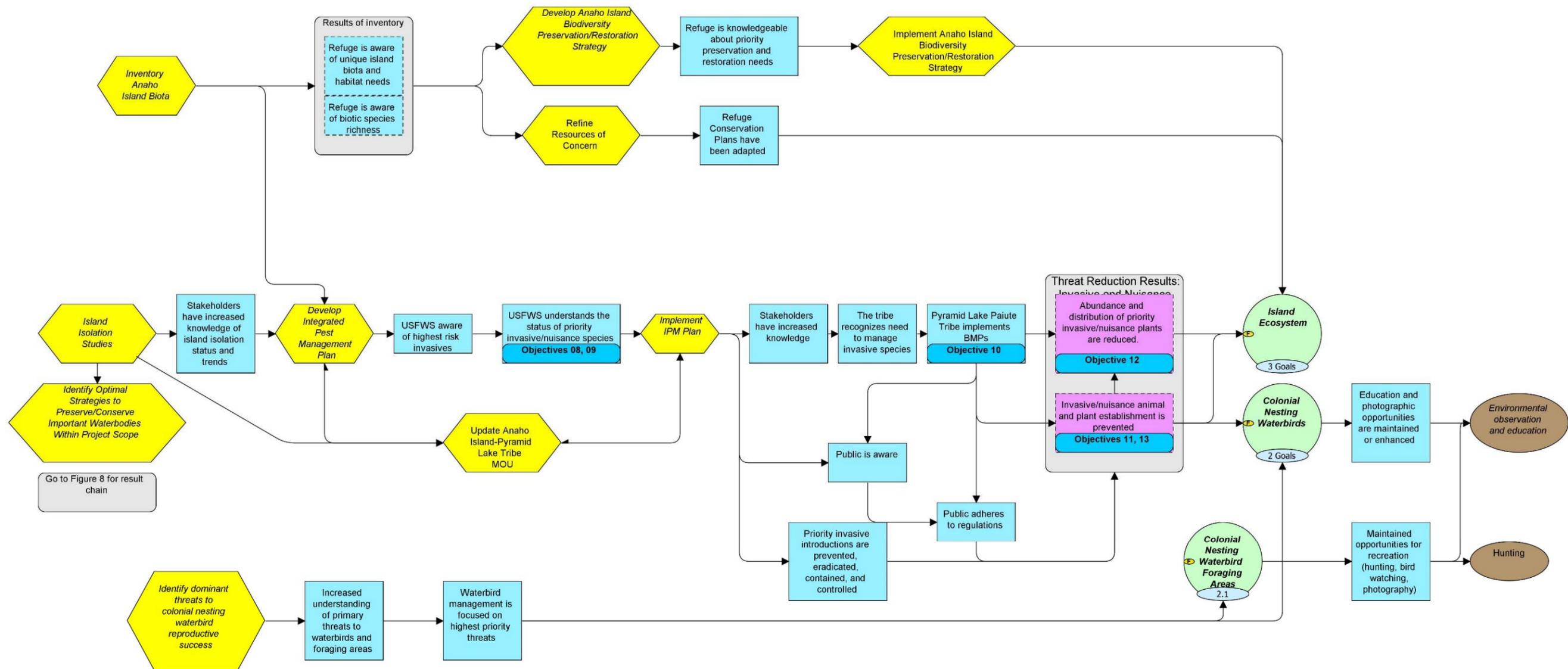
Currently the refuge has limited species occurrence information, especially for birds (other than waterbirds) and invertebrates. Biotic inventories will increase the refuge staff's understanding of current species richness, reveal trends in species richness when compared

with legacy data, support development of refuge management strategies including biodiversity preservation and restoration and pest management, and provide a baseline for evaluating biotic response to management actions and anticipated chronic threats like climate change. The collection and utilization of biotic inventory data will ultimately contribute to long-term conservation of refuge targets.

**Table 9. Conservation targets, objectives, and activities associated with inventory of Anaho Island biota (Strategy S01).**

Strategy S01—Inventory Anaho Island biota			
Conservation targets: Anaho Island ecosystem and colonial nesting waterbirds			
Objective(s): no objectives directly linked to this strategy; biotic inventories will inform Strategies S02, S03, and S06.			
<i>Activity</i>	<i>Start date</i>	<i>Activity lead</i>	<i>Comments</i>
S01.1—Prioritize taxa for inventory	2015	Refuge wildlife biologist	Evaluate conservation status of species documented on Anaho Island Refuge. Evaluate conservation status of species known to occur on lands surrounding Pyramid Lake and which have the potential to occur on Anaho Island Refuge (for example, Carson wandering skipper butterfly).
S01.2—Summarize existing documentation of Anaho Island Refuge species occurrences; compile list of potential species	2015	Refuge wildlife biologist	Currently underway as part of NRMP process.
S01.3—Develop species observation database and populate with legacy data	2015	Refuge wildlife biologist	Currently underway as part of NRMP process.
S01.4—Identify funding sources and partners to support inventories	2015	Refuge wildlife biologist	Explore internal (Service) and external funding sources and partners.
S01.5—Develop inventory designs for priority taxa	2015	Refuge wildlife biologist	Work with Region 8 Inventory and Monitoring and others to develop inventory designs.
S01.6—Conduct biotic inventories	2016	Refuge wildlife biologist	Inventory invertebrates, birds, mammals, and reptiles.
S01.7—Update and maintain species observation database	2016	Refuge wildlife biologist	Update database with inventory information. Maintain and update the database over the life of the NRMP.
S01.8—Describe species–habitat relationships and conservation importance	2017	Refuge wildlife biologist	Compile information for new species observations across all taxa. Incorporate habitat and conservation status information into species observation database.
S01.9—Perform genetic testing of potentially unique species	2018	Refuge wildlife biologist	Island isolation impacts on genetic/morphological changes from mainland species. Identify unique species or subspecies.

Note: Start dates are based on Federal Government funding year, which is October–September.



**Figure 7. Assumptions linking Strategies S01–S11 to Anaho Island National Wildlife Refuge conservation targets (strategy = yellow hexagon; strategy result = blue square; altered threat = purple square; conservation target = green oval; human wellbeing target = brown oval).**



## Strategies S02 and S04—Develop (S02) and Implement (S04) Anaho Island National Wildlife Refuge Biodiversity Preservation and Restoration Strategy

### Description

Develop and carry out activities (table 10) that will maintain, enhance, or restore native biodiversity of Anaho Island Refuge. Examples include preserving native plant species by creating a seed bank, maintaining breeding stock of animals and invertebrates, and restoring native plant species and communities. Anaho Island biotic inventories (Strategy S01) will inform these strategies.

### Priority Threats Addressed

Invasive species, water use and management, and climate change

### Assumptions Linking This Strategy to Conservation Targets (figure 7)

Invasive species, reduced Pyramid Lake water levels, and climate change have the potential to alter the biodiversity of Anaho Island. For example, impacts could include plant community shifts or species extinctions (both directly, as with mortality from extreme events, and indirectly, as with exacerbation of existing threats). Evaluation of trends in species richness (Strategy S01) and species–habitat requirements will help the refuge staff identify optimal and feasible actions to maintain Anaho Island biodiversity over time. Implementation and monitoring of high priority preservation and restoration actions will increase the likelihood of maintaining island biodiversity in light of climate change and other threats.

**Table 10. Conservation targets, objectives, and activities associated with development and implementation of an Anaho Island National Wildlife Refuge biodiversity preservation and restoration strategy (Strategies S02 and S04).**

Strategy S02—Develop Anaho Island Refuge biodiversity preservation and restoration strategy			
Strategy S04—Implement Anaho Island Refuge biodiversity preservation and restoration strategy			
Conservation targets: Anaho Island ecosystem			
Objective(s): Objective 14			
<i>Activity</i>	<i>Start date</i>	<i>Activity lead</i>	<i>Comments</i>
S02.1—Continue existing plant restoration studies and trials underway by FY2014	2015	Refuge wildlife biologist	Continue ongoing study by University of Nevada at Reno: greenhouse trials followed by planting out natives that survive in greenhouse. Lead is Dr. Elizabeth Leger.
S02.2—Evaluate past and potential future trends in biodiversity	2015–2016	Refuge wildlife biologist	Review internal and external Anaho Island legacy data for species documentation. Compare species richness and abundance trends with recent (2014–2015) inventory data. Evaluate trends in relation to local and larger landscape environmental factors including precipitation and invasive species. Assess projected climate change impacts on species richness and abundance. Produce a written summary of past and potential future trends in biodiversity (for example, species richness).
S02.3—Develop alternative strategies for preserving and enhancing island biodiversity	2017	Refuge wildlife biologist	Review scientific literature and consult with experts.

<i>Activity</i>	<i>Start date</i>	<i>Activity lead</i>	<i>Comments</i>
S02.4—Identify optimal set of high impact and feasible restoration and enhancement management strategies	2017	Refuge wildlife biologist	Incorporate highest ranked management actions into an Anaho Island Refuge long-term preservation and restoration plan.
S02.5—Prepare Anaho Island Refuge preservation and restoration plan; update NRMP result chains and objectives; update IMP as needed	2018	Refuge wildlife biologist	Plan presents optimal actions refuge staff members can take to preserve and restore island biodiversity. The plan will identify status and trends in biodiversity, priority preservation and restoration alternatives, a timeline for implementation, potential partners, and funding and staffing requirements.
S04.1—Conduct preservation and restoration activities	2019	Refuge wildlife biologist	To be determined.
S04.2—Monitor preservation and restoration success	2020	Refuge wildlife biologist	To be determined.
S04.3—Report on progress and adapt as needed	2020	Refuge wildlife biologist	To be determined.

Note: Start dates are based on Federal Government funding year, which is October–September.

### **Strategy S03—Refine Anaho Island Priority Resources of Concern (Conservation Targets)**

#### *Description*

Use results from biotic inventories (Strategy S01) to re-assess Anaho Island Refuge conservation targets and associated KEAs, the viability assessment, and goals (table 11).

#### *Priority Threats Addressed*

Invasive species, water use and management, and climate change

#### *Assumptions Linking This Strategy to Conservation Targets (figure 7)*

The identification of conservation targets was a foundational step in developing this NRMP. Integral to this process was evaluating documented species occurrences on Anaho Island Refuge. With new biotic inventories (Strategy S01), the refuge staff will have a better understanding of current biodiversity on the refuge. This new understanding will be used to re-evaluate conservation targets and may result in refinement of refuge conservation plans including the CCP, NRMP, IMP, and the biodiversity preservation and restoration plan.

**Table 11. Conservation targets, objectives, and activities associated with refinement of Anaho Island National Wildlife Refuge priority resources of concern (conservation targets) (Strategy S03).**

Strategy S03—Refine Anaho Island Refuge priority resources of concern (conservation targets)			
Conservation targets: Anaho Island ecosystem			
Objective(s): no objectives directly linked to this strategy. This strategy will inform refinement of refuge conservation plans and ultimately conservation of the Anaho Island ecosystem.			
<i>Activity</i>	<i>Start date<sup>1</sup></i>	<i>Activity lead</i>	<i>Comments</i>
S03.1—Re-evaluate conservation targets and determine need for refinement with new information from biotic inventories	2016	Refuge wildlife biologist	Add species to conservation target identification process and determine if targets or nested targets change. If yes, consider revising targets and associated goals.
S03.2—Update NRMP, IMP, and associated database(s)	2017	Refuge wildlife biologist	Update conservation targets and other databases, such as the Miradi conservation tracking database, as needed.

Note: Start dates are based on Federal Government funding year, which is October–September.

## Strategy S05—Conduct Anaho Island Isolation Studies

### *Description*

Work with USGS, the Pyramid Lake Paiute Tribe, or other partners to:

- model the relationship between Pyramid Lake water levels and bathymetry;
- evaluate past and future water-level trends in Pyramid Lake associated with climate change, water use, and other factors;
- determine the primary threats to Pyramid Lake water levels, including climate change, economic development, and other factors;
- identify Pyramid Lake water level thresholds for mammalian access to Anaho Island;
- identify points where mammalian crossings are likely to occur (table 12).

### *Priority Threats Addressed*

Water use and management, climate change, and invasive species

### *Assumptions Linking This Strategy to Conservation Targets (figures 7 and 8)*

Water supply to Pyramid Lake is critical to preventing formation of a land bridge and preserving Anaho Island biodiversity. If Pyramid Lake water levels continue to decline, the risk of introduction of novel predators and nuisance species increases—examples include coyotes, horses, and cows. These introductions will result in significant changes to colonial nesting waterbird populations and the island ecosystem. Increased understanding of the status and trend of Pyramid Lake water levels and the relationship to critical threats like invasive species will provide the refuge and its partners with a basis for taking action and improving water supply to Pyramid Lake. Information generated by this strategy will be used by refuge staff members to prevent or control new invasive introductions (Strategy S06), to improve water conservation and management in the NRMP scope (Strategy S09), and ultimately contribute to conservation of colonial nesting waterbirds and the Anaho Island ecosystem.

