San Pablo Bay National Wildlife Refuge
Final Comprehensive Conservation Plan

Prepared By
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Implementation of this Comprehensive Conservation Plan and alternative management actions/programs have been assessed consistent with the requirements of the National Environmental Policy Act (42 USC 4321 et seq.).

Disclaimer

Comprehensive Conservation Plans provide long term guidance for management decisions and set forth goals, objectives, and strategies needed to accomplish refuge purposes and identify the Service's best estimate of future needs. These plans detail program planning levels that are substantially above current budget allocations and, as such, are primarily for Service strategic planning and program prioritization purposes. The plans do not constitute a commitment for staffing increases, operational and maintenance increases, or funding for future land acquisition.

U.S. Fish and Wildlife Service

San Pablo Bay National Wildlife Refuge

Final Comprehensive Conservation Plan and Environmental Assessment

Vision Statement

"San Pablo Bay National Wildlife Refuge lies within the larger San Francisco Estuary, one of the largest estuaries along the Pacific Coast. The location of San Pablo Bay relative to freshwater influences of the Sacramento and San Joaquin Rivers and saline waters of the Pacific Ocean result in a unique and rich array of physical and biological conditions. Large contiguous expanses of pickleweed-dominated tidal marsh support high densities of the endangered salt marsh harvest mouse, as well as provide habitat for the endangered California clapper rail and other sensitive estuarine-dependent species. This Estuary is of hemispheric importance to shorebirds. Hundreds of thousands of shorebirds and waterfowl use this area to overwinter or rest and feed as they migrate along the Pacific Flyway.

Through history, humans have altered San Pablo Bay, resulting in high levels of contaminants and conversion of tidal environments to agricultural lands, salt ponds, and other non-tidal conditions. Despite these changes and the proximity to a highly urbanized environment, lands immediately surrounding the Refuge are dominated by open space. These open spaces provide opportunities to restore historic tidal and upland environments, directly linking them to adjacent uplands and freshwater seasonal wetlands, a rare historic feature of the larger San Francisco Estuary and a condition that will enhance and sustain populations of native flora and fauna.

The Refuge, working with partners, will play an important role in protecting, enhancing, and restoring tidal and upland environments of San Pablo Bay, especially where opportunities exist to expand or link tidal wetlands to uplands and freshwater seasonal wetlands. Our efforts will focus on the use of natural processes, where possible, to achieve desired environmental structure and function. An adaptive management framework will be used to respond to changing environmental conditions, especially with respect to invasive species, enhancement and restoration projects, and projected climate-related events.

Although humans have had negative impacts on San Pablo Bay, a century of agricultural uses has resulted in the preservation of open spaces where tidal wetlands and native grasslands can be restored. This environment links people to open space and their agrarian past. The Refuge will be an open space resource where wildlife and people connect—where people belong with nature and are immersed in it. The Refuge will be inclusive of all age groups, backgrounds, and skill levels by providing a variety of opportunities, including fishing, hunting, trails, interpretive signs and guided tours, and off-refuge environmental education to facilitate that connection, that belonging, that immersion."

U.S. Fish and Wildlife Service
San Francisco Bay National Wildlife Refuge Complex
9500 Thornton Avenue
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U.S. Department of the Interior
Fish and Wildlife Service
Pacific Southwest Region

FINDING OF NO SIGNIFICANT IMPACT

Environmental Assessment for Management of San Pablo Bay National Wildlife Refuge
Sonoma, Napa, and Solano Counties, California

The U.S. Fish and Wildlife Service (Service) has completed the Comprehensive Conservation Plan (CCP) and the Environmental Assessment (EA) for the San Pablo Bay National Wildlife Refuge (Refuge). The CCP will guide Refuge management for the next 15 years. The CCP and EA (herein incorporated by reference) describe the Service's proposals for managing the Refuge and their associated effects on the human environment under their alternatives, including the no action alternative.

Decision

Following comprehensive review and analysis, the Service selected Alternative C for implementation because it is the alternative that best meets the following criteria:

- Achieves the mission of the National Wildlife Refuge System;
- Achieves the purposes of the San Pablo Bay National Wildlife Refuge;
- Achieves the Service's vision and goals for the Refuge;
- Maintains and restores the ecological integrity of the habitats and populations of the Refuge;
- Addresses important issues identified during the scoping process;
- Addresses the legal mandates of the Service and the Refuge;
- Is consistent with scientific principles of sound fish and wildlife management; and
- Incorporates priority public uses which are compatible with the Refuge purposes and the Refuge System mission.

Alternatives Considered

The following is a brief description of the alternatives for managing San Pablo Bay Refuge, including the selected alternative (Alternative C). For a complete description of each alternative, see the EA.

Alternative A

Under the No Action Alternative, the Service would continue current management activities on the Refuge. The Refuge currently has no comprehensive management plan. Current management activities include wildlife surveys and research; non-native vegetation and native plant restoration; tidal restoration and enhancements; mosquito management; wildlife-oriented recreational opportunities; and limited environmental education. This alternative was not selected because it provides limited restoration efforts, does not manage for all wildlife on the Refuge, and provides limited wildlife-oriented and environmental education opportunities.

Alternative B
Under Alternative B, the Service would expand current management activities including: develop an inventory and monitoring program; expand and prioritize tidal restoration and enhancement activities; assess climate change impacts on refuge resources; provide considerable additions for visitor access; and increase the environmental education program. This alternative was not selected because it provides limited native plant restoration actions and fewer environmental education opportunities.

Alternative C (selected alternative)
Under Alternative C, the Service would implement activities as described under Alternative B. In addition, the Service would develop wildlife population goals and considerably expand environmental education and interpretation opportunities. Additional habitat management activities would be conducted including improving hydrological connectivity of tidal marsh habitat and developing priorities for conservation and restoration of sub-tidal habitat. A visitor services plan would be developed to provide further detail and design of public opportunities on the Refuge.

Effects of management of the Refuge on the human environment
As described in the EA, implementing the selected alternative is not expected to have significant impacts on any of the environmental resources identified in the EA. A summary of the impacts analysis and conclusions follows:

Hydrology
Tidal restoration and enhancement as well as improving hydrological connectivity activities prescribed in the selected alternative are expected to have a positive benefit to hydrologic patterns of tidal marshes where little water circulation has resulted in poor quality vegetation. The selected alternative is not likely to result in any adverse impacts to private properties. The Service has concluded that implementation of the CCP will have no significant impact to hydrology.

Water Quality and Contaminants
Tidal restoration and enhancement activities may result in short-term erosion and increased turbidity in waterways. However, in the long-term these activities will restore tidal exchange of water through the tidal marshes that will improve overall water quality. Removal of non-native vegetation through manual, chemical and other appropriate methods is not expected to affect water quality. Only herbicides approved for aquatic environments will be permitted for use near water bodies. Soil that is disturbed through manual weed removal will be replanted with native plants to offset erosion potential. Other best management practices that will be implemented to minimize soil erosion include constructing fencing to prevent soil from escaping the area. The Service has concluded that implementation of the CCP will have no significant impact to water quality.

Geology and Soils
Chemical and manual removal of nonnative vegetation; construction of environmental education and other public access infrastructure; tidal marsh restoration and enhancement activities; and increased public visitation may result in soil erosion. Soils are not expected to

be affected by herbicides because they will be applied in low concentrations and approved for use under a Pesticide Use Proposal. Nonnative vegetation will be replaced by native tidal marsh plants to offset long-term erosion. Infrastructure will be placed in sites with the least soil disturbance and signs will be installed to direct the public to stay on trails. Tidal restoration activities such as breaches or lowering of berms to restore tidal influence could result in disturbance to soils, erosion and increased sedimentation. Other best management practices that will be implemented to minimize soil erosion include constructing fencing to prevent soil from escaping the area. The Service has concluded that implementation of the CCP will have no significant impact to soils.