**Table 12. Conservation targets, objectives, and activities associated with Anaho Island isolation studies (Strategy S05).**

Strategy S05: Conduct Anaho Island isolation studies			
Conservation targets: colonial nesting waterbirds and Anaho Island ecosystem			
Objective(s): no objectives directly linked to this strategy. Information generated from this strategy will be used to inform the development of an integrated pest management plan (Strategy S06) and a water conservation plan (Strategy S09).			
<i>Activity</i>	<i>Start date<sup>1</sup></i>	<i>Activity lead</i>	<i>Comments</i>
S05.1—Evaluate past bathymetric data	2015	Refuge wildlife biologist, Region 8 GIS specialist	Obtain legacy bathymetric data. Compare 1970s data to 2008 bathymetry data and evaluate the extent to which bathymetry changes through time. This will inform whether new bathymetry is needed.
S05.2—Identify partners to lead bathymetric studies	2015	Refuge wildlife biologist	Identify partners for studies to (1) model the relationship between bathymetry, water surface elevation, and water depth; (2) assess trends in water levels and project future trends (for example, climate change); and (3) identify water level thresholds for invasive or nuisance animal access to Anaho Island. Potential partners include USGS and academic institutions.
S05.3—Collect new Pyramid Lake bathymetry	2015	Refuge wildlife biologist	If needed (see Activity S05.1).
S05.4—Develop hydrologic model; develop water elevation conversion factor	2015	Refuge wildlife biologist	Model the relationship among bathymetry, water surface elevation, water depth. Assess trends in water levels and project future trends (for example, climate change). Develop a conversion factor that will translate Pyramid Lake water levels (from USGS) to water depth surrounding Anaho Island and distance to the lake perimeter. Use conversion factor to monitor risk of invasive animal and plant introductions.
S05.5—Identify Pyramid Lake water level thresholds	2016	Refuge wildlife biologist	Using the bathymetric model, identify water levels and timeframe (climate projections) when a land bridge would form or would permit access to Anaho Island by terrestrial predators (such as coyotes) and other invasive animals (such as cows).
S05.6—Identify optimal water management regime	2016	Refuge wildlife biologist	Identify Truckee River flows needed to sustain Pyramid Lake water levels given current and projected threats including and climate change and human uses such as agriculture and development.
S05.7—Develop an island isolation monitoring protocol	2016	Refuge wildlife biologist	Develop a protocol for acquiring and utilizing Pyramid Lake water elevations (from USGS) to evaluate risk of predators and nuisance species introductions to Anaho Island. Develop an early detection monitoring system.

<i>Activity</i>	<i>Start date<sup>1</sup></i>	<i>Activity lead</i>	<i>Comments</i>
S05.8—Update NRMP, IMP, and integrated pest management plan with information generated by this strategy; feed information into development of other strategies (see NRMP result chains)	2016	Refuge wildlife biologist	Update NRMP viability scale. Update IMP with island isolation monitoring protocol. Use information generated by this strategy to inform the refuge integrated pest management plan (Strategy S06) and water conservation plan.
S05.9—Distribute results to stakeholders	2017	Refuge wildlife biologist	Share information with agencies and organizations that influence water supply and rights in the NRMP scope (Strategy S09) (for example, the Nevada Department of Wildlife and the Pyramid Lake Paiute Tribe).

Note: Start dates are based on Federal Government funding year, which is October–September.



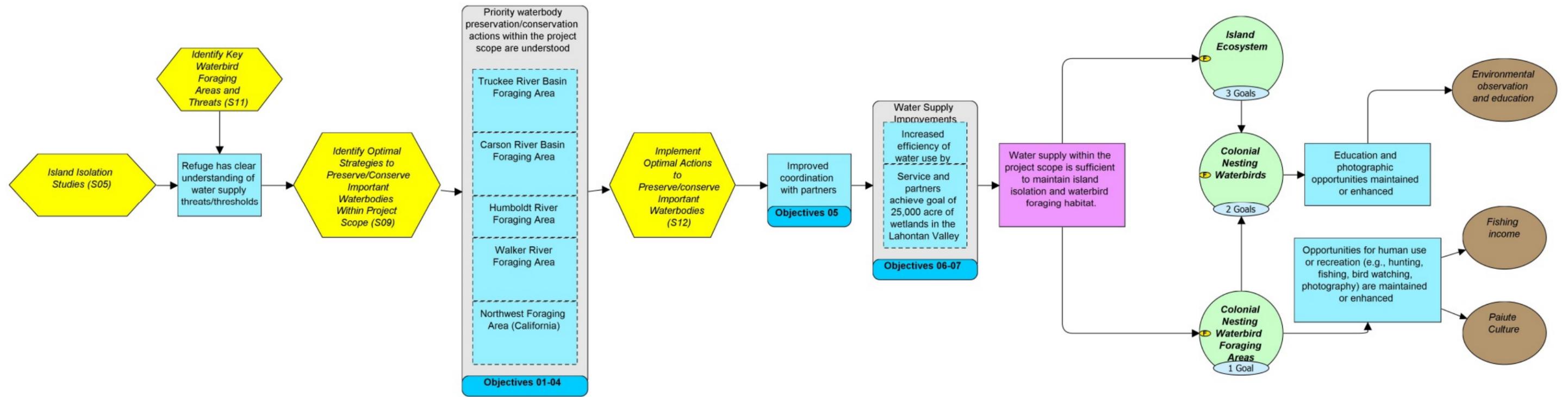


Figure 8. Assumptions linking Strategies S05, S09, S10, S11, and S12 to Anaho Island National Wildlife Refuge conservation targets (strategy = yellow hexagon; strategy result = blue square; altered threat = purple square; conservation target = green oval; human wellbeing target = brown oval).



## Strategies S06 and S08—Develop (S06) and Implement (S08) an Anaho Island Integrated Pest Management Plan

### Description

Develop an integrated pest management plan in cooperation with the Pyramid Lake Paiute Tribe and local weed management districts (table 13). The plan will identify actions needed to prevent, control, or eradicate invasive plants, animals, and pathogens.

### Priority Threats Addressed

Invasive species, water use and management, and climate change

### Assumptions Linking This Strategy to Conservation Targets (figure 7)

Invasive species pose a critical threat to Anaho Island biota. Introduction of invasive animals or nuisance animals like coyotes or dogs could significantly alter wildlife reproductive success

and survival. Introduction of new invasive plants or expansion of existing invasive plant populations are expected to negatively impact refuge biota. Although there is little evidence, we assume invasive plants are already negatively impacting native biota, especially native plants. Currently the refuge does not have an integrated pest management plan, and the staff does not clearly understand which invasive species should be a focus of management nor what actions should be taken to control invasive species. Development and implementation of an integrated pest management plan will lead to a better understanding of priority invasive threats, clarify the status of threats (via an inventory or other means), and provide a framework for adaptive management of invasive species. Successful implementation of the integrated pest management plan is expected to prevent new invasions and successfully reduce existing invasive populations. Prevention and reduction of invasive threats will reduce current stress on native plant and animal habitats, prevent future stress, and ultimately contribute to conservation of Anaho Island biota.

**Table 13. Conservation targets, objectives, and activities associated with developing and implementing an Anaho Island National Wildlife Refuge integrated pest management plan (Strategies S06 and S08).**

Strategy S06—Develop Anaho Island Refuge integrated pest management plan			
Strategy S08—Implement Anaho Island Refuge integrated pest management plan			
Conservation targets: colonial nesting waterbirds and Anaho Island ecosystem			
Objective(s): Objectives 08–13			
<i>Activity</i>	<i>Start date</i>	<i>Activity lead</i>	<i>Comments</i>
S06.1—Identify and prioritize current and potential future invasive threats	2015	Refuge wildlife biologist	Work with regional invasive species coordinator to prioritize invasive species threats. Prioritization includes all taxa but with an initial focus on mammals and plants. Process involves evaluating invasive threats on lands surrounding Pyramid Lake and reviewing current literature on invasive species with a focus on ecology, impacts on wildlands, reproductive capacity, climate change, and other selected topics. Produce a prioritized list of invasive threats with documentation and rationale.

<i>Activity</i>	<i>Start date</i>	<i>Activity lead</i>	<i>Comments</i>
S06.2—Assess status of priority nuisance and invasive threats	2016	Refuge wildlife biologist	Map the distribution and abundance of current priority invasive and nuisance threats on Anaho Island Refuge. Review status information on lands surrounding Pyramid Lake. Produce a spatial database showing distribution and abundance of priority invasive species on Anaho Island Refuge and surrounding lands (perimeter of Pyramid Lake if external information is available).
S06.3—Evaluate relationships between distribution of invasive and nuisance species and Anaho Island Refuge natural resources	2016	Refuge wildlife biologist	Overlay invasive distributions with priority natural resources, abiotic resources such as bare ground, and infrastructure to evaluate patterns of spread and risk to conservation targets.
S06.4—Identify and document optimal invasive threat-reduction strategies and associated ecological risks	2016	Complex invasive species coordinator	Identify optimal strategies to prevent, contain, reduce, or eradicate high priority invasive species: review literature, consult with experts, and assess potential negative impacts on biotic and abiotic resources. Strategies for threat-reduction may include prevention, chemical or mechanical treatments, and outreach and education.
S06.5—Develop SMART invasive and nuisance threat-reduction objectives and associated indicators	2016	Complex invasive species coordinator	Develop species-specific, SMART objectives (that is, objectives that are specific, measurable, achievable, relevant, and time-bound).
S06.6—Prepare integrated pest management plan	2016	Complex invasive species coordinator	Address the following elements in the plan: priority species, status, optimal strategies, risks, climate change, objectives, monitoring, data management, reporting, timeline, and budget. The plan will be updated when data from bathymetric studies become available.
S06.7—Update NRMP strategies, objectives, and monitoring; update IMP	2017	Refuge wildlife biologist	Update information in Miradi or other database used to track refuge conservation progress.
S08.1—Implement integrated pest management plan	2018	Refuge wildlife biologist, fire management officer	Conduct early detection and rapid response of priority invasive and nuisance species, eradicate or control priority invasive and nuisance species, and implement prevention strategies.
S08.2—Monitor and track progress, manage data, report on results, and adapt integrated pest management plan as needed	2018	Refuge wildlife biologist, fire management officer	To be determined.

Note: Start dates are based on Federal Government funding year, which is October–September.

## Strategy S07—Update Anaho Island–Pyramid Lake Paiute Tribe Memorandum of Understanding (S07)

### Description

Update the Anaho Island Refuge–Pyramid Lake Paiute Tribe memorandum of understanding, which guides how the Service and the Pyramid Lake Paiute Tribe work together to manage natural resources on Anaho Island Refuge.

### Priority Threats Addressed

Invasive species, water use and management, and climate change

### Assumptions Linking This Strategy to Conservation Targets (figure 7)

Information generated by Strategies S01, S02, S05, S06, S09, and S10 can inform updates to the Anaho Island Refuge–Pyramid Lake Paiute Tribe memorandum of understanding (table 14). If activities in the memorandum of understanding are fully implemented by the refuge staff and the tribe, the likelihood of reducing threats will increase and contribute to the conservation of Anaho Island biota. For example, to prevent the introduction of invasive species, the integrated pest management plan (Strategy S06) may identify specific tribal actions such as preventing unauthorized human access to the refuge.

**Table 14. Conservation targets, objectives, and activities associated with updating the Anaho Island National Wildlife Refuge–Pyramid Lake Paiute Tribe memorandum of understanding (Strategy S07).**

Strategy S07—Update Anaho Island Refuge–Pyramid Lake Paiute Tribe memorandum of understanding			
Conservation targets: colonial nesting waterbirds and Anaho Island ecosystem			
Objective(s): no objectives directly linked to this strategy. Future memorandum of understanding updates will be informed by developing NRMP strategies (for example, the integrated pest management plan, biotic inventories, and colonial waterbird studies) and identifying trends in other threats (for example, renewable energy and economic development).			
<i>Activity</i>	<i>Start date</i>	<i>Activity lead</i>	<i>Comments</i>
S07.1—Refine and update memorandum of understanding with new information	2015	Refuge manager	Update memorandum of understanding with information generated by Strategies S01, S02, S05, S06, S09, and S10. Other information may also influence updates such as trends in renewable energy, law enforcement, public use, and economic development.
S07.2—Consult with Region 8 leadership and the Pyramid Lake Paiute Tribe to update memorandum of understanding	2015	Refuge manager	

Note: Start dates are based on Federal Government funding year, which is October–September.