Air Quality and Climate
Activities such as tidal marsh restoration and construction of public access infrastructure under the selected alternative are expected to minimally increase air particulates in the immediate area, primarily from increased dust and tailpipe emission from heavy equipment operation. Dust generated from restoration activities will be minimized by dampening the soil. Any prescribed burns will comply with San Francisco Bay Area Air Quality Management District permit requirements and best management practices. Increased vehicle emissions from additional management activities and increased visitation would result in minor increases in tailpipe emissions to the area. However, it is reasonable to assume that an increase in visitation to the Refuge may reflect visitors' choosing the Refuge as their destination rather than another location offering similar opportunities in the San Francisco Bay area. For this reason the Service anticipates that there would be no new or a minimal increase in vehicle trips. The Service has concluded that implementation of the CCP will have no significant impact to air quality or the climate of the area.

Hazardous Materials and Safety Issues
Herbicides and pesticides are the only known hazardous materials that will be used on the Refuge. Only approved herbicides and pesticides will be permitted for use on the Refuge. Herbicides are not expected to result in any significant impacts as they will be stored in an approved spill-proof locker, applied according to label instructions, and only applied by trained personnel. Public access will be improved with the addition of safe entry and exit points to public access sites and the office headquarter. The Service has concluded that implementation of the CCP will have no significant impact to safety or from hazardous materials.

Wilderness
There is no designated wilderness at the Refuge; therefore implementing the CCP will have no impact on wilderness.

Vegetation and Habitat
Management under the selected alternative will result in widespread removal of non-native vegetation. This vegetation will be replaced by native vegetation which is beneficial to the tidal marsh species on the Refuge. Herbicides and manual removal will be used to reduce non-native vegetation. To minimize the effects of herbicides on native species, herbicides will be used when native plants are not in their growing season. Tidal restoration and enhancement will improve hydrology to the tidal marsh that will also improve the quality of

vegetation in these areas. Increased public access opportunities should result in minor loss or damage to vegetation as law enforcement, signage, and closures of sensitive areas will reduce impacts. The Service has concluded that implementation of the CCP will have no significant impact to native vegetation.

Wildlife

Long-term benefits for wildlife are expected under the selected alternative. Expanded research, monitoring, and development of wildlife population goals will provide information on lesser-known species on the Refuge as well as improve long-term understanding of wildlife impacts and needs. Vegetation removal, mosquito management, and tidal restoration would result in disturbance to wildlife but will improve wildlife habitat in the long term. Management activities will be conducted during non-sensitive breeding periods when feasible. Acquisition objectives will be beneficial to wildlife by increasing habitat availability. Hunting will result in both temporary disturbances to some wildlife and mortality of individual waterfowl. However, this activity is not expected to result in a population level effect to waterfowl species at a local, regional, or Pacific Flyway scale. Other public access opportunities may also increase disturbance. Access will be located in less sensitive wildlife areas while law enforcement, signage, and fencing would be augmented to support these opportunities. Implementing the CCP will have no significant impact to wildlife.

Fish and Marine Invertebrates

Tidal restoration could result in entrapment of fish and marine invertebrates during low tide conditions. Mitigation elements include avoiding construction activities during migration periods and use of water control structures to prevent entrapment. Restoration is expected to increase sub-tidal habitat that will benefit fish and marine invertebrate populations. Sub-tidal monitoring will improve knowledge of fish and marine invertebrates. Fishing activity will increase as a result of shoreline fishing at Cullinan and potentially Guadalcanal. However, the Service has concluded that demand is expected to be small with no adverse effects to fish population levels. Implementing the CCP will have no significant impact to fish and marine invertebrates.

Endangered Species

Long-term benefits for Federally listed species are expected under the selected alternative. Several threatened and endangered species are or may be present on the Refuge: the California clapper rail, salt marsh harvest mouse, California red-legged frog, steelhead, Chinook salmon, delta smelt, and green sturgeon. The Federally listed plant, soft bird's-beak, may also be present on the Refuge but individuals have not been identified. Tidal marsh restoration and enhancement, removal of nonnative vegetation, mosquito management, and restoration of native plant communities may result in disturbance to individuals and/or temporary loss of habitat. Potential mitigation measures to reduce impact to individuals may include surveying for presence or absence of individuals; providing a buffer near nest locations; avoiding activities during the nesting season; avoiding construction during fish migration periods; using water control structures to prevent fish entrapment; trapping and transplanting individuals to other sites; installing barrier fence to prevent re-entry; and slow flooding to allow mammals to seek refugia in higher elevation pickleweed. In the long-term,

these activities are expected to benefit listed species by increasing high quality habitat. Habitat known to have listed species will remain closed or restricted to public access. Refuge staff is in consultation with the Sacramento Fish and Wildlife Office under Section 7 of the Endangered Species Act regarding the potential effects of implementing the CCP on the California clapper rail, salt marsh harvest mouse, California red-legged frog, delta smelt, and soft bird's-beak. In addition to the mitigation measures identified in the EA, we will implement any reasonable and prudent measures, and terms and conditions in the Intra-Service biological opinion. No new activities under the CCP will be initiated until this consultation is complete. The CCP is a programmatic document and as tidal restoration projects are developed in the future, the Service will consult with the Sacramento Fish and Wildlife Office to ensure that all measures to minimize potential impacts to listed species are included in the project design. Therefore, we have concluded that implementing the CCP will have no significant adverse impact to threatened and endangered species under the jurisdiction of the Service.

Steelhead, Chinook salmon, and green sturgeon are under the jurisdiction of the National Marine Fisheries Service. The Service has consulted with National Marine Fisheries Service and has concluded that the programmatic activities broadly described in the CCP are not likely to adversely affect these fish species. As tidal restoration projects are developed in the future, the Service will consult with the National Marine Fisheries Service to ensure that all measures to minimize potential impacts to listed fish species are included in the project design. Tidal restoration projects will have long-term beneficial effects for fish species. Therefore, we have concluded that implementing the CCP will have no significant adverse impact to threatened and endangered species under the jurisdiction of the National Marine Fisheries Service.

Recreation

Under the selected alternative, a variety of wildlife-dependent opportunities would be expanded to provide an estimated 5,000 additional visits annually (current estimated visits in 2009 was 5,550). Public access will be provided in locations where compatible with wildlife. Recreational opportunities will be expanded to include docent-led tours by foot and by non-motorized boat (e.g., kayak). Shoreline fishing would be developed, but there will be no net increase in the waterfowl hunt area. An expanded field-based environmental education program at the Sonoma Baylands (when acquired) would also be developed under the selected alternative. The Service has concluded that actions in the CCP will have a beneficial impact on visitor services.

Economy

The selected alternative provides increased opportunities for public use of an additional 5,000 visits annually. This increase in visitors could benefit the local economy and employment if visitors also utilize local businesses on their visit to the Refuge. The Service has concluded that implementation of the CCP will have no significant impact on the local region's social and economic environment.

Cultural Resources

There are no identified historic or prehistoric elements on the Refuge. However, the office headquarters is located on an old farm property. While not identified as historically significant, we will strive to maintain the character of these farm structures during any renovation, repair, or modification. Any identified cultural resource on the Refuge will receive protection guided by Federal laws including but not limited to, the Archaeological Resources Protection Act; the Archaeological and Historic Preservation Act; the Native American Graves Protection and Repatriation Act; and the National Historic Preservation Act. The Service has concluded that implementation of the CCP will have no significant impact on cultural resources.