## Strategies S09 and S12—Identify (S09) and Implement (S12) Optimal Strategies and Actions to Preserve and Conserve Waterbodies Important to Waterbirds within the NRMP Scope

### Description

Identify and implement priority actions the Service can take to conserve waterbodies important to Anaho Island Refuge colonial nesting waterbirds and the Anaho Island ecosystem. Waterbodies within the NRMP scope are grouped into five key areas: Truckee River Basin, Carson River Basin, Humboldt River drainage, Walker River drainage, and California (table 15).

### Priority Threats Addressed

Water use and management and climate change

### Assumptions Linking These Strategies to Conservation Targets (figures 7 and 8)

Water availability is critical to the persistence of Anaho Island biota. Continued decline of Pyramid Lake water levels will lead to formation of a land bridge between Anaho Island and the mainland. Persistence of waterbodies in the NRMP scope is considered a primary driver of reproductive success for colonial nesting waterbirds, especially American white pelicans. Although the Service has little control over water use and management in the NRMP scope, the refuge staff, via the Stillwater Refuge Complex, believe there are opportunities to improve water conservation and management. Developing and implementing a water management strategy is expected to better facilitate coordination among water users and improve efficiency in water uses, including agricultural, commercial, and conservation. These efforts are critically important in light of anticipated impacts from climate change, which is expected to exacerbate existing water demands.

**Table 15. Conservation targets, objectives, and activities associated with identifying and implementing optimal strategies and actions to preserve and conserve important waterbodies within the Anaho Island National Wildlife Refuge Natural Resource Management Plan scope (Strategies S09 and S12).**

Strategy S09—Identify optimal strategies to preserve and conserve waterbodies important to waterbirds within the NRMP scope			
Strategy S12—Implement optimal actions to preserve and conserve waterbodies important to waterbirds within the NRMP scope			
Conservation targets: colonial nesting waterbirds, Anaho Island ecosystem, and waterbird foraging areas			
Objective(s): Objectives 01–07			
Activity	Start date	Activity lead	Comments
S09.1—Remain an active advisor to Truckee River Operating Agreement (TROA)	2015	Deputy State Supervisor, Endangered Species and Ecological Services, Nevada Field Office	Continue to advise TROA partners, providing information on threats to Pyramid Lake, climate change implications, economic implications, and other related subjects.
S09.2—Engage in Lahontan Valley partnership (purchasing)	2015	Nevada Realty Office	Continue to work with partners to purchase water rights for conservation.

<i>Activity</i>	<i>Start date</i>	<i>Activity lead</i>	<i>Comments</i>
S09.3—Engage with Lahontan Valley partnership (coordination)	2015	Refuge manager	Continue to engage Lahontan Valley Partnership to coordinate water management for conservation.
S09.4—Identify and summarize legislation and legal framework of water and rights use within each major foraging area of the NRMP scope (see strategy description)	2015	Refuge manager	Produce an internal written summary. Determine if this work is already completed for some areas of the NRMP scope. For example, summarize Public Law 101 and other water-related legislation influencing water rights within the Truckee Carson River portions of NRMP scope. Bureau of Reclamation may have an overview of TROA, the Newlands Project Operating Criteria and Procedures, and Public Law 101.
S09.5—Identify and prioritize points of influence within each major foraging area of the NRMP scope	2016	Refuge manager	Identify opportunities to improve conservation of waterbodies and wetlands in the NRMP scope. Major foraging areas include the Truckee River Basin, Carson River Basin, Humboldt River drainage, Walker River drainage, and northeast California.
S09.6—Develop and prioritize water conservation strategies within major foraging areas of the NRMP scope	2017	Refuge wildlife biologist	Produce an internal report. Focal drainage basins may vary with time in relation to political climate, changes in land ownership, and other factors.
S09.7—Update NRMP	2019	Refuge wildlife biologist	Update NRMP objectives related to water use and management.
S12.1—Implement optimal actions as identified by Strategy S09	2020	Refuge manager, Nevada Realty Office	Implement key actions identified by Strategy S09 that should be implemented by the Service to ensure preservation and conservation of waterbodies important to Anaho Island biota within the NRMP scope.
S12.2—Monitor results of implementation	2021	Refuge manager	Develop and implement monitoring methods.

Note: Start dates are based on Federal Government funding year, which is October–September.

## **Strategy S10 and S11—Identify Dominant Threats to Colonial Nesting Waterbird Reproductive Success**

### *Description*

Identify dominant threats within the NRMP scope that influence colonial nesting waterbird reproductive success such as food availability, contaminants, disturbance, habitat loss or alteration, and disease (table 16).

### *Priority Threats Addressed*

Invasive species, water use and management, and climate change

### *Assumptions Linking This Strategy to Conservation Targets (figure 8)*

Reduced water supply and inefficient water management in the NRMP scope, which together reduce the extent of waterbodies and wetlands, are considered primary threats to colonial nesting waterbirds. The project team assumes that a reduction in the extent of waterbodies and wetlands is positively correlated with aquatic food availability and American white pelican reproductive success. In addition, reduced water supply to Pyramid Lake may ultimately lead to the introduction of mammalian predators to Anaho Island. Such introductions would negatively impact waterbird species richness and reproductive

success. Analysis of long-term waterbird data in relation to trends in water supply and use and other threats identified in this NRMP (table 7) will test the assumption that water use and management is the most critical threat to waterbird reproductive success. Results of this

work will inform refinement of the threat analysis (“Chapter 5—Threat Assessment”), refinement of refuge management strategies, and ultimately contribute to conservation of Anaho Island Refuge colonial nesting waterbirds.

**Table 16. Conservation targets, objectives, and activities associated with identifying dominant threats to colonial nesting waterbird reproductive success (Strategy S10).**

Strategy S10–11—Identify dominant threats to colonial nesting waterbird reproductive success			
Conservation targets: colonial nesting waterbirds, Anaho Island ecosystem, and waterbird foraging areas			
Objective(s): no objectives directly linked to this strategy. Information gained from this strategy will be used to refine Anaho Island Refuge NRMP threat rankings, strategies, and objectives.			
<i>Activity</i>	<i>Start date</i>	<i>Activity lead</i>	<i>Comments</i>
S10.1—Analyze waterbird legacy data	2015	Refuge wildlife biologist	Evaluate Anaho Island waterbird trends, including species richness, breeding population, and reproductive success.
S10.2—Review scientific literature and grey literature and work with experts to gather information on threat trends within NRMP scope	2018	Refuge wildlife biologist	Gather information; examples include past, projected, and future trends in water use and management, diseases and pathogens, and invasive species. Identify science needs.
S10.3—Analyze relationship between trends in waterbirds and threats	2018	Refuge wildlife biologist	Produce a report summarizing regional and refuge waterbird trends and associated threats.
S10.4—Revise Anaho Island Refuge NRMP as needed	2018	Refuge wildlife biologist	Use results from Activity S10.3 to update NRMP threat rankings, strategies, and objectives as needed.
S10.5—Identify funding and organizational mechanisms for addressing science needs	2018	Refuge wildlife biologist	Collaborate with staff from other refuges, Service Divisions, and other conservation groups and agencies.
S10.6—Conduct studies and revise NRMP as new information becomes available	2018	Refuge wildlife biologist	To be determined.

Note: Start dates are based on Federal Government funding year, which is October–September.

## 7.4 Strategy Timeline and Budget

### 7.4.1 Timeline

Refuge staff members worked together to identify when strategies could be feasibly implemented given current and anticipated staffing and funding levels (table 17).

**Table 17. The expected timeline for implementation of Anaho Island National Wildlife Refuge Natural Resource Management Plan conservation strategies, Fiscal Year 2015 through Fiscal Year 2029.**

<i>Strategy number</i>	<i>Strategy name</i>	<i>FY15</i>	<i>FY16</i>	<i>FY17</i>	<i>FY18</i>	<i>FY19</i>	<i>FY20</i>	<i>FY21</i>	<i>FY22</i>	<i>FY23</i>	<i>FY24</i>	<i>FY25</i>	<i>FY26</i>	<i>FY27</i>	<i>FY28</i>	<i>FY29</i>
S01	Inventory Anaho Island biota	X	X	X	X	X	X									
S02	Develop Anaho Island Refuge biodiversity preservation and restoration strategy	X	X	X	X											
S03	Refine Anaho Island Refuge priority resources of concern (conservation targets)		X	X	X	X	X	X								
S04	Implement Anaho Island Refuge biodiversity preservation and restoration strategy					X	X	X	X	X	X	X	X	X	X	X
S05	Conduct Anaho Island isolation studies	X	X	X												
S06	Develop Anaho Island Refuge integrated pest management plan	X	X	X												
S07	Update Anaho Island Refuge–Pyramid Lake Paiute Tribe memorandum of understanding	X														
S08	Implement Anaho Island Refuge integrated pest management plan				X	X	X	X	X	X	X	X	X	X	X	X

<i>Strategy number</i>	<i>Strategy name</i>	<i>FY15</i>	<i>FY16</i>	<i>FY17</i>	<i>FY18</i>	<i>FY19</i>	<i>FY20</i>	<i>FY21</i>	<i>FY22</i>	<i>FY23</i>	<i>FY24</i>	<i>FY25</i>	<i>FY26</i>	<i>FY27</i>	<i>FY28</i>	<i>FY29</i>
S09	Identify optimal strategies to preserve and conserve waterbodies important to waterbirds in the NRMP scope	X	X	X	X	X	X									
S10–S11	Identify dominant threats to colonial nesting waterbird reproductive success				X	X										
S12	Implement optimal actions to preserve and conserve waterbodies important to waterbirds within the NRMP scope						X	X	X	X	X	X	X	X	X	X

## 7.4.2 Budget

The Stillwater Refuge Complex project leader and wildlife refuge specialist estimated Service staff requirements, staff salary costs, and other operational costs associated with strategy implementation for the period FY2015–FY2017 (table 18). Refuge staff members will assess conservation progress over the next 2 years and use this information to update the NRMP, including estimated costs beyond FY2016.

For each strategy, the total Service staff cost was estimated in hours, converted into full-

time equivalents (1 FTE=2,080 hours), and multiplied by the FTE annual pay rate for the specific position(s) projected to work on a strategy. Staff salary costs from all positions participating in the strategy were then summed to provide a total estimated staff salary cost for the period FY2015–FY2017. Non-staff costs (for example, equipment, fuel, and vehicle maintenance) were estimated as operations costs. The estimated cost for Anaho Island Refuge NRMP strategy implementation for the latter half of FY2015 through FY2017 is \$184,438.

**Table 18. Estimated cost of Anaho Island National Wildlife Refuge Natural Resource Management Plan strategies, Fiscal Year 2015 through Fiscal Year 2017.**

<i>Strategy number</i>	<i>Strategy name</i>	<i>Service staff cost</i>	<i>Operations cost</i>	<i>Total cost</i>
S01	Inventory Anaho Island biota	\$17,785	\$70,100	\$87,885
S02	Develop Anaho Island Refuge biodiversity preservation and restoration strategy	NA	NA	NA
S03	Refine Anaho Island Refuge priority resources of concern (conservation targets)	NA	NA	NA
S04	Implement Anaho Island Refuge biodiversity preservation and restoration strategy	NA	NA	NA
S05	Conduct Anaho Island Refuge isolation studies	\$26,612	\$0	\$26,612
S06	Develop Anaho Island Refuge integrated pest management plan	\$20,235	\$700	\$20,935
S07	Update Anaho Island–Pyramid Lake Paiute Tribe memorandum of understanding	\$6,171	\$10,000	\$16,171
S08	Implement Anaho Island Refuge integrated pest management plan	NA	NA	NA
S09	Identify optimal actions to preserve and conserve waterbodies important to waterbirds in the NRMP scope	\$27,837	\$5,000	\$32,837
S10–S11	Identify dominant threats to colonial nesting waterbird reproductive success	NA	NA	NA
S12	Implement optimal actions to preserve and conserve waterbodies important to waterbirds within the NRMP scope	NA	NA	NA
Total				\$184,438

**Key:** NA = strategy will be not be implemented in FY2015–FY2017 and therefore is not expected to require refuge staff time or funds.

**Notes:** Total Service staff cost was estimated in total hours, converted into full-time equivalents (1 FTE=2,080 hours), and multiplied by the FTE cost for the position(s) projected to work on a strategy. Staff salary costs from all positions participating in the strategy were then summed to provide a total estimated staff salary cost for the period FY2015–FY2017.

Operations costs are non-staff costs and include transportation (for example, fuel and vehicle maintenance), equipment, and other costs (for example, contracts and training volunteers).



# Chapter 8—Inventory, Monitoring, and Research

The project team identified inventory, monitoring, and research activities (referred to as “surveys” in the refuge’s IMP) that directly inform progress towards meeting conservation target goals and threat-reduction objectives and to adapt management strategies (as needed). The term “monitoring” refers to the periodic gathering of data related to NRMP goals and objectives that allows the refuge staff to know what adjustments, if any, may be needed to improve conservation results. Monitoring provides the basis for adaptive management by helping the refuge staff determine what is

working and what is not working. This, in turn, enables the refuge staff to improve its strategies or develop new strategies.

Tables 19 and 20 provide an overview of the inventory, monitoring, and research activities that the refuge staff expects to conduct over the next 15 years. Additional details, such as survey leads and annual costs, are provided in the refuge’s IMP (U.S. Fish and Wildlife Service 2014a). In some cases, field surveys are not required to assess conservation progress, but instead the indicator represents an important management milestone or interim result.

**Table 19. Conservation goals and associated monitoring for Anaho Island National Wildlife Refuge, October 2014 through October 2030.**

<i>Goal</i>	<i>NRMP indicator</i>	<i>IMP survey name(s) (type)</i>
Goal 1.1. Over the next 15 years, Anaho Island Refuge continues to support breeding populations of at least five colonial nesting waterbird species annually. Waterbird abundance will be incorporated into this goal in the future following development of methods to estimate waterbird abundance.	Colonial nesting waterbird species richness and abundance	Colonial nesting waterbird species richness (M)
Goal 1.2. Over the next 15 years, annual American white pelican fledging success at Anaho Island Refuge is $\geq 0.3$ juvenile pelicans fledged per active nest.	American white pelican fledging success	American white pelican fledging success (M)
Goal 2.1. Over the next 30 years, waterbody surface area (hectares) within the NRMP scope is greater than 2013 levels to sustain Anaho Island Refuge colonial nesting waterbird populations.	Waterbody surface area (hectares) within the Anaho Island NRMP scope	Colonial nesting waterbird foraging areas (M)
Goal 3.1. Over the next 15 years, Anaho Island Refuge vegetation cover is maintained at $\leq 20\%$ , and $>50\%$ of the vegetation is composed of native plant species.	Vegetation cover and composition	Vegetation cover and composition (M)
Goal 3.2. Over the next 30 years, $>80\%$ of native bird and plant species documented on Anaho Island (since first records in the late 1800s) continue to persist.	Bird and plant species richness	Bird species richness monitoring (M), vegetation cover and composition (M)
Goal 3.3. Over the next 30 years, the water surface elevation of Pyramid Lake is $\geq 1,166$ meters in order to maintain island isolation and preserve island biodiversity.	Pyramid Lake water surface elevation	Anaho Island isolation monitoring (M)

Key: NRMP = natural resource management plan; IMP = inventory and monitoring plan. Survey types: I = inventory; M = monitoring; CR = cooperative research.

**Table 20. Inventory, monitoring and research for Anaho Island National Wildlife Refuge conservation strategies and threat-reduction objectives, October 2014 through October 2030.**

<i>Strategy</i>	<i>Threat-reduction objective or management milestone (MM)</i>	<i>NRMP indicator</i>	<i>IMP survey name (type)</i>
Strategy S01—Inventory Anaho Island biota	Management milestone	SI01.1 Bird inventory completion (yes or no)	Bird species inventory (I)
Strategy S01—Inventory Anaho Island biota	Management milestone	SI01.2 Invertebrate inventory completion (yes or no)	Invertebrate species inventory (I)
Strategy S01—Inventory Anaho Island biota	Management milestone	SI01.3 Mammal inventory completed (yes or no)	Mammal species inventory (I)
Strategy S01—Inventory Anaho Island biota	Management milestone	SI01.4 Reptile inventory completed (yes or no)	Reptile species inventory (I)
Strategy S02—Develop Anaho Island Refuge biodiversity preservation and restoration strategy	Objective 14. By FY2020, priority natural resource preservation and restoration needs at Anaho Island Refuge have been identified and documented (Strategy S02).	O14.1 Priority restoration needs to preserve and restore island biodiversity have been identified and documented (% completion)	% completion of preservation and restoration plan (MM)
Strategy S05—Conduct Anaho Island isolation studies	Management milestone	SI05.1 Anaho Island isolation studies (% completion)	Anaho Island isolation study (CR)
Strategies S06 and S08—Develop (S06) and implement (S08) Anaho Island Refuge integrated pest management plan	Objective 08. By FY2018, the Service identifies priority invasive animal and plant threats to Anaho Island biodiversity and develops optimal strategies to prevent, eradicate, or mitigate their impacts.	O8.1 Invasive priorities identified (% completion) O8.2 Integrated pest management plan (% completion)	Invasive priorities identified (% completion) (MM); integrated pest management plan (% completion) (MM)
Strategies S06 and S08—Develop (S06) and implement (S08) Anaho Island Refuge integrated pest management plan	Objective 09. By FY2018, spatially referenced data on the distribution and abundance of priority invasive or nuisance plant species on Anaho Island Refuge are collected, summarized, and shared with the Pyramid Lake Paiute Tribe.	O8.3 Invasive plant inventory (% completion)	Invasive plant inventory completed (% completion)
Strategies S06 and S08—Develop (S06) and implement (S08) Anaho Island Refuge integrated pest management plan	Objective 10. Over the next 15 years, the Pyramid Lake Paiute Tribe continues to monitor human activity within the Anaho Island buffer zone.	O10.1 Tribal monitoring of human activity within buffer zone (yes or no)	Pyramid Lake Paiute Tribe monitors human activity within the Anaho Island buffer zone (yes or no) (MM)

<i>Strategy</i>	<i>Threat-reduction objective or management milestone (MM)</i>	<i>NRMP indicator</i>	<i>IMP survey name (type)</i>
Strategy S06 and S08—Develop (S06) and implement (S08) Anaho Island Refuge integrated pest management plan	Objective 11. Over the next 15 years, new priority invasive plant species are not established on Anaho Island Refuge. “Established” here means that a species that grows and reproduces on Anaho Island.	O11.1 Establishment of new invasive plant species (yes or no)	Invasive and nuisance species early detection (M)
Strategy S06 and S08—Develop (S06) and implement (S08) an Anaho Island Refuge integrated pest management plan	Objective 12. Over the next 15 years, the abundance of priority invasive plants on Anaho Island Refuge does not increase above 2009–2010 levels (abundance categories; Kulpa and Leger 2013).	O12.1 Invasive plant abundance	Invasive and nuisance plant management effectiveness monitoring (M)
Strategy S06 and S08—Develop (S06) and implement (S08) an Anaho Island Refuge integrated pest management plan	Objective 13. Over the next 15 years, priority invasive animal species are not established on Anaho Island Refuge. “Established” here means that the species persists on Anaho Island Refuge for >1 year, even if only seasonally.	O13.1 Establishment of new invasive animal species (yes or no)	Invasive and nuisance animal management effectiveness monitoring (M)
Strategy S09 and S12—Identify (S09) and implement (S12) optimal strategies and actions to preserve and conserve waterbodies important to waterbirds within the NRMP scope	Objective 01. By FY2016, the Service identifies priority waterbody preservation and conservation actions within the Truckee River Basin and Carson River Basin waterbird foraging areas.	O1.1 Priority waterbody preservation and conservation actions within the Truckee River Basin and Carson River Basin are identified and documented (% completion)	Priority waterbody preservation and conservation actions within the Truckee River Basin and Carson River Basin are identified and documented (% completion) (MM)
Strategies S09 and S12—Identify (S09) and implement (S12) optimal strategies and actions to conserve important waterbodies within the NRMP scope	Objective 02. By FY2016, the Service identifies priority waterbody preservation and conservation actions within the Humboldt River drainage basin.	O2.1 Priority waterbody preservation and conservation actions within the Humboldt River drainage basin are identified and documented (% completion)	Priority waterbody preservation and conservation actions within the Humboldt River drainage basin are identified and documented (% completion) (MM)
Strategies S09 and S12—Identify (S09) and implement (S12) optimal strategies and actions to preserve and conserve waterbodies important to waterbirds within the NRMP scope	Objective 03. By FY2017, the Service identifies priority waterbody preservation and conservation actions within the Walker River drainage basin.	O3.1 Priority waterbody preservation and conservation actions within the Walker River drainage basin are identified and documented (% completion)	Priority waterbody preservation and conservation actions within the Walker River drainage basin are identified and documented (% completion) (MM)

<i>Strategy</i>	<i>Threat-reduction objective or management milestone (MM)</i>	<i>NRMP indicator</i>	<i>IMP survey name (type)</i>
Strategies S09 and S12—Identify (S09) and implement (S12) optimal strategies and actions to preserve and conserve waterbodies important to waterbirds within the NRMP scope	Objective 04. By FY2018, the Service identifies priority waterbody preservation and conservation actions within the California portion of the Anaho Island Refuge NRMP scope.	O4.1 Priority waterbody preservation and conservation actions within the California portion of the Anaho Island Refuge NRMP scope are identified and documented (% completion)	Priority waterbody preservation and conservation actions within the California portion of the Anaho Island Refuge NRMP scope are identified and documented (% completion) (MM)
Strategies S09 and S12—Identify (S09) and implement (S12) optimal strategies and actions to preserve and conserve waterbodies important to waterbirds within the NRMP scope	Objective 05. By 2018, the Stillwater Refuge Complex staff are coordinating water use and management (on lands next to the complex) with at least two of the following partners: Fallon Paiute Shoshone Tribe, Canvasback Club, Naval Air Station Fallon, and the City of Fallon.	O5.1 % of total water rights users with whom complex staff is coordinating	% of total water rights users with whom complex staff is coordinating (MM)
Strategies S09 and S12—Identify (S09) and implement (S12) optimal strategies and actions to preserve and conserve waterbodies important to waterbirds within the NRMP scope	Objective 06. Over the next 50 years, Pyramid Lake is at or above a surface water elevation that prevents the formation of a land bridge between Anaho Island and the mainland or that prevents access by priority invasive animal species.	O6.1 Pyramid Lake water surface elevation	Pyramid Lake water elevation monitoring (M)
Strategies S09 and S12—Identify (S09) and implement (S12) optimal strategies to preserve and conserve waterbodies important to waterbirds within the NRMP scope	Objective 07. Over the next 30 years, waterbody surface area (hectares) within the NRMP scope is greater than 2013 levels in order to sustain Anaho Island Refuge colonial nesting waterbird populations.	O7.1 Waterbody surface area (hectares) within the Anaho Island Refuge NRMP scope	Colonial nesting waterbird foraging areas (M)
Strategy S10-11—Identify dominant threats to colonial nesting waterbird reproductive success			Colonial nesting waterbird threats study (CR)

Key: NRMP = natural resource management plan; IMP = inventory and monitoring plan. Survey types: CR = cooperative research; I = inventory; M = monitoring; MM = management milestone.

Note: Management milestones do not require field surveys and represent important management results along the way to reaching conservation goals or objectives.

## **Additional Refuge Research, Data Analysis, and Data Management Needs**

Below is a list of additional research needs identified during the NRMP process but not identified as priority management strategies or related activities. Information generated from these efforts will help refine conservation target viability scales, goals, objectives, and strategies and improve conservation delivery. The refuge staff will work with other Service programs and partners to address these needs as additional resources become available.

- Develop standardized data structures to manage inventory and monitoring data. Efficient and effective management of refuge data will improve their utility and credibility.

- Study inter-specific interactions among Anaho Island Refuge’s waterbird species. Question: are California gulls threatening other waterbird species at Anaho Island? Information gained from this work may lead to new integrated pest management strategies.
- Investigate waterbird range shifts. Question: is the breeding range of American white pelicans or other Anaho Island Refuge waterbirds shifting in response to climatic changes, and what is the projected range shift over the next 50 years? Information gained from this work will inform refinement of Anaho Island Refuge conservation goals, objectives, and strategies.