Climate Change
The selected alternative is not expected to significantly impact climate change. Tidal restoration and enhancement activities are expected to reduce climate change by increasing carbon sequestration. Refuge staff would also implement methods to reduce its carbon footprint. The Service has concluded that implementation of the CCP will have no significant impact on climate change.

Environmental Justice
No minority and low-income populations or communities would be disproportionately affected by the selected alternative. Outreach efforts will be directed towards local minority and low-income populations. The Service has concluded that no disproportionate adverse human health or environmental effects would result from the selected alternative.

Public Review
The planning process incorporated public involvement in developing and reviewing the CCP. This included a public scoping meeting, two planning updates, and public review and comment on the planning documents. The details of the Service's public involvement process are described in the CCP and EA.

Conclusions
Based on review and evaluation of the information contained in the supporting references, I have determined that implementing Alternative C as the CCP for management of San Pablo Bay National Wildlife Refuge is not a major Federal action that would significantly affect the quality of the human environment, within the meaning of section 102(2)(c) of the National Environmental Policy Act of 1969, as amended. Accordingly, the Service is not required to prepare an environmental impact statement.

This Finding of No Significant Impact and supporting references are on file at the U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, 1 Marshlands Road, Fremont, California, 94536 (telephone 510/ 792 0222); U.S. Fish and Wildlife Service, San Pablo Bay National Wildlife Refuge, 7715 Lakeville Highway, Petaluma, California, 94954 (telephone 707/ 769 4200); and the U.S. Fish and Wildlife Service, California/Nevada Refuge Planning Office, 2800 Cottage Way, Sacramento, California, 95825 (telephone 916/ 414 6500). These documents can also be found on the Internet at http://www.fws.gov/cno/refuges/planning.html. These documents are available for public inspection. Interested and affected parties are being notified of this decision.

Supporting References

U.S. Fish and Wildlife Service. 2011. Final Comprehensive Conservation Plan and Environmental Assessment for the San Pablo Bay National Wildlife Refuge.

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10.5.2011
Date

Table of Contents

Chapter 1. Introduction and Background **1**
Introduction 1
Purpose and Need for this CCP 1
The U.S. Fish and Wildlife Service and the National Wildlife Refuge System 2
U.S. Fish and Wildlife Service 2
The National Wildlife Refuge System 2
Legal and Policy Guidance 3
Appropriate Use Policy 3
Compatibility Policy 4
Biological Integrity, Diversity, and Environmental Health Policy 4
Wilderness Review 5
The San Francisco Bay National Wildlife Refuge Complex 5
The San Pablo Bay National Wildlife Refuge 7
Location 7
Refuge Setting 7
History of Refuge Establishment and Acquisition 8
Land Protection 9
Land Conservation Methods 9
Refuge Purposes 10
Related Projects and Studies in the Area 11
Conservation Priorities and Initiatives 11
Chapter 2. The Comprehensive Conservation Planning Process **15**
Introduction 15
The Planning Process: How this CCP was Developed 15
The Planning Core Team 16
The Planning Expanded Team 16
Public Involvement in Planning 16
Issues, Concerns, and Opportunities Identified by the Public 17
Management Issues and Challenges Identified by Staff 17
Development of the Refuge Vision 19
Development of the Refuge Goals, Objectives, and Strategies 19
Development of Alternatives 20
Selection of the Refuge Proposed Action 21
Plan Implementation 21
Chapter 3. Affected Environment **23**
Ecoregion Setting 23
Flyway Setting 23
Natural and Historic Context 24
Physical Environment 24
Topography 24
Geology and Soils 26
Hydrology 26

Water Quality 28
Climate and Air Quality 29
Hazardous Materials and Contaminants 30
Habitat 32
Biological Resources 36
Invertebrates 37
Fish 38
Birds 43
Mammals 50
Federally Listed Wildlife Species at the Refuge 51
Federally Listed Plant Species at the Refuge 56
Other Sensitive Species 57
Reptiles and Amphibians 51
Description by Unit 57
Sears Point 58
Lower Tubbs Island 59
Tubbs Island Setback 59
Tolay Creek 61
Figueras Unit 62
Cullinan Ranch 63
Strip Marsh 64
Guadalcanal 64
Sonoma Baylands 65
Skaggs Island 66
Open Bay and Mudflats 66
Cultural Resources 66
Social and Economic Environment 67
Transportation 67
Employment 67
Local Economy 68
Land Use 68
Demographics 69
Public Use 70
Wildlife Observation and Photography 70
Boating 70
Fishing 70
Hunting 71
Chapter 4. Current Refuge Management and Programs **73**
Habitat Management, Enhancements, and Restoration 73
Acquisitions 75
Vegetation Management 77
Invasive species 77
Early Detection 79
Plant Restoration 80

Fish and Wildlife Management 80
Migratory Bird Management 80
Threatened and Endangered Species Management 81
Fish and Invertebrate Management 81
Recreational Fishing and Hunting Management 83
Other Management Activities that Affect the Refuge 85
Fire Prevention and Hazard Reduction 85
Law Enforcement and Resource Protection 85
Facilities Maintenance 85
Safety 86
Public Uses 86
Environmental Education and Outreach 86
Existing Partnerships 87
Chapter 5. Refuge Management Direction: Objectives and Strategies **89**
San Pablo Bay NWR Vision Statement 89
Wildlife Management 90
Habitat Management 95
Compatible Wildlife-Oriented Recreation 106
Environmental Education and Outreach 108
Chapter 6. Plan Implementation **113**
Implementation 113
Funding and Personnel 113
Step-Down Management Plan 116
Appropriate Uses and Compatibility Determinations 117
Compliance Requirements 117
Monitoring and Evaluation 118
Partnership Opportunities 118
Adaptive Management 118
Plan Amendment and Revision 119

Tables

Table 1. Habitat Goals for the San Francisco Bay Joint Venture 12
Table 2. Changes in Acres of Habitat Types in San Francisco Bay Estuary 24
Table 3. Tidal Datum for Petaluma River Entrance 27
Table 4. Water Quality Contaminant Trends for the San Francisco Estuary 28
Table 5. Impaired Water Bodies in the Vicinity of San Pablo Bay 29
Table 6. 2003 Contaminants Survey at Cullinan Ranch 31
Table 7. Arithmetic Means and Standard Deviations of Trace Elements (mg/kg dry wt) in Core Samples Taken from Cullinan Ranch Tidal Marsh Areas. Recommended Concentrations are Given for Comparison . 31
Table 8. Arithmetic Means and Standard Deviations of Trace Elements (mg/kg dry wt) in Core Samples Taken from Strip Marsh Tidal Marsh Areas. Recommended Concentrations are Given for Comparison 32
Table 9. Invertebrates that Hatch or Rear in San Pablo Bay 37
Table 10. CDFG Otter Trawl Survey Totals of Highest Recorded Number Species (combined) in San Pablo Bay, 2000-2007 40

Table 11. CDFG Mid-water Trawl Survey Totals of Highest Recorded Number Species (combined) in San Pablo Bay, 2000-2007 40
Table 12. Fish Species that Hatch or Rear in San Pablo Bay 42
Table 13. Dominant Shorebird Species of the San Francisco Bay Wetlands 44
Table 14. Results of the November 2006 Shorebird Survey of San Francisco Bay 45
Table 15. Aquatic Species Found at Tolay Creek, 1999-2003 Surveys 62
Table 16. Cullinan Ranch Wetland Acreages 63
Table 17. Employment Demographics for Sonoma County (2002) 67
Table 18. Employment Demographics for Solano County (2002) 68
Table 19. Solano County Demographic (2006 estimate) 69
Table 20. Sonoma County Demographic (2006 estimate) 69
Table 21. Examples of Recent and Long-term Monitoring, Research, and Investigations that Occur Within San Pablo Bay 82
Table 22. Staffing Plan and Needs 115
Table 23. Budget Proposal for San Pablo Bay NWR Comprehensive Conservation Plan 115
Table 24. Sample of Maintenance Costs Associated with San Pablo NWR 116