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# Appendix A

## *Stakeholders and Expert Advisors Consulted*

**Table A-1. Stakeholders for the Anaho Island National Wildlife Refuge Natural Resource Management Plan.**

<i>Name</i>	<i>Organization</i>	<i>Position</i>
Albert John	Pyramid Lake Paiute Tribe, Pyramid Lake Fisheries	Executive director
Arturo Garzon	U.S. Congress, Office of Congressman Amodei, 2nd Congressional District	Constituent service representative
Ashley Carrigan	U.S. Congress, Office of Senator Dean Heller	District director
Autumn Bryson	Pyramid Lake Paiute Tribe	Environmental director
Beverly Harry	Pyramid Lake Paiute Tribe	Environmental manager
Cory Hunt	Nevada, Office of Governor Sandoval	Policy analyst
Elwood Lowery	Pyramid Lake Paiute Tribe	Tribal chairman
Lucas Ingvaldstad	U.S. Congress, Office of Senator Harry Reid	Regional representative
Mary Conelly	U.S. Congress, Office of Senator Harry Reid	State director
Meghan Brown	U.S. Congress, Office of Senator Dean Heller	Rural representative
Nancy Vucinich	Pyramid Lake Paiute Tribe, Pyramid Lake Fisheries	Fishery biologist
Pam Robinson	U.S. Congress, Office of Senator Dean Heller	Nevada policy advisor
Robert Gastonguay	U.S. Congress, Office of Congressman Amodei, 2nd Congressional District	Staff assistant
Stacy Parobek	U.S. Congress, Office of Congressman Amodei, 2nd Congressional District	District director

**Table A-2. Advisory team for the Anaho Island National Wildlife Refuge Natural Resource Management Plan.**

<i>Name</i>	<i>Organization</i>	<i>Position</i>
Ali Duvall	Intermountain West Joint Venture	Assistant coordinator
Arthur Shine	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8, Visitor Services	Chief
Athena Brown	U.S. Department of the Interior, Bureau of Indian Affairs, Western Nevada Agency	Superintendent

<i>Name</i>	<i>Organization</i>	<i>Position</i>
Bruce Petersen	U.S. Department of Agriculture, Natural Resources Conservation Service, Nevada State Office	State conservationist
Carl Lunderstadt	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8, Stillwater National Wildlife Refuge Complex	Deputy project leader
Chris Feldman	University of Nevada, Reno, Department of Biology	Associate professor
Chris Nicolai	U.S. Fish and Wildlife Service, Migratory Bird Program, Region 8	Migratory bird biologist
Colleen Moulton	Idaho Department of Fish and Game	Avian ecologist
Cris Tomlinson	Nevada State Department of Wildlife, Wildlife Diversity Division	Supervisory refuge wildlife biologist
Curtis McCasland	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	Refuge supervisor
Damian Ciotti	U.S. Fish and Wildlife Service, External Affairs and Tribal Partnerships	Tribal partnerships
Daniel W. Anderson	University of California, Davis	Professor of wildlife biology (emeritus)
Dave Smith	Intermountain West Joint Venture	Coordinator
Debra Brackley	U.S. Department of Agriculture, Natural Resources Conservation Service, Fallon Service Center	Area conservationist
Don Harper	U.S. Fish and Wildlife Service, Southern Nevada Field Office	Geographer
Elisabeth Ammon	Great Basin Bird Observatory	Executive Director
Elizabeth Leger	University of Nevada, Reno	Associate professor of plant ecology
Erik Anderson	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8, Stillwater National Wildlife Refuge Complex	Administrative officer
Erin Hourihan	U.S. Department of Agriculture, Natural Resources Conservation Service, Nevada State Office	Range management specialist
Gary Scopettone	U.S. Geological Survey, Western Fisheries Center	Section chief (retired)
Janet Phillips	Tahoe Pyramid Lake Bikeway	President
Jon Sjoberg	Nevada State Department of Wildlife, Fisheries Division	Chief
Karen Laing	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8, Inventory and Monitoring Program	Coordinator
Karletta Chief	University of Arizona Department of Soil, Water, Environmental Science	Climate Change Vulnerability of Native Americans in the Southwest
Kenneth Parr	U.S. Department of the Interior, Bureau of Reclamation	Lahontan Basin area manager
Laura Richards	Nevada State Department of Wildlife, Wildlife Diversity Division	Chief

<i>Name</i>	<i>Organization</i>	<i>Position</i>
Lisa Heki	U.S. Fish and Wildlife Service, Lahontan National Fish Hatchery Complex	Complex manager
Mark Fabes	U.S. Geological Survey, Western Fisheries Research Center–Reno Field Station	Fishery biologist
Mark Pelz	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8, Natural Resources Program	Chief
Michael Woodbridge	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8	Public affairs officer
Paul McKim	U.S. Fish and Wildlife Service, External Affairs	Assistant regional director
Pete Rissler	U.S. Geological Survey, Western Fisheries Center	Fishery biologist
Richard Grimes	U.S. Fish and Wildlife Service, Nevada Realty Field Office	Supervisory realty specialist
Sue Donaldson	Washoe County Cooperative Extension	Water quality education and invasive weed specialist
Robin Tausch	U.S. Department of Agriculture Forest Service	Emeritus research range scientist (retired)
Robin Wilson	Audubon Society, Nevada Important Bird Area Program	Nevada director of bird conservation
Sarah Kulpa	U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office	Botanist
Scott Flaherty	U.S. Fish and Wildlife Service, National Wildlife Refuge System, Region 8, External Affairs	Deputy assistant regional director
Scott Mensing	University of Nevada, Reno, Department of Geography	Professor
Susan Abele	U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office, Nevada Bird Conservation Partnership	Co-chair (northern Nevada)
Ted Koch	U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office	Nevada State supervisor
Todd Hopkins	Great Basin Landscape Conservation Cooperative	Science coordinator
Tommy King	U.S. Department of Agriculture, Wildlife Services National Wildlife Research Council	Research refuge wildlife biologist
Wendy Hanson-Mazet	Washoe County Cooperative Extension	Program officer



# Appendix B

## *Summary of Pertinent Water Rights and Regulations*

This appendix summarizes water rights and regulations relevant to the scope of the “Anaho Island National Wildlife Refuge Natural Resources Management Plan” (NRMP scope).

Nevada’s first water statute was enacted in 1866 and has been amended many times since.<sup>1</sup> Nevada’s water law, considered one of the most comprehensive water laws in the western United States, is based on two fundamental concepts: prior appropriation and beneficial use. Prior appropriation (also known as “first in time, first in right”) allows for the orderly use of the state’s water resources by granting priority to senior water rights. This concept ensures the senior uses are protected, even as new uses for water are allocated. All water within Nevada may be appropriated for beneficial use by the people of the state. Irrigation, mining, recreation, commercial, industrial, and municipal uses are examples of beneficial uses. In-stream flow, maintenance of natural aquatic systems, and wildlife are beneficial uses more recently recognized by the State of Nevada. The Nevada Division of Water Resources provides overviews of the chronologic history of water use and related issues for the Carson River, Truckee River, Walker River, and Humboldt River systems.<sup>2</sup> In addition to State law, many Federal laws, decrees, plans, and agreements influence water supply and management in the NRMP scope and ensure valid water rights are served while preserving the rights of American Indian Tribes and minimizing impacts on natural ecosystems and listed species. Major influences over water allocation and management within the NRMP scope are summarized below.

- The U.S. Bureau of Reclamation’s Lahontan Basin Area Office has jurisdiction over four reclamation projects that promoted the settlement and economic development of water supply in this portion of Nevada.<sup>3</sup> The Newlands Project, Washoe Project, and Truckee River Storage Project are located within the Truckee and Carson River systems. The Humboldt Project is located within the Lower Humboldt River system.
- The Newlands Project Operating Criteria and Procedures (OCAP), first established in 1967 (and most recently revised in 1997), ensure the Secretary of the Interior, through the Bureau of Reclamation, can meet water responsibilities to the various entities on the Carson and Truckee Rivers including private water right holders, tribes, and fish and wildlife as well as their wetland habitats. OCAP is intended to balance water uses across Truckee and Carson and increase efficient use of available water.
- The Truckee–Carson–Pyramid Lake Water Rights Settlement Act of 1990 (Title II of Public Law 101–618 [104 Stat.3289,3294], November 16, 1990) provides for the equitable apportionment of the waters of the Truckee River, Carson River, and Lake Tahoe; fulfills the Federal Trust obligations toward American Indian Tribes; and promotes the enhancement and recovery of the Pyramid Lake fishery, among other purposes. The various provisions contained in this law provide the best available framework for minimizing further declines in the water levels of Pyramid Lake.

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<sup>1</sup> For more information, see <http://water.nv.gov/waterrights/waterlaw/index.cfm>.

<sup>2</sup> For more information, see <http://water.nv.gov/mapping/chronologies/>.

<sup>3</sup> For more information, see <https://www.usbr.gov/mp/lbao/index.html>.

- Diversions of water from the Truckee River to the Newlands Project contributed to a significant decline in the water level of Pyramid Lake (between 1905 and the 1960s) and resulted in negative impacts on fisheries. In response, the Bureau of Reclamation finalized the Truckee River Operating Agreement (TROA) in 2008. TROA modifies operations of Truckee River reservoirs upstream of Reno, Nevada, and enhances the flexibility and coordination of water allocations while meeting flood control and dam safety requirements.
- In 2002, Title VIII of Public Law 107–282, referred to as the Humboldt Project Conveyance Act, authorized the transfer of the Humboldt Project, as soon as practicable, to the Pershing County Water Conservation District. The transfer is expected to take several years to finalize, but the first transfer of lands in the Humboldt Project was completed February 26, 2013.
- Section 2507 of Public Law 107–171 (2002 Farm Bill enacted May 13, 2002) provided funding to be used by the Secretary of the Interior, acting through the Commissioner of Reclamation, “to provide water to at-risk natural desert terminal lakes” such as Pyramid Lake. This bill was later amended under Public Law 108–7, Section 207 to include language “restoration of fish, wildlife, and associated habitats in watersheds of certain lakes” and specified that only Pyramid, Summit, and Walker Lakes in the State of Nevada were to be considered under Section 2507, Public Law 107–171.<sup>4</sup>
- Anaho Island waterbird foraging areas in California occur primarily within three hydrologic regions identified by the California Department of Water Resources: the North Lahontan hydrologic region and the eastern halves of the Sacramento River and San Joaquin River hydrologic regions.<sup>5</sup> The 2013 California Water Plan provides a collaborative planning framework for elected officials, agencies, tribes, water and resource managers, businesses, academia, stakeholders, and the public to develop findings and recommendations and make informed decisions for California’s water future. The plan, updated every 5 years, presents the status and trends of California’s water-dependent natural resources; water supplies; and agricultural, urban, and environmental water demands for a range of plausible future scenarios. The California Water Plan also evaluates different combinations of regional and statewide resource management strategies to reduce water demand, increase water supply, reduce flood risk, improve water quality, and enhance environmental and resource stewardship.<sup>6</sup>

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<sup>4</sup> For more information, see [https://www.usbr.gov/mp/lbao/desert\\_terminal/index.html](https://www.usbr.gov/mp/lbao/desert_terminal/index.html).

<sup>5</sup> For more information, see <http://www.waterplan.water.ca.gov/docs/maps/regions.pdf>.

<sup>6</sup> For more information, see <http://www.waterplan.water.ca.gov/index.cfm>.

# Appendix C

## *Threats to Anaho Island Refuge Conservation Targets*

Below is a summary of the 19 direct threats to the 3 Anaho Island National Wildlife Refuge (Anaho Island Refuge) conservation targets: colonial nesting waterbirds, waterbird foraging areas, and Anaho Island ecosystem. The focus of this threat assessment was the spatial scope of the Anaho Island Refuge natural resource management plan (NRMP scope).

### **C.1 Threat Category: Climate Change**

#### **Threat T01—Greenhouse Gas Emissions**

##### *Affected Conservation Targets*

Anaho Island ecosystem, colonial nesting waterbirds, and colonial nesting waterbird foraging areas

##### *Threat Description*

Threats from long-term climatic changes that may be linked to global warming and other severe climatic and weather events that are outside of the natural range of variation, or potentially can wipe out a vulnerable species or habitat.

##### *Threat Details*

Greenhouse gases are those gaseous constituents of the atmosphere that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by Earth's surface, the atmosphere itself, and by clouds. As these gases increase in the atmosphere as a result of human activities, they cause what is known as the "greenhouse effect." The greenhouse effect is an important driver of global climate change.

Here we assess the threat of climate change over the next 50 years (rather than the 15-year

timescale of the Anaho Island Refuge NRMP) to assess the vulnerability of the conservation targets to climate change. Vulnerability was assessed using climate reports, peer-reviewed literature, and freely available climate tools. Of particular value to this process was the recently published report, "Assessment of Climate Change in the Southwest United States" (Garfin et al. 2013). The report summarizes information from a broad range of experts and provides detailed projections about climate change effects in the Southwest. Despite the availability of information on climate change and the magnitude and rate of climatic changes within the NRMP scope (for example, temperature, precipitation, and drought), and the resulting impact on Anaho Island Refuge conservation targets remains uncertain.

Below is a summary of projected changes in temperature, precipitation, snowpack, and fire as a result of climate change. The project team believes Anaho Island conservation targets are vulnerable to these climatic factors.

**Temperature.** There is a high level of confidence that summer temperatures will increase throughout the region. Annual average temperature in Nevada has been increasing (Nevada Climate Tracker) and is projected to increase in the oncoming years (Garfin et al. 2013, The Nature Conservancy 2009). Maximum summer temperatures are expected to rise up to 2.61 degrees Fahrenheit (°F) by the year 2020 and up to 5.76 °F by 2060 (Comer et al. 2013), and model projections show an increase in summer heat wave frequency and intensity (Garfin et al. 2013). Model projections of increased summer temperatures would exacerbate the threat of water use, especially during droughts; however, it should be noted that droughts in the last century lack the severity and duration of droughts in the preceding 2,000 years (Garfin et al. 2013).

A synthesis of temperature information in the NRMP scope by Esralew (2014) showed:

- mean monthly temperature at Anaho Island ranged from 26.1 to 80.5 °F (based on 1983–2012 data), with maximum temperatures in July and minimum temperatures in December;
- since 1910, minimum temperatures increased in almost every month, season, and time period;
- since 1910, minimum temperatures showed persistent increasing trends;
- since 1910, median annual minimum temperature increase ranged from 0.04 to 0.09 °F per year;
- since 1910, there were no significant trends in maximum temperatures during the growing season (April–June) across season, month, or time period.

Persistent rising minimum temperatures in the NRMP scope indicate that there could be less relief from heat spells and an increase in the evapotranspiration demand for water, especially during summer. Because precipitation is generally low within the NRMP scope and does not appear to be increasing (see Precipitation section below), water deficits are likely to increase in the future (and therefore the irrigation demand to keep water levels at desirable levels) (Esralew 2014). Increases in temperature with no increases in precipitation could result in earlier spring snowmelt and will shift the timing of streamflow, and therefore water delivery, to earlier in the year. Over the long-term these changes could reduce the amount of water available within the larger waterbird foraging area, resulting in reduced food availability and reduced waterbird reproductive success.

**Precipitation.** Precipitation departures vary locally throughout the Southwest, but for the region as a whole, median annual average precipitation values are slightly negative (Garfin et al. 2013). Fall and winter average

precipitation, on the other hand, has seen a positive trend in Nevada since 1895 (Nevada Climate Tracker n.d.<sup>7</sup>). Winter precipitation extremes may become more frequent and intense, and the northern portion of the Sierra Nevada watersheds may become wetter and less drought prone, but confidence is low for these projections (Garfin et al. 2013). A synthesis of precipitation data of the NRMP scope (Esralew 2014) shows a slight decrease in August and September (a reduction of 0.01–0.06 inch) and only since 1983.

**Snowpack.** Model projections for the Sierra Nevada range show a greatly reduced snowpack by the year 2090 (California Energy Commission 2014<sup>8</sup>). Streamflow and snowmelt in snowmelted streams of the Southwest tended to arrive earlier in the year during the latter half of the 20th century. Up to 60 percent of the change in arrival time has been attributed to increasing greenhouse gas concentrations in the atmosphere (Garfin et al. 2013). Projected reduction of late winter-spring mountain snowpack in the Southwest over the 21st century and streamflow timing trends across much of western North America suggest even earlier springtime snowmelt than observed to date (Garfin et al. 2013, Stewart et al. 2004). Increasing temperatures and more precipitation falling as rain instead of snow, resulting in a reduced snowpack, will strain water resources in the NRMP scope.

**Fire.** Warming and the earlier onset of spring are expected to increase wildfire activity in the western United States. Robust statistical associations between wildfire and hydroclimate in western forests indicate that increased wildfire activity over recent decades reflects subregional responses to changes in climate (Westerling et al. 2006).

<sup>7</sup> Monthly gridded data from the PRISM database are used to assess climate across the state.

<sup>8</sup> Cal-Adapt.org data provided by Scripps Institution of Oceanography, California Nevada Applications Program (CNAP), Data Set Contributed: Projected Snow Water Equivalent: Projected Monthly Snow

Water Equivalent (amount of water contained within the snowpack). These data layers were downscaled using a bias correction and spatial downscaling (bcSD) approach and include data for four different models (PCM1, CCSM3, GFDL, and CNRM) for two different scenarios (A2 and B1).

## Summary of Potential Climate Change Effects on Anaho Island Refuge Conservation Targets.

Competition for water by neighboring agricultural, industrial, residential, and conservation entities will almost certainly increase if not mitigated by increases in winter precipitation. Although there is uncertainty, the combination of multiple direct and indirect factors likely driven by climate change—such as increases in temperature, weather extremes, disease prevalence, and decreases in water quantity and quality—may exacerbate existing threats and further stress Anaho Island Refuge conservation targets. In estimating the amount of water available to basins and subbasins using hydrologic modeling coupled with water demand models that factor in human uses, refuge staff can evaluate future impacts of increased temperatures on water availability timing and magnitude and the natural resources dependent upon that water.

A decrease in water availability in the NRMP scope would threaten the Anaho Island ecosystem and food availability for colonial nesting birds. Additionally, warming temperatures and an increase in carbon dioxide (CO<sub>2</sub>) levels could potentially cause attenuation or elimination of seasonal overturn in Pyramid Lake, which could lead to reduced water quality and productivity (Hostetler and Giorgi 1995). A reduction in fish populations would force colonial nesting waterbirds on Anaho Island to rely more heavily on surrounding foraging areas. However, if increased spring runoff inputs are not diverted for agriculture or other anthropogenic uses, terminal lake systems such as Walker Lake and Pyramid Lake could have a substantial beneficial effect over time in mitigating existing, declining water quality conditions and benefitting resident fishes and avian species (Wildlife Action Plan Team 2012).

Warming temperatures and reductions to water supply within the NRMP scope may increase disease prevalence, but the interaction between climate change and disease dynamics in wildlife is complex and as yet poorly understood (Wildlife Action Plan Team 2012). Increases in summer temperatures and extremes along with reduced water supply may lead to an increased number of bird and fish die-offs, thus contributing to an increase in disease pathogens such as botulism. Additionally, nutritional stress from a potential reduction in food could weaken

resistance to disease and other pathogens in colonial nesting waterbirds.

Exposure to more frequent and intense storm events may affect the Anaho Island ecosystem, but most notably colonial nesting birds. In previous years, hail storms have caused direct chick mortality on Anaho Island (Donna Withers, wildlife refuge specialist, Stillwater National Wildlife Refuge Complex, personal communication). Chick die-offs due to severe weather events have been recorded at the Chase Lake and Bitter Lake American white pelican colonies in the northern plains. In most cases, chicks seemed to be most vulnerable at 12–19 days old, the age at which parents stop brooding and chicks form crèches (Sovada and Pietz 2013).

Exposure to elevated CO<sub>2</sub> might enhance the long-term success and dominance of exotic annual grasses in the region (Smith et al. 2000). Changes in landcover in the Southwest are predicted to be substantial (Garfin et al. 2013). Within the Lahontan Basin, significant ecological departure due to climate change is predicted for several habitat types including mixed salt desert and big sagebrush upland (Provencher and Anderson 2011). Annual grasses, such as cheatgrass and red brome, are predicted to increase in many parts of mixed salt desert and greasewood communities and replace native plant communities (Wildlife Action Plan Team 2012). The continued spread of invasive grasses will likely decrease cover habitat for waterbird chicks, reptiles, and mammals and increase the risk and severity of wildfire at Anaho Island Refuge.

Increasing summer temperatures and changes in vegetation may have a significant impact on Anaho Island birds and reptiles. Heat stress has been well documented as a threat to colonial nesting waterbirds (Bartholomew and Dawson 1954, Howell and Bartholomew 1962). Increasing summer temperatures, particularly intense heat waves, coupled with a lack of shade-providing shrub cover, could greatly affect reproductive success for all waterbirds nesting on Anaho Island Refuge. Increasing temperatures may also result in reptiles, such as lizards, spending greater time seeking cover for thermal regulation and less time foraging. Reduction in foraging time results in less energy for reproduction (Huey et al. 2010). This effect may be enhanced by loss of shrub cover due to invasive annual grasses.

## C.2 Threat Category: Water Management and Use

### Threat T02—Water Use For Conservation Areas

#### *Affected Conservation Targets*

Anaho Island ecosystem, colonial nesting waterbirds, and colonial nesting waterbird foraging areas

#### *Threat Description*

Changing water supply or flow patterns from their natural range of variation as a result of conservation water management. Here we consider conservation management activities in the NRMP scope that may be in conflict with conservation of Anaho Island Refuge conservation targets (also known as priority resources of concern).

#### *Threat Details*

Reduced water inputs to Pyramid Lake could result in the formation of a land bridge or water levels shallow enough to enable invasive or nuisance animals to access Anaho Island, resulting in negative impacts on its natural resources; these include increased mortality, reduced reproductive success, and habitat alteration. Reduced water inputs to wetlands, lakes, and other riparian areas threaten waterbird aquatic food resources in the NRMP scope. Areas using water for the purpose of natural resource conservation in the NRMP scope include Stillwater National Wildlife Refuge, Carson Lake and Pasture, Fernley Wildlife Management Area, Lahontan Reservoir, and Fallon Paiute-Shoshone Indian Reservation Wetlands. Management and protection of these waterbodies provide benefits to Anaho Island waterbirds, but in some cases management may result in waterbird foraging habitat loss or reduced water delivery to Pyramid Lake.

### Threat T03—Water Use for Residential and Commercial Development

#### *Affected Conservation Targets*

Anaho Island ecosystem, colonial nesting waterbirds, and colonial nesting waterbird foraging areas

#### *Threat Description*

Changing water supply or flow patterns from their natural range of variation as a result of residential or commercial development.

#### *Threat Details*

The human population in Washoe County is projected to grow from 434,519 in 2010 to 590,997 in 2030 (Truckee Meadows Regional Planning Agency 2010), which will increase demand for water resources in the area. The U.S. Geological Survey (USGS) National Water Use database shows public and domestic water use in 2005 was the second highest consumer of ground and surface waters (USGS Water Use Information Program; Washoe, Churchill, Lyon, and Storey Counties [U.S. Geological Survey 2005]).

### Threat T04—Water Use for Agriculture

#### *Affected Conservation Targets*

Anaho Island ecosystem, colonial nesting waterbirds, and colonial nesting waterbird foraging areas

#### *Threat Description*

Changing water supply or flow patterns from their natural range of variation as a result of agriculture.

#### *Threat Details*

Dairy farms and subsequent flood-irrigated alfalfa and pasture farming make up the majority of agricultural use in the Truckee Carson Irrigation District (Truckee-Carson Irrigation District 2010). The USGS National Water Use database shows water use for irrigation in 2005 (Washoe, Church, Lyon, and Storey Counties) was the dominant source of water use in the region, followed by domestic and public water use (U.S. Geological Survey 2005). Dairy farms and subsequent flood-

irrigated alfalfa and pasture farming make up the majority of agricultural use in the Truckee Carson Irrigation District (Truckee-Carson Irrigation District 2010).

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## C.3 Threat Category: Invasive and Other Problematic Species

### Threat T05—Invasive or Nuisance Animal Species

#### *Affected Conservation Targets*

Anaho Island ecosystem, colonial nesting waterbirds, and colonial nesting waterbird foraging areas

#### *Threat Description*

Harmful animals not originally found within the ecosystem(s) in question and directly or indirectly introduced and spread by human activities.

#### *Threat Details*

Invasive animal species on Anaho Island can compete with native species, alter interactions between species (for example, by predation), alter water regimes, and ultimately result in reduced biotic diversity (Wildlife Action Plan Team 2012). The formation of a land bridge between Anaho Island and the perimeter of Pyramid Lake, or the creation of shallow water conditions, could result in invasive or nuisance terrestrial animal introductions to Anaho Island Refuge. Such introductions pose one of the greatest threats to waterbirds and other biota of Anaho Island Refuge. Novel predators, such as coyotes, could significantly increase wildlife mortality rates and decrease reproductive success. Introduction of feral horses and domestic cattle could cause disturbance to breeding waterbirds, trample eggs, and alter vegetation. In October 2012, canine tracks and scat were found on Anaho Island Refuge, although no animal was ever found (Donna Withers, wildlife refuge specialist, Stillwater National Wildlife Refuge Complex, personal communication). American white pelicans are particularly sensitive to the presence of predators and readily abandon nest sites after

disturbance. In 2004, a subcolony of American white pelicans at Chase Lake abandoned 7,000 nests after being disturbed by coyotes that were removed within 1 week of discovery (Sovada et al. 2008). Subcolonies of California gulls at Mono Lake, California, experienced loss of eggs and altered vegetation. Although a land bridge was not formed, coyotes crossed from the mainland when the water barrier was reduced to less than 20 meters in width and approximately 0.4 meter or less in depth at Negit Island and 50 meters in width and 0.2 meter in depth at Pancake Islet. Coyotes crossed at Negit Island despite the installation of an electric fence on the mainland near Negit Island (Dierks 1991).