Figures

Figure 1. San Francisco Bay NWR Complex 6
Figure 2. San Francisco Bay Sub-regions 7
Figure 3. Units of San Pablo Bay NWR 8
Figure 4. CCP Planning Process 16
Figure 5. Preliminary Assessment of Habitat Types for San Pablo Bay NWR 33
Figure 6. 1997–2007 Waterfowl Survey Results in North Bay in the San Francisco Bay Estuary (number of birds surveyed per 100 transect miles) 48
Figure 7. Sensitive Species on San Pablo Bay NWR 57
Figure 8. Map of Refuge Units 58
Figure 9. Mapping Results for 2005-06 Invasive Pepperweed Census 78
Figure 10. Hunting Areas in the North Bay 84

Appendices

Appendix A References
Appendix B Species List
Appendix C Environmental Assessment
Appendix D Appropriate Use Determinations
Appendix E Compatibility Determinations
Appendix F Wilderness Inventory
Appendix G Mosquito Management Plan and Environmental Assessment
Appendix H Applicable Laws and Executive Orders
Appendix I Persons Responsible for Preparing this Document, Core Team Members, and Expanded Team Members
Appendix J Response to Comments

Glossary of Terms and Acronyms

Bay	San Francisco Bay
BMP	Best Management Practice
Caltrans	California Department of Transportation
CCP	Comprehensive Conservation Plan
CDFG	California Department of Fish and Game
CNDDB	California Natural Diversity Database
DO	Dissolved oxygen
EA	Environmental Assessment
EDRR	Early Detection and Rapid Response
EO	Executive Order
FMTS	Fall Mid-Water Trawl Survey
GIS	Geographic Information System
IPM	Integrated Pest Management
I&M	Inventory and Monitoring
ISP	Invasive Spartina Project
MMS	Maintenance Management System
MSMVCD	Marin-Sonoma Mosquito and Vector Control District
NEPA	National Environmental Policy Act
NRCS	U.S. Department of Agriculture/Natural Resources Conservation Service
NWR	National Wildlife Refuge
NWRS/Refuge System	National Wildlife Refuge System
PCB	Polychlorinated biphenyl
PRBO	PRBO Conservation Science (founded as Point Reyes Bird Observatory)
Refuge	San Pablo Bay National Wildlife Refuge
RLGIS	Refuge Lands Geographic Information System
RONS	Refuge Operating Needs System
Service/ USFWS	U.S. Fish and Wildlife Service
SF	San Francisco
SLT	Sonoma Land Trust
Draft Tidal Marsh Recovery Plan	Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California
USGS	U.S. Geological Survey
1997 Improvement Act	The National Wildlife Refuge System Improvement Act of 1997
WHSRN	Western Hemisphere Shorebird Reserve Network
WNV	West Nile Virus

Chapter 1. Introduction and Background

Introduction

San Pablo Bay National Wildlife Refuge (Refuge) is located in San Pablo Bay in northern California. The Refuge is composed of eight units, some of which are owned by the State of California but managed by the U.S. Fish and Wildlife Service (Service). The Refuge supports habitat for migratory birds on the Pacific Flyway and endangered species.

The Service prepared this Final Comprehensive Conservation Plan (CCP) to guide refuge management for the next 15 years. The CCP provides a description of the desired future conditions and long-range guidance to accomplish the purposes for which the Refuge was established. The CCP and accompanying Environmental Assessment (EA) address Service legal mandates, policies, goals, and National Environmental Policy Act (NEPA) compliance.

The CCP is divided into six chapters: Chapter 1, Introduction and Background; Chapter 2, The Comprehensive Conservation Planning Process; Chapter 3, Affected Environment; Chapter 4, Current Refuge Management and Programs; Chapter 5, Refuge Management Direction: Objectives and Strategies; and Chapter 6, Plan Implementation.

Purpose and Need for this CCP

No formal management plan currently exists for the Refuge. The National Wildlife Refuge System Improvement Act of 1997 (16 United States Code [USC] 668dd-668ee) (1997 Improvement Act) requires that all refuges be managed in accordance with an approved CCP by 2012. Under the 1997 Improvement Act, the National Wildlife Refuge System (Refuge System, NWRS) is to be consistently directed and managed to fulfill the specific purpose(s) for which each refuge was established, as well as the Refuge System mission. The planning process helps the Service achieve the refuge purposes and the Refuge System mission by identifying specific goals, objectives, and strategies to implement on each Refuge. The purposes of this CCP are listed below.

- Provide a clear statement of direction for the management of the Refuge during the lifetime of the CCP.
- Provide long-term continuity in Refuge management.
- Communicate the Service's management priorities for the Refuge to its neighbors and the public.
- Provide an opportunity for the public to help shape the future management of the Refuge.
- Ensure that management programs on the Refuge are consistent with the legal and policy mandates for the Refuge System and the purpose of the Refuge as set forth in establishing documentation.
- Ensure that management of the Refuge is, to the extent practicable, consistent with Federal, State, and local plans.
- Provide a basis for budget requests to support the Refuge's needs for staffing, operations, maintenance, and capital improvements.

- Evaluate existing and proposed uses on each of the Refuges to ensure that they are compatible with the Refuge purpose(s); the Refuge System mission; and the maintenance of biological integrity, biodiversity, and environmental health.

The U.S. Fish and Wildlife Service and the National Wildlife Refuge System

U.S. Fish and Wildlife Service

The mission of the Service is: "Working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people." The Service is the primary Federal agency responsible for conserving, protecting, and enhancing the Nation's fish, wildlife, and plant populations and their habitats for the continuing benefit of the American people. Although the Service shares this responsibility with other Federal, tribal, State, local, and private entities, the Service has specific responsibilities for migratory birds, threatened and endangered species, interjurisdictional fish, and certain marine mammals. These are referred to as Federal Trust Species. The Service also manages the Refuge System and National fish hatcheries; enforces Federal wildlife laws and international treaties related to importing and exporting wildlife; assists State fish and wildlife programs; and helps other countries develop wildlife conservation programs.

The National Wildlife Refuge System

The National Wildlife Refuge System is the world's largest collection of lands specifically managed for fish and wildlife conservation. Unlike other Federal lands that are managed under a multiple-use mandate (e.g., National forests and lands administered by the U.S. Bureau of Land Management), the Refuge System is managed primarily for the benefit of fish, wildlife, and plant resources and their habitats. The Refuge System consists of more than 552 units that provide more than 150 million acres of important habitat for native plants and many species of mammals, birds, and fish, including threatened and endangered species.

The mission of the 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" (1997 Improvement Act).

The goals of the National Wildlife Refuge System are as follows:

- *Conserve a diversity of fish, wildlife, and plants and their habitats, including species that are endangered or threatened with becoming endangered.*

- *Develop and maintain a network of habitats for migratory birds, anadromous and interjurisdictional fish, and marine mammal populations that is strategically distributed and carefully managed to meet important life history needs of these species across their ranges.*

- *Conserve those ecosystems; plant communities; wetlands of national or international significance; and landscapes and seascapes that are unique, rare, declining, or underrepresented in existing protection efforts.*

- *Provide and enhance opportunities to participate in compatible wildlife-dependent recreation (hunting, fishing, wildlife observation and photography, and environmental education and interpretation).*

- *Foster understanding and instill appreciation of the diversity and interconnectedness of fish, wildlife, and plants and their habitats.*

Legal and Policy Guidance

Refuges are guided by the purposes of the individual refuge, the mission and goals of the Refuge System, Service policy, laws, and international treaties. Relevant guidance includes the Refuge Recreation Act of 1962, the 1997 Improvement Act, and selected portions of the Code of Federal Regulations and the U.S. Fish and Wildlife Service Manual. Refuges are also governed by a variety of other Federal laws, executive orders (EO), treaties, interstate compacts, regulations, and policies pertaining to the conservation and protection of natural and cultural resources (see Appendix H and Service Manual 602 FW 1 (1.3)).

The 1997 Improvement Act's main components include:

- A strong and singular wildlife conservation mission for the Refuge System.
- Recognition of six priority public uses of the Refuge System (hunting, fishing, wildlife observation and photography, and environmental education and interpretation).
- A requirement that the Secretary of the Interior maintain the biological integrity, diversity, and environmental health of Refuge System lands.
- A new process for determining compatible uses on refuges.
- A requirement for preparing a comprehensive conservation plan for each refuge by 2012.

First and foremost, refuges are managed for fish, wildlife, plants, and their habitats. In addition, units of the Refuge System are legally closed to all public access and use, including economic uses, unless and until they are officially opened through an analytical process called the *appropriate use* and *refuge compatibility* process. All refuge uses are subservient to the Refuge System's primary wildlife management responsibility, and they must be determined compatible to be authorized.

Appropriate Use Policy

The appropriate use policy describes the initial decision process the refuge manager follows when first considering whether to allow a proposed use on a refuge. The refuge manager must find a use appropriate before undertaking a compatibility review of the use. An appropriate use as defined by the Appropriate Use Policy (603 FW 1 of the Service Manual) is a proposed or existing use on a refuge that meets at least one of the following four conditions:

- The use is a wildlife-dependent recreational use as identified in the Improvement Act.
- The use contributes to fulfilling the refuge purpose(s), the Refuge System mission, or goals or objectives described in a refuge management plan approved after October 9, 1997, the date the Improvement Act was signed into law.
- The use involves the take of fish and wildlife under State regulations.
- The use has been found to be appropriate as specified in Section 1.11 (603 FW 1 of the Service Manual).

If an existing use is not appropriate, the refuge manager will eliminate or modify the use as expeditiously as practicable. If a new use is not appropriate, the refuge manager will deny the use without determining compatibility. If a use is determined to be an appropriate refuge use, the refuge manager will then determine if the use is compatible (see Compatibility Policy in the following section). Although a use may be both appropriate and compatible, the refuge manager retains the authority to not allow the use or modify the use. Uses that have been administratively determined to be appropriate are the six wildlife-dependent recreational uses (hunting, fishing, wildlife observation and photography, environmental education, and interpretation) and take of fish and wildlife under State regulations.

Compatibility Policy

Lands within the Refuge System are different from other multiple use public lands in that they are closed to all public uses unless deemed compatible and formally allowed. The Improvement Act established the formal process for determining compatibility of wildlife-dependent recreational use or any other public use of a refuge. The Improvement Act states, "... the Secretary shall not initiate or permit a new use of a Refuge or expand, renew, or extend an existing use of a Refuge, unless the Secretary has determined that the use is a compatible use and that the use is not inconsistent with public safety."

A compatible use is one which, in the sound professional judgment of the refuge manager, will not materially interfere with or detract from the fulfillment of refuge purpose(s) or the Refuge System mission. The Service strives to provide wildlife-dependent public uses when compatible. If financial resources are not available to design, operate, and maintain a priority use, the refuge manager will take reasonable steps to obtain outside assistance from the State and other conservation interests.

When a determination is made as to whether a proposed use is compatible or not, this determination is provided in writing and is referred to as a compatibility determination. Draft compatibility determinations were prepared concurrently and available for public review with the draft CCP. The final compatibility determinations are appended to this CCP (Appendix E).

Biological Integrity, Diversity, and Environmental Health Policy

The Improvement Act directs the Service to "ensure that the biological integrity, diversity, and environmental health of the Refuge System are maintained for the benefit of present and future generations of Americans..." To implement this directive, the Service has issued the Biological Integrity, Diversity, and Environmental Health Policy (601 FW 3 of the Service Manual), which provides policy for maintaining and restoring, where appropriate, the biological integrity, diversity, and environmental health of the Refuge System. The policy is an additional directive for refuge managers to follow while achieving the refuge purpose(s) and Refuge System mission. It provides for the consideration and protection of the broad spectrum of fish, wildlife, and habitat resources found on refuge and associated ecosystems. Further, it provides refuge managers with an evaluation process to analyze their refuge and recommend the best management direction to prevent further degradation of environmental conditions and restore lost or severely degraded components where appropriate and in concert with refuge purposes and the Refuge System mission. When evaluating the appropriate management direction for refuges, refuge managers will use sound professional judgment to determine their refuges' contribution to biological integrity, diversity, and environmental health at multiple landscape scales.

Wilderness Review

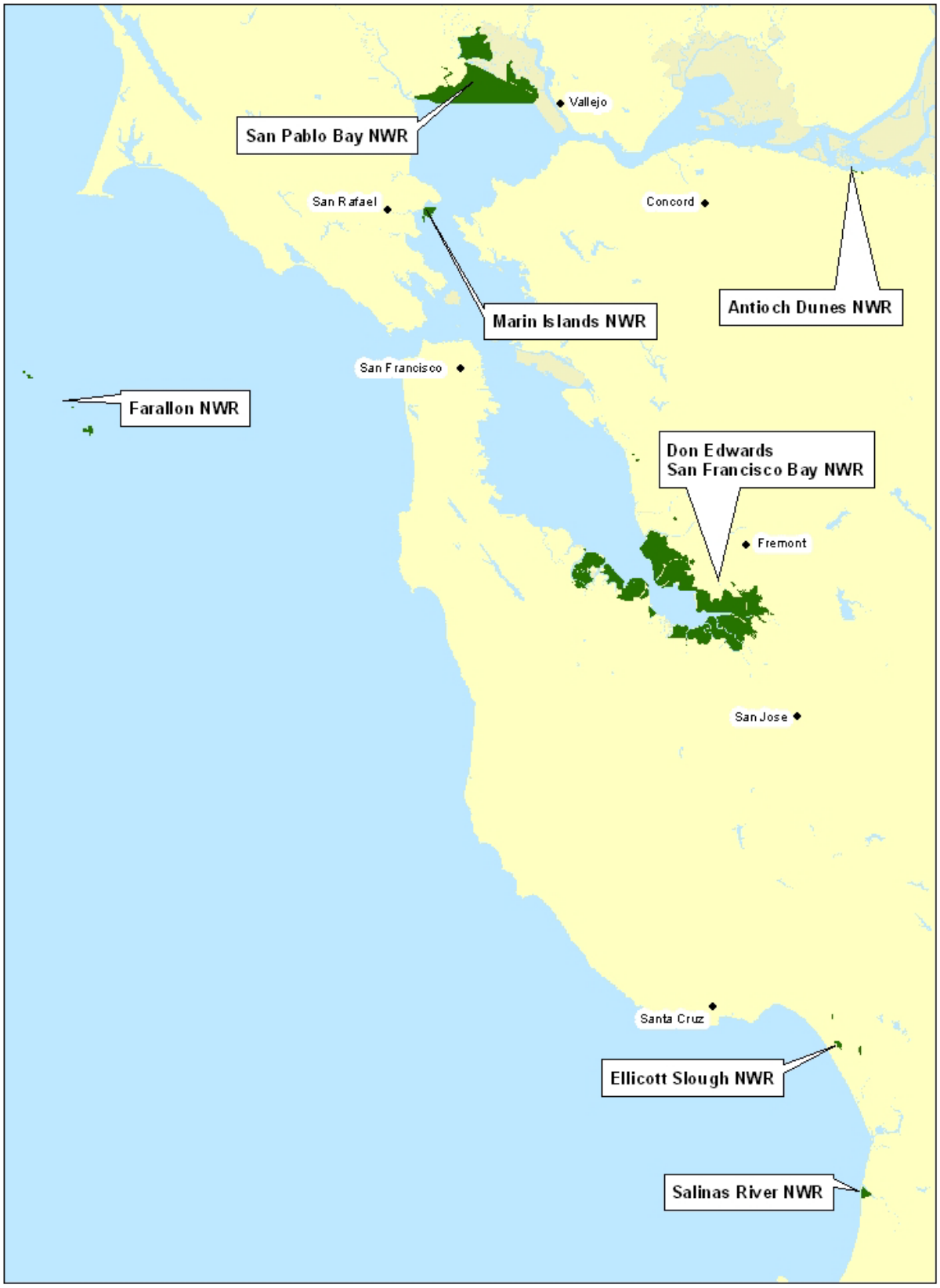
As required by Service planning policy, a review of wilderness areas was conducted for the Refuge in the form of a Wilderness Inventory (Appendix F). None of the lands were eligible for wilderness designation.