Invasive invertebrates, such as the Asian clam (*Corbicula fluminea*), zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena bugensis*) can alter ecosystem dynamics, water flows and quality, and may even enhance incidents of botulism (Perez-Fuentetaja et al. 2006) and other viruses, bacteria, and contaminants (Sousa 2012). Ultimately, these invertebrates can alter waterbird food availability (for example, fish), especially species dependent upon aquatic food resources such as American white pelicans. Asian clams are established in nearby Lake Tahoe and were documented in the Lower Truckee River in 1981 by the Pyramid Lake Paiute Tribe (Wittmann et al. 2008). Zebra and Quagga mussels have both rapidly spread from the eastern U.S. and are found as far West as California. Nevada waters have been invaded by the quagga mussel, which was first found in the Lake Mead National Recreational Area in 2007. The mussel population has increased dramatically in Lakes Mead and Mohave and more recently in the NRMP scope (Lahontan and Rye Patch Reservoirs) (Benson 2014, Pyramid Lake Fisheries n.d.). Efforts are underway by several entities (Truckee River Water Authority, Pyramid Lake Paiute Tribe) to prevent further introductions and spread of these invasive invertebrate species.

### Threat T06—Invasive or Nuisance Plant Species

#### *Affected Conservation Targets*

Anaho Island ecosystem and colonial nesting waterbird foraging areas

### *Threat Description*

Harmful plants not originally found within the ecosystem(s) in question and directly or indirectly introduced and spread by human activities.

### *Threat Details*

Invasive plant species on Anaho Island compete with native species, alter fire and water regimes, and ultimately result in reduced biotic diversity (Wildlife Action Plan Team 2012). Invasive plant seeds or plant parts can be transported in a variety of ways including by humans (by way of their vehicles, tools, shoes, or other items) and wildlife such as birds. Established populations then spread along roads, waterways, and other vector pathways. Invasive plants documented at Anaho Island Refuge, including cheatgrass (*Bromus tectorum*) and red brome (*Bromus rubens*), increase fire risk and severity and can displace native vegetation. Vegetation studies at Anaho Island suggest both cheatgrass and red brome cover have increased since the 1960s (Kulpa and Leger 2013). Medusahead (*Taeniatherum caput-medusae*) is another invasive annual grass species that could threaten the Anaho Island ecosystem, namely through increased fire risk. Although not documented on Anaho Island Refuge, this species has expanded its range throughout northern Nevada over the last 5 years (Wildlife Action Plan Team 2012), increasing the risk of introduction at Anaho Island Refuge.

Invasive plants also threaten waterbodies throughout the waterbird foraging areas. According to the “Pyramid Lake Indian Reservation Comprehensive Resource Management Plan” (Pyramid Lake Paiute Tribe and U.S. Department of Agriculture Natural Resources Conservation Service 2005), approximately 363,000 acres (76 percent) of the Pyramid Lake Paiute Tribe Reservation had invasive plant infestations, including salt cedar (*Tamarix ramosissima*) at approximately 5,000–6,400 acres (1 percent) and perennial pepperweed (*Lepidium latifolium*) at 9,000–12,000 acres (3 percent). The Pyramid Lake Paiute Tribe is also concerned about the spread of Russian olive (*Elaeagnus angustifolia*) along the Truckee River corridor. Russian olive and salt cedar, both phreatophytes, dominate parts of the Truckee River corridor and can

significantly alter the ecosystems they invade, affecting water availability, soil chemistry, fire regimes, and plant composition. Aquatic invasive plants, such as Eurasian watermilfoil (*Myriophyllum spicatum*), also pose a significant threat to waterbodies of the NRMP scope. This species can expand rapidly and form dense canopies at the water surface, ultimately impacting aquatic ecosystems (Parkinson et al. 2010). Eurasian watermilfoil has invaded the Truckee River in areas next to the Pyramid Lake Paiute Tribe Reservation, and eradication efforts are underway by the Truckee Meadows Water Authority and Tahoe Resource Conservation District (DeLong 2014, Pyramid Lake Paiute Tribe and U.S. Department of Agriculture Natural Resources Conservation Service 2005).

## **Threat T07—Pathogens: Aquatic Biota**

### *Affected Conservation Targets*

Colonial nesting waterbird foraging areas

### *Threat Description*

Pathogens such as parasites, bacteria, or viruses that have become out-of-balance or released directly or indirectly due to human activities. Here we are considering pathogens impacting colonial nesting waterbird food resources, specifically fish.

### *Threat Details*

Colonial nesting waterbirds on Anaho Island Refuge rely on fish from Pyramid Lake and the surrounding foraging areas. Although effects of pathogens on cultured fish have been extensively documented, their effects on wild populations have received considerably less attention (Hedrick 1998, Krkosek et al. 2006), and even less so for non-game species. Potential hazards to fish within the NRMP scope include whirling disease, furunculosis, bacterial kidney disease, bacterial gill disease, Ich, and Costia (U.S. Fish and Wildlife Service Lahontan National Fish Hatchery 2005). *R. salmoninarum*, a bacterium found primarily in salmonids, is a causative agent in bacterial kidney disease, which can cause high mortality in fish. This bacterium has been isolated in hatchery-raised Lahontan cutthroat trout and occurs in wild populations of brook, brown, and

rainbow trout within the Truckee River watershed (Stead 2007). Whirling disease, introduced to western states in 1965, is present in the Lahontan Basin. Despite the occurrence of skeletal anomalies symptomatic of whirling disease in Lahontan waters, there has been no clear evidence of their effect on population numbers (Modin 1998). Although individual pathogens alone may not lead to direct mortality in great numbers of fish, their cumulative impacts along with other environmental and ecological factors have the potential to be major controlling factors in fish abundance.

## Threat T08—Pathogens: Terrestrial Biota

### *Affected Conservation Targets*

Anaho Island ecosystem and colonial nesting waterbirds

### *Threat Description*

Pathogens such as parasites, bacteria, or viruses that have become out-of-balance or released directly or indirectly due to human activities. Here we are considering pathogens of Anaho Island biota.

### *Threat Details*

Avian botulism, West Nile virus, and New Castle disease occur both within and outside the NRMP scope. These pathogens infect wildlife and can result in diminished health or death of infected individuals. West Nile virus has been detected in birds (>300 species), mammals, amphibians, and reptiles (Centers for Disease Control and Prevention 2014, Dauphin et al. 2004), including waterbirds. While West Nile virus did not cause any major die offs in the 1978–2003 time period (Rocke et al. 2005), the virus was attributed to increased mortality in American white pelicans breeding in the northern plains (Sovada et al. 2008) and was the most important cause of late season (mid-July to fledging) chick death in the 2006–2008 breeding seasons (Sovada et al. 2013). At Anaho Island Refuge, West Nile virus has been having less of an impact since its arrival (Donna Withers, wildlife refuge specialist, Stillwater National Wildlife Refuge Complex, personal communication). West Nile virus documentation in Washoe County over the last 5 years is low (birds—1, humans—2, mosquitos—18, and

sentinel flock—1) (Centers for Disease Control and Prevention 2014), suggesting this pathogen is not a current threat to Anaho Island Refuge natural resource targets. Avian botulism causes some mortality in pelicans every year in Nevada, but it affects waterfowl much more than other waterbirds (Neel 1999). Records of reported die-offs of the American white pelican held by the U.S. Geological Survey National Wildlife Health Center from 1978 through 2003 indicate that type C botulism (caused by *Clostridium botulinum*) was the major cause of mortality nationwide but had limited impacts in Nevada (Rocke et al. 2005). Newcastle disease is a viral disease affecting all bird species (U.S. Department of Agriculture Animal and Plant Health Inspection Service n.d.). In recent years it was responsible for deceased and sick (later euthanized) cormorant fledglings on the Anaho Island Refuge (U.S. Geological Survey 2006; Donna Withers, wildlife refuge specialist, Stillwater National Wildlife Refuge Complex, personal communication). The prevalence of Newcastle disease in the NRMP scope is unknown.

Parasites can also degrade health of colonial nesting waterbirds or the food sources they depend on. Evidence suggests that some parasites, mostly flies and other arthropods but also nematodes and digeneans, can produce detrimental behavioral or pathologic changes in American white pelicans (Overstreet and Curran 2005).

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## C.4 Threat Category: Energy Production and Mining

### Threat T09—Renewable Energy

#### *Affected Conservation Targets*

Colonial nesting waterbirds and colonial nesting waterbird foraging areas

#### *Threat Description*

Exploring, developing, and producing renewable energy, specifically geothermal power production, solar farms, and wind farms.

#### *Threat Details*

Large portions of Nevada hold potential for the production of energy from solar, wind, and

geothermal sources (U.S Department of the Interior and U.S. Department of Agriculture 2011). Although renewable energy provides benefits to humans, large-scale renewable energy projects could reduce waterbird access to food or cause direct mortality. A wind farm is proposed within the Pah Rah mountain range (Virginia Peak Wind Project), surrounding Pyramid Lake, and would consist of 20–50 wind turbines. Research on offshore wind farms in Europe indicates that turbines can be responsible for high collision mortality in waterbirds (but more so than at terrestrial sites) and that wind farms tend to alter migration routes (Kuvlesky et al. 2007). Solar power, which requires water for cooling, may add additional strain to water resources within the NRMP scope. One of the largest solar farms in the nation, Fish Springs Solar Ranch, is currently under development in Northern Washoe County (Solar Energy Industries Association 2013). Research on avian mortality at solar power plants indicates that collisions with structures, which may be enhanced due to mirrored surfaces, are the main cause of mortality followed by burning in standby points (McCrary and McKernan 1986). Several geothermal projects currently exist in Washoe County and neighboring Churchill, Humboldt, Lyon, Lander, and Pershing Counties. Biomass, methane, and hydro make up the other types of power plants in counties surrounding Pyramid Lake (NVEnergy 2014).

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## C.5 Threat Category: Biological Resource Use

### Threat T10—Fishing and Harvesting Aquatic Resources

#### *Affected Conservation Targets*

Anaho Island ecosystem and colonial nesting waterbirds

#### *Threat Description*

Harvesting aquatic wild animals or plants for commercial, recreation, subsistence, research, or cultural purposes, or for control or persecution reasons; includes accidental mortality and by-catch.

#### *Threat Details*

Sport fishing is a common recreational activity at Pyramid Lake. Pyramid Lake is highly valued by anglers because of its “fame as a trophy trout fishery” (Pyramid Lake Paiute Tribe and U.S. Department of Agriculture Natural Resources Conservation Service 2005). Recreational fishing has the potential to impact the island ecosystem and colonial nesting waterbirds as a result of human disturbance and introduction of invasive or nuisance plants and animals. Boats operating in close proximity to the island or illegal island access by humans and their dogs can stress island wildlife and plants by causing mortality, reducing reproductive success, or altering habitat. The Pyramid Lake Paiute Tribe established a closed boating zone around the island (305-meter [1,000-foot] buffer zone) in order to prevent island access and associated impacts on Anaho Island natural resources (Pyramid Lake Paiute Tribe 2011). The last confirmed illegal access event on the island was in the 1960s (Donna Withers, wildlife refuge specialist, Stillwater National Wildlife Refuge Complex, personal communication).

### Threat T11—Gathering Terrestrial Plants

#### *Affected Conservation Targets*

Anaho Island ecosystem and colonial nesting waterbirds

#### *Threat Description*

Harvesting plants, fungi, and other non-timber and non-animal products for subsistence or cultural purposes.

#### *Threat Details*

Historically, the Pyramid Lake Paiute Tribe collected plants for cultural and subsistence purposes, although the refuge has no record of tribal plant collection at Anaho Island. If plant collection were to occur, it could stress colonial nesting waterbirds (during the breeding season) or other island biota by increasing mortality, reducing reproductive success, and altering habitat. This is not a current threat at Anaho Island Refuge, and it is uncertain if tribal gathering of plants for cultural or subsistence purposes would occur in the future.

## **Threat T12—Hunting and Collecting Terrestrial Animals**

### *Affected Conservation Targets*

Anaho Island ecosystem and colonial nesting waterbirds

### *Threat Description*

Killing or trapping terrestrial wild animals for subsistence or cultural purposes.

### *Threat Details*

Historically, the Pyramid Lake Paiute Tribe collected animal resources (for example, eggs and feathers of colonial nesting birds) at Anaho Island for cultural or subsistence purposes (Evermann 1923, Hall 1925). Collection of bird eggs and feathers could stress colonial nesting waterbirds, resulting in reduced reproductive success or population size. Animal collection could also stress other island biota through increasing mortality, reducing reproductive success, and altering habitat. This is not a current threat at Anaho Island, and it is uncertain if tribal gathering of terrestrial animals for cultural or subsistence purposes would occur in the future.