The San Francisco Bay National Wildlife Refuge Complex

The San Francisco Bay (Bay) area has had a significant human presence stretching back thousands of years. A number of Native American tribes have inhabited the area, including the earliest residents, the Ohlone. Later, Spanish settlers immigrated to the area in the late 1700s. The years following the California gold rush in 1849 caused explosive growth and development that placed greater demands on the sensitive lands surrounding the Bay. For example, the salt industry converted tens of thousands of acres of salt marsh into commercial salt ponds.

Conversion of wetlands to support development continued well into the 20th century, and today, nearly 85 percent of the Bay's original marshes and shorelines have been altered. With the support of citizens and public officials, seven national wildlife refuges (NWRs) have been created in the San Francisco and Monterey Bay Areas: Farallon NWR (1909), Salinas River NWR (1973), San Pablo Bay NWR (1974), Don Edwards San Francisco Bay NWR (1974), Ellicott Slough NWR (1975), Antioch Dunes NWR (1980), and Marin Islands NWR (1992). These seven refuges, stretching from Monterey Bay to the San Francisco Bay Delta, were combined to create the Refuge Complex (See Figure 1). These refuges provide a variety of critical nesting habitat and resting points for migratory birds of the Pacific Flyway. The refuges also provide breeding and foraging habitat for endangered species and other species of concern. Unlike other refuges located in remote locations, each of the seven refuges shares the task of pursuing wildlife conservation objectives while providing wildlife-dependent recreation, when compatible, in this highly urbanized area.

Figure 1. San Francisco Bay NWR Complex



The San Pablo Bay National Wildlife Refuge

Location

The Refuge is part of the San Francisco Estuary, which includes the San Francisco Bay, Suisun Bay, and Delta region (at the confluence of the Sacramento and San Joaquin Rivers). San Francisco Bay is further divided into three units: North Bay, Central Bay, and South Bay (See Figure 2). The Refuge abuts the northern edge of the North Bay, which is also known as San Pablo Bay. The Refuge extends into Sonoma, Napa, and Solano Counties. Highway 37 bisects the Refuge and provides the primary access road.

Figure 2. San Francisco Bay Sub-regions

Refuge Setting

The Refuge is located in lowland, marsh areas which would have been open water or marsh during prehistoric times. Less than 150 years ago, the Napa-Sonoma marshes surrounding San Pablo Bay comprised one of the most extensive wetland systems along the Pacific coast. This system provided habitat for millions of migrating waterfowl and shorebirds as well as resident wildlife. Plants specialized to live in aquatic habitats grew bountifully, sheltering and feeding a rich diversity of wildlife and fish species.

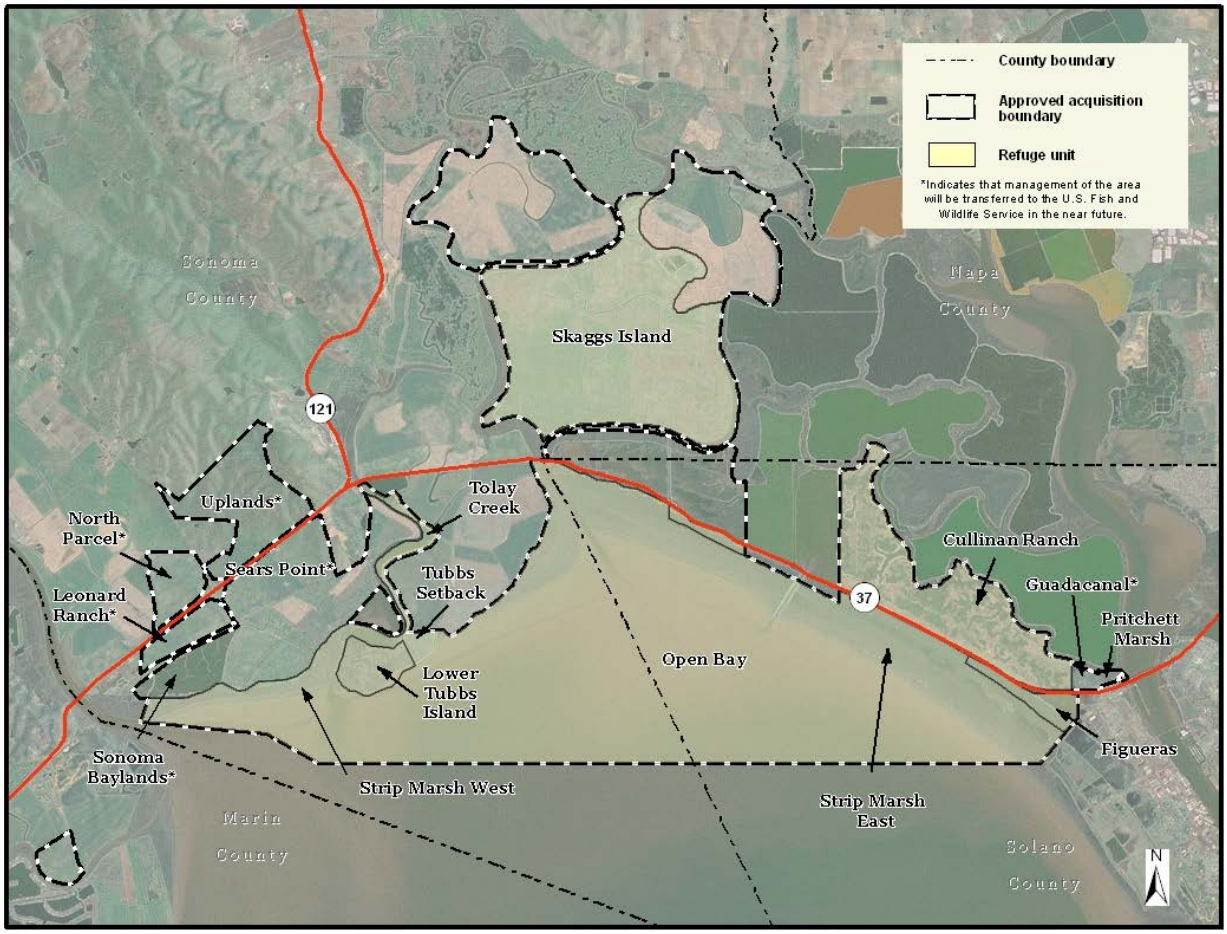
Rapid development of the area began with the discovery of gold in the Sierra Nevada foothills in the 1850s. Hydraulic mining operations contributed huge amounts of sediment to the San Francisco Bay Estuary, resulting in the expansion of some tidal marsh bordering San Pablo Bay. For the next hundred years, the marshes were filled, diked, or drained to support the Bay's development as a major center of commerce. Today, only 15 percent of the Bay's historic tidal lands remain. Since the 1960s, conservation agencies, non-profit organizations, and local grassroots efforts have worked to restore and protect the Bay.

History of Refuge Establishment and Acquisition

The Refuge acquisition boundary was established in 1970, but first lands were not acquired until 1974. One of the first properties acquired was the Figueras unit, a privately farmed unit which totals 185 acres. Lower Tubbs Island, approximately 249 acres, was acquired in 1978. Tubbs Island Setback, approximately 72 acres, was leased in 1981 under a 66-year agreement with the California State Lands Commission. The 63-acre portion of the Strip Marsh, once known as the Prati lands, was acquired 1986. Cullinan Ranch, located in both Napa (28 acres) and Solano (1,465 acres) Counties, was acquired in 1991.

Today, eight non-contiguous units make up the Refuge, with some of the units owned by the California State Lands Commission but leased and managed by the Service (see Figure 3). Some 11,200 of these acres were leased from the State in 1980, with 5,290 acres owned in fee title by the Service. The San Francisco Bay Conservation and Development Commission has regulatory jurisdiction over Bay waters (up to mean high tide) and marshes (up to five feet above mean sea level), and for lands on the shoreline of San Pablo Bay (a 100-foot band upland of the shoreline). Several other acquisitions are in discussion, including Guadalcanal, Skaggs Island, Sears Point Ranch, North Parcel, and Sonoma Baylands (all to be acquired around 2011).

Figure 3. Units of San Pablo Bay NWR



Land Protection

The approved acquisition boundary for the Refuge—the area within which the Service is authorized to work with willing landowners to acquire and/or manage land—is 23,702 acres. An approved acquisition boundary only designates those lands which the Service has authority to acquire and/or manage through various agreements, based upon planning and environmental compliance processes. Approval of an acquisition boundary does not grant the Service jurisdiction or control over lands within the boundary, and it does not make lands within the acquisition boundary part of the National Wildlife Refuge System. Lands do not become part of the National Wildlife Refuge System unless they are purchased or are placed under an agreement that provides for management as part of the Refuge System. These acquisition approaches may include technical assistance, cooperative agreements, memoranda of understanding, and acquisition (from willing sellers) of conservation or agricultural easements and fee title interest.

To date, the Service manages 16,490 acres within the approved project boundary, including 11,200 acres leased from the California State Lands Commission; the remaining portion is in fee title. Recent boundary expansions and agreements will result in the addition of approximately 4,200 acres to the Refuge around 2011, bringing the total number of acres managed by the Refuge to 17,390 acres.

Land Conservation Methods

Working with willing landowners and local and State agencies, the Service may use various means to conserve or manage fish and wildlife and their habitats within the approved Refuge boundary. These may include fee title acquisition, conservation easements, memoranda of understanding and cooperative agreements, financial incentives and technical assistance, and education and outreach. It is the established policy of the Service to seek the minimum degree of interest in property needed to accomplish refuge land conservation objectives.

In fee title acquisitions, the Service acquires full ownership of property through fee simple purchase, donation, exchange, or transfer from another Federal agency. Land acquired in fee title by the Service is removed from county tax rolls. To partially offset this loss, the Service provides annual payments to counties as authorized by the Refuge Revenue Sharing Act (Public Law 95-469). The Service is required under the U.S. Constitution to pay fair market value for property, and purchases are dependent on the availability of funds.

In acquiring a conservation easement, the Service purchases the minimum rights needed to conserve fish and wildlife habitat, while allowing the existing landowner to retain title to the land. Easements may include wetland or waterfowl habitat easements, upland easements, agricultural practices easements, and non-development easements. The easement interest acquired by the Service becomes part of the Refuge and is subject to applicable laws and regulations pertaining to refuges. The easement is a permanent interest in the property that runs with the land, and the landowner remains responsible for all property taxes.

The Service may also assist in securing financial incentives for landowners who are not willing to sell an interest in their property but wish to explore conservation or enhancement of fish and wildlife habitats on their property. For example, through the Partners for Fish and Wildlife program, landowners may apply for financial assistance from the Service to protect, enhance, or restore wetland, riparian, or native grassland habitats on their property. In addition, the Service could assist a landowner in securing funds from Farm Bill programs available from the U.S.

Department of Agriculture/Natural Resources Conservation Service (NRCS). Potential NRCS programs that could benefit landowners and further Refuge land conservation objectives include the Conservation of Private Grazing Land Program, Environmental Quality Incentives Program, Farmland Protection Program, Wetlands Reserve Program, and Wildlife Habitat Incentives Program. Finally, Service staff is available to provide technical assistance and education and outreach information to willing landowners who are interested in conserving fish and wildlife habitats on their lands.

The Refuge has achieved much of its land acquisition and restoration efforts with grants from State and Federal agencies and private organizations. These sources have played a vital role in advancing the Refuge's land conservation and management programs.

Refuge Purposes

Lands within the Refuge System are acquired and managed under a variety of legislative acts and administrative orders and authorities. The official purpose or purposes for a refuge are specified in or derived from the law, proclamation, executive order, agreement, public land order, funding source, donation document, or administrative memorandum establishing, authorizing, or expanding a refuge, refuge unit, or refuge subunit. The purpose of a refuge is defined when it is established or when new land is added to an existing refuge. When an addition to a refuge is acquired under an authority different from the authority used to establish the original refuge, the addition takes on the purposes of the original refuge, but the original refuge does not take on the purposes of the addition. Refuge managers must consider all of the purposes. However, purposes that deal with the conservation, management, and restoration of fish, wildlife, and plants and their habitats take precedent over other purposes in the management and administration of a refuge (601 FW 1 of the Service Manual).

The Refuge System Improvement Act directs the Service to manage each refuge to fulfill the mission of the Refuge System, as well as the specific purposes for which that refuge was established. Refuge purposes are the driving force in developing refuge vision statements, goals, objectives, and strategies in the CCP. Refuge purposes are also critical to determining the compatibility of all existing and proposed refuge uses.

San Pablo National Wildlife Refuge was established under the authority of three Federal acts. These acts and the corresponding purposes are:

Migratory Bird Conservation Act (16 U.S.C.715d) - "... for use as an inviolate sanctuary, or for any other management purpose, for migratory birds."

An Act Authorizing the Transfer of Certain Real Property for Wildlife, or other purposes (16 U.S.C. 667b) - "... particular value in carrying out the national migratory bird management program."

Endangered Species Act of 1973 (16 U.S.C. 1534) – "... to conserve (A) fish or wildlife which are listed as endangered species or threatened species.... or (B) plants ..."

California State Enabling Legislation, Division 7, Chapter 1, Article 3; Section 10680 and 18685 of California Fish and Game code was also required for Fish and Game Commission and County approval. Largely comprised of thousands of acres of tidelands leased from the California State Lands Commission, the Refuge's ultimate plans include protection and conservation of more than 20,000 acres of critical wildlife habitat in northern San Pablo Bay.