## **Threat T13—Biotic/Abiotic Monitoring and Other Conservation Work**

### *Affected Conservation Targets*

Anaho Island ecosystem and colonial nesting waterbirds

### *Threat Description*

People spending time in or traveling in natural environments for reasons other than recreation or military activities. Includes research, biotic/abiotic monitoring or inventories, law enforcement surveillance, etc.

### *Threat Details*

Various monitoring efforts are conducted by refuge staff and its partners at Anaho Island, including colonial nesting waterbird reproductive monitoring (February–September). Past banding activities on Anaho Island have resulted in losses of young pelicans (Donna Withers, wildlife refuge specialist, Stillwater National Wildlife Refuge Complex, personal communication). Effects of human

activities around colonial nesting birds include predation of eggs or chicks, cooling or overheating and dehydration of eggs or chicks, accidental crushing of eggs by adults, trampling, and unnecessary stress or regurgitation of foods. Additionally, human intrusion into waterbird nest sites can cause abandonment, especially early in the breeding season during nest site selection, nest building, and incubation (Ryder and Manry 1994). Disturbance keeps adults away from nests and can lead to hypothermia or hyperthermia of eggs and young, increased predation, and ultimately reduced production. Disturbance during the late portion of the nesting season is particularly harmful because late nesting birds will not have another chance to nest. American white pelicans and double-crested cormorants are particularly sensitive to human disturbance (Shuford 1998). Access to the island for the purpose of monitoring or other conservation work could also result in the introduction of invasive species or cause impacts on vegetation communities (for example, trampling). To reduce disturbance, Anaho Island Refuge staff now monitor colonial nesting birds from a distance and do not enter nesting colonies.

## **Threat T14—Recreational Activities**

### *Affected Conservation Targets*

Anaho Island ecosystem and colonial nesting waterbirds

### *Threat Description*

People spending time in nature or traveling in vehicles outside of established transport corridors, usually for recreational reasons. May include consumptive uses like fishing and non-consumptive uses like bird watching.

### *Threat Details*

Recreational activities on and surrounding Pyramid Lake include hunting, fishing, boating, discharging fireworks, and other tribal economic endeavors (for example, special events, festivals, fishing tournaments, and so on). Numerous studies point to recreational boating as a potential disturbance to waterbirds (York 1994). In the early half of the 20th century, tourists and boaters frequently accessed the island resulting in a great number of trampled nests and mortality in young pelicans (Donna Withers, wildlife refuge specialist, Stillwater National

Wildlife Refuge Complex, personal communication; Hall 1925). Hunting, trapping, and possession of firearms by non-tribal members within the boundaries of the Pyramid Lake Paiute Tribe Reservation are prohibited. It is, however, lawful to discharge fireworks on the west side of Pyramid Lake. Results of a recent disturbance study of Brandt's cormorants indicated that fireworks launch sites in close proximity (up to several kilometers) to nesting seabirds can result in unlawful disturbance and nest failure (Stephensen et al. 2012). Disturbance observations made on brown pelicans in Southern California showed that recreational activities such as waterfowl hunting and dog-walking caused a great deal of disturbance to nesting birds (Jaques et al. 1996). The Pyramid Lake Paiute Tribe established a closed boating zone around the island (152-meter [500-foot] buffer zone) in order to prevent island access and associated impacts on Anaho Island natural resources. The risk of human disturbance at Anaho Island could increase significantly if Pyramid Lake water levels continue to decline and a land bridge forms between Anaho Island and the perimeter of Pyramid Lake.

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## C.6 Threat Category: Pollution

### Threat T15—Agricultural and Forestry Effluents

#### *Affected Conservation Targets*

Colonial nesting waterbirds and colonial nesting waterbird foraging areas

#### *Threat Description*

Water-borne pollutants from agricultural, silvicultural, and aquaculture systems that include nutrients, toxic chemicals, and sediments along with the effects of these pollutants on the sites where they are applied.

#### *Threat Details*

Indirect and direct exposure to water-borne pollutants may affect colonial nesting waterbirds on Anaho Island and the aquatic food resources on which they rely in the surrounding NRMP scope. Mining, logging, and sawmill operations have historically led to severe degradation of water quality throughout the Truckee and

Carson Rivers (U.S. Bureau of Reclamation et al. 2008). Agriculture is the primary source of pollutants in wetlands and important water bodies of the NRMP scope (Donna Withers, wildlife refuge specialist, Stillwater National Wildlife Refuge Complex, personal communication). Agricultural runoff, along with streamflow reductions and alterations, loss of riparian vegetation that shades the river, and discharge of treated sewage effluent, currently promote degraded water quality and increased water temperature in the Truckee River. In the past, uncontrolled cattle grazing, poor agricultural practices, and feral horses resulted in the additional loss of instream and riparian habitat of the Lower Truckee River leading to increased turbidity and nitrogen levels and threatening local fish species. The Pyramid Lake Paiute Tribe has taken steps to address these issues by installing cattle fencing, installing solar powered wells and water tanks, leveling agricultural fields, and restoring sections of riverbanks and wetlands (U.S. Environmental Protection Agency n.d.).

### Threat T16—Industrial and Military Effluents

#### *Affected Conservation Targets*

Colonial nesting waterbirds and colonial nesting waterbird foraging areas

#### *Threat Description*

Water-borne pollutants from industrial and military sources including mining, energy production, and other resource extraction industries that include nutrients, toxic chemicals, and sediments.

#### *Threat Details*

Indirect and direct exposure to water-borne pollutants may affect colonial nesting waterbirds on Anaho Island Refuge and the aquatic food resources they rely upon in the surrounding NRMP scope. The primary source of industrial pollutants in waterbodies of the NRMP scope is mining (Donna Withers, wildlife refuge specialist, Stillwater National Wildlife Refuge Complex, personal communication). Historical gold mining has been a source of pollution at Pyramid Lake. Several mines exist within the borders of the Pyramid Lake Indian Reservation, including the Packard Mine, Sano

Mine, Lakeview Mine, Guanomi Mine, and Sand Pass gravel pit. In 1994, the Bureau of Land Management listed the Guanomi site, and abandoned molybdenum mine, as the most potentially hazardous on the reservation. Runoff from the mine that is highly acidic drains through a wetland area and small stream that lead directly to Pyramid Lake. In 2004 the Pyramid Lake Paiute Tribe Environmental Department began reclamation on the mine (Pyramid Lake Paiute Tribe and U.S. Department of Agriculture Natural Resources Conservation Service 2005). The Carson River basin, from New Empire to Stillwater and the Carson Sink (Lyon, Storey, and Churchill Counties) is a designated Superfund site because of the high levels of methyl mercury. Humans are advised against eating any fish from Big and Little Washoe Lakes, Lahontan Reservoir, and the Carson River from Dayton downstream to the reservoir (U.S. Environmental Protection Agency 2014). Within and near the greater NRMP scope, gravel, gypsum, limestone, clay, diatomite, and gold have been the focus materials of major active mines (Driesner and Coyner 2011). The effects of gravel, gypsum, limestone, clay, and diatomite on waterbird health are not currently known by refuge staff, although it is suspected that they contribute to sediment deposition in foraging areas.

Since construction of the Newlands Project (an early Bureau of Reclamation irrigation project) wetlands within the NRMP scope have been partially maintained with drainwater, which can contain contaminants. Historically, sediments from some wetlands contained elevated concentrations of arsenic, lithium, mercury, molybdenum, and zinc and biological tissues from some wetlands also contained elevated concentrations of materials associated with adverse biological effects on wildlife, particularly migratory birds (U.S. Bureau of Reclamation et al. 2008). Organochlorine pesticide and PCB concentrations in American white pelican eggs tested on Anaho Island were below known effect levels, with biologically insignificant shell thinning (Wiemeyer et al. 2001). Mercury concentrations continue to be of greatest concern due to the elevated levels found in livers of some adult pelicans from the area. However, no evidence of adverse effects of mercury on hatching success at the Anaho

Island Refuge colony has been found to date. Historically, sediments from some wetlands contained elevated concentrations of arsenic, lithium, mercury, molybdenum, and zinc and biological tissues from some wetlands also contained elevated concentrations of materials associated with adverse biological effects on wildlife, particularly migratory birds (U.S. Bureau of Reclamation et al. 2008). Organochlorine pesticide and PCB concentrations in American white pelican eggs tested on Anaho Island were below known effect levels, with biologically insignificant shell thinning (Wiemeyer et al. 2001). Mercury concentrations continue to be of greatest concern due to the elevated levels found in livers of some adult pelicans from the area. However, no evidence of adverse effects of mercury on hatching success at the Anaho Island colony has been found to date (Wiemeyer et al. 2004).

## **Threat T17—Household Sewage and Urban Waste Water**

### *Affected Conservation Targets*

Colonial nesting waterbirds and colonial nesting waterbird foraging areas

### *Threat Description*

Water-borne sewage and non-point runoff from housing and urban areas that include nutrients, toxic chemicals, or sediments.

### *Threat Detail*

Indirect and direct exposure to water-borne pollutants may affect colonial nesting waterbirds on Anaho Island Refuge and the aquatic food resources they rely upon in the surrounding NRMP scope. During the 1980s, nitrogen and phosphorus loads associated with non-point sources such as discharge from Truckee Meadows Water Reclamation Facility (TMWRF) significantly impacted the Truckee River by enhancing benthic algal growth that resulted in oxygen depletion (U.S. Bureau of Reclamation 2013). Water reclamation facilities still discharge treated waste water into the Truckee River but have since expanded phosphorus and nitrogen removal facilities. Other current non-point sources that may be contributing to pollutants in the Truckee River include residential areas (septic systems, stormwater, underground storage tanks,

construction), recreational activities (special events, camping, lake recreation, boat servicing), and waste disposal (illegal dumping, solid waste management, spills and emergency response) (Anderson 2013).

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## C.7 Threat Category: Transportation and Service Corridors

### Threat T18—Flight Paths

#### *Affected Conservation Targets*

Anaho Island ecosystem and colonial nesting waterbirds

#### *Threat Description*

Air and space transport

#### *Threat Details*

Aircraft flights over Anaho Island Refuge and surrounding waterbodies could disturb wildlife, especially birds. Military, private, and commercial aircraft regularly fly over Anaho Island Refuge and the surrounding foraging areas. Refuge biologists have witnessed aircraft flying well below the recommended 2,000-foot flight ceiling set in place by the Federal Aviation Administration (Donna Withers, wildlife refuge specialist, Stillwater National Wildlife Refuge Complex, personal communication). There are no reports of waterbird disturbance from low-flying aircraft while refuge staffs were present on or near Anaho Island. Low flying aircraft over the Stum Lake American white pelican breeding colony in British Columbia have caused high levels of disturbance and offspring mortality (Bunnell et al. 1981, Dunbar 1984). Behavioral observations of brown pelicans in southern California, on the other hand, showed that although low-flying aircraft were the among the most frequent disturbance events they had a much lower impact on the colony compared to nearby hunting and recreation (Jaques et al. 1996). There are no reported aircraft strikes by pelicans, cormorants, terns, herons, or egrets for 1990–2013 in Nevada. During the same period, there were 14 strikes by gulls, 4 of them being California gulls, 1 ring-billed gull, and 9

unidentified gull species (Federal Aviation Administration 2014).

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## C.8 Threat Category: Fire and Fire Suppression

### Threat T19—Altered Fire Regime

#### *Affected Conservation Targets*

Anaho Island ecosystem

#### *Threat Description*

Fire suppression to protect homes, inappropriate fire management, escaped agricultural fires, arson, campfires, and fires for hunting.

#### *Threat Details*

Although there has only been one recorded incident of wildfire on the island, a single fire could potentially devastate the entire ecosystem on Anaho Island. Highly flammable invasive grasses on the island (cheatgrass and red brome) increase the risk of a devastating fire as well as the further spread of invasive plant species (Wildlife Action Plan Team 2012). Some species on the island, such as the long-lived, slow reproducing and possibly endemic rattlesnake, are particularly vulnerable to environmental disasters such as fire (Terrill 2007). Various fires have burned a large portion of the surrounding Pyramid Lake Paiute Tribe Reservation land and changed the dominant vegetation structure (Pyramid Lake Paiute Tribe and U.S. Department of Agriculture Natural Resources Conservation Service 2005). Bureau of Land Management fire data from 1980 to 2013 indicate that the frequency (number of fires per year) and area (number of acres burned per year) of fires on surrounding tribal land are increasing, and that the majority of these fires are human-made rather than natural. Hall (1925) described how boaters and tourists, after becoming stranded on the island, would light fires to stay warm through the cold desert night. Despite a no-boating buffer zone, the possibility of unauthorized persons accessing the island is always a threat.

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