Related Projects and Studies in the Area

Several ongoing restoration projects are also in the region where the Refuge is located. These projects are in concert with the aims and mission of the Refuge and are described in the following text.

The San Pablo Bay Watershed Restoration Program. The U.S. Army Corps of Engineers, California Coastal Conservancy, and the Bay Institute are working to restore 50,000 acres of wetlands to provide habitat for endangered species such as the California clapper rail (*Rallus longirostris obsoletus*) and the salt marsh harvest mouse (*Reithrodontomys raviventris*). Also, tributary streams will provide valuable habitat for fish such as Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*), as well as other aquatic animals.

Sears Point Restoration Project. Sonoma Land Trust will restore the 2,300-acre site to tidal marsh, diked marsh, riparian, vernal pool, seasonal marsh, and grasslands. This project began in 2004 and is not slated for completion until 2012.

Napa-Sonoma Marsh Restoration Project. In 1994, the California Department of Fish and Game (CDFG) purchased about 9,000 acres of salt-making ponds from Cargill Salt Company. The State is planning to restore the historic wetlands upon which the salt ponds were originally built. In order to accomplish that goal, the salinity of several ponds needs to be reduced to levels that are harmless to fish and wildlife. The Bay Institute is working with the CDFG and the Sonoma County Water Agency to import reclaimed water from surrounding communities and use the water to dilute the salty ponds. This innovative approach not only will enable faster restoration of the marshes, but will also reduce the amount of discharge to the Bay from North Bay water treatment plants.

Petaluma Marsh Expansion. This project is sponsored by Marin Audubon Society, California State Coastal Conservancy, and Calfed. It will restore approximately 100 acres of diked tidal marsh as part of 2,000 acres of Petaluma tidal marsh, the largest undiked tidal marsh remaining in the Bay. The project will benefit special status bird and fish species.

Sonoma Baylands Restoration. This 348-acre former diked farmland was returned to full tidal action in 1996 through a partnership with Sonoma Land Trust, the California State Coastal Conservancy, and the U.S. Army Corp of Engineers. The SF Bay Trail runs along the levee top.

Conservation Priorities and Initiatives

The conservation and restoration plans in place to help guide the direction of the CCP are described in the following text.

Southern Pacific Shorebird Conservation Plan. This conservation plan is one of 11 regional plans associated with the U.S. Shorebird Conservation Plan. The plan identifies information and needs for the conservation of shorebirds on the coast and in the Central Valley of California. The plan identifies several shorebird species, some of which are U.S. Fish and Wildlife Service (USFWS) species of concern that rely on the Southern Pacific region. The plan also has developed conservation priorities, some species-specific and other habitat-specific.

San Francisco Bay Joint Venture. The goal of the San Francisco Bay Joint Venture is to protect, restore, increase, and enhance all types of wetlands, riparian habitat, and associated uplands throughout the San Francisco Bay region to benefit birds, fish, and other wildlife. The Joint Venture is made up of a management board consisting of public agencies and private organizations. The Joint Venture has developed objectives for acquiring additional habitat for restoration or protection (See Table 1)

Table 1. Habitat Goals for the San Francisco Bay Joint Venture

SFBJV Habitats		SFBJV Tracked Habitat Goals (acres)			SFBJV Habitat Goals Categories (acres)		
SFBJV Habitat Goal Categories	**Tracked Habitats**	**Acquire**	**Restore**	**Enhance**	**Acquire**	**Restore**	**Enhance**
Bay Habitats	Tidal Marshes	43,000	32,000	20,000	63,000	37,000	35,000
	Tidal Flats	12,000	4,000	6,000			
	Lagoons	1,500	50	1,500			
	Beaches	113	60	35			
	Salt Ponds	6,000	1,000	7,500			
Seasonal Wetland	Diked Wetlands	16,000	6,000	12,000	37,000	7,000	23,000
	Moist Grasslands	21,000	1,000	11,500			
Creeks and Lake	Lakes	3,000	1,000	6,000	7,000	5,000	22,000
	Creeks	4,000	4,000	16,000			

Notes: 1. Numbers are to the nearest thousand. 2. Numbers are double counted in instances where restoration takes place on acquired land. 3. SFBJV is a non-regulatory entity, and thus acquisition goals reflect working cooperatively with a willing seller.

Source: http://www.sfbayjv.org/strategy.php#habitat_goals

Tidal Marsh Recovery Plan. The Service released a Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California in January 2010. This recovery plan is an expansion and revision of the California Clapper Rail and Salt Marsh Harvest Mouse Recovery Plan (USFWS 1984). The recovery plan also encompasses four other federally listed plant species and 11 species of concern that occur in a variety of tidal marsh habitats. The recovery plan identifies goals, objectives, criteria, and actions needed to recover all focal listed species so they can be delisted.

2008-2012 National Invasive Species Management Plan. A revision of the 2001 National Invasive Species Management Plan, the 2008 plan will continue to provide direction for Federal efforts to prevent, control, and minimize invasive species and their impacts. The 2008 Plan focuses upon five strategic goals: prevention, early detection and rapid response, control and management, restoration, and organizational collaboration.

Baylands Ecosystem Habitat Goals. Completed in 1999, this report presents findings of the San Francisco Bay Area Wetlands Ecosystem Goals Project. The Goals Project describes historical and present conditions of the baylands (areas around the San Francisco Bay between the lines of high and low tide; they are lands touched by the tides, and lands that the tides would touch in the absence of any levees or other unnatural structures), as well as key habitat types. It also provides guidance for restoration and enhancement of the baylands and adjacent habitats of the San Francisco Estuary. The Project involved assistance from a variety of participants, including Federal agencies, local governments, State agencies, academics, and non-governmental organizations.

Subtidal Habitat Goals Project. The San Francisco Bay Subtidal Habitat Goals Project is a collaborative effort to establish a comprehensive, long-term management vision for research, restoration, and management of the subtidal habitats of the San Francisco Bay. Subtidal habitats refer to marine or estuarine environments that lie below mean low-water and are always (or almost always) submerged in a tidally-influenced area. The Project will plan for submerged environments below mean low water to the bottom of San Francisco Bay. The Project is an interagency partnership between the San Francisco Bay Conservation and Development Commission, the California Coastal Conservancy, the National Oceanic and Atmospheric Administration, and the San Francisco Estuary Partnership. As of the writing of this CCP, the planning process for the Subtidal Habitat Goals Project is still in preparation.

San Francisco Bay Plan. The Bay Plan was prepared by the San Francisco Bay Conservation and Development Commission over a three-year period pursuant to the McAteer-Petris Act of 1965 which established the Commission as a temporary agency to prepare an enforceable plan to guide the future protection and use of San Francisco Bay and its shoreline. In 1969, the Legislature acted upon the Commission's recommendations in the Bay Plan and revised the McAteer-Petris Act by designating the Commission as the agency responsible for maintaining and carrying out the provisions of the Act and the Bay Plan for the protection of the Bay and its great natural resources and the development of the Bay and shoreline to their highest potential with a minimum of Bay fill.

Chapter 2. The Comprehensive Conservation Planning Process

Introduction

This CCP/EA for the Refuge is intended to meet the dual requirements of compliance with the 1997 Improvement Act and NEPA of 1969 (42 USC 4321). The development of this CCP/EA was also guided by the Refuge Planning Policy outlined in Part 602, Chapters 1, 3, and 4 of the Service Manual (Fish and Wildlife Service 2000). Service policy, the 1997 Improvement Act, and NEPA provide specific guidance for the planning process. For example, Service policy and NEPA require the Service to actively seek public involvement in the preparation of environmental documents such as EAs.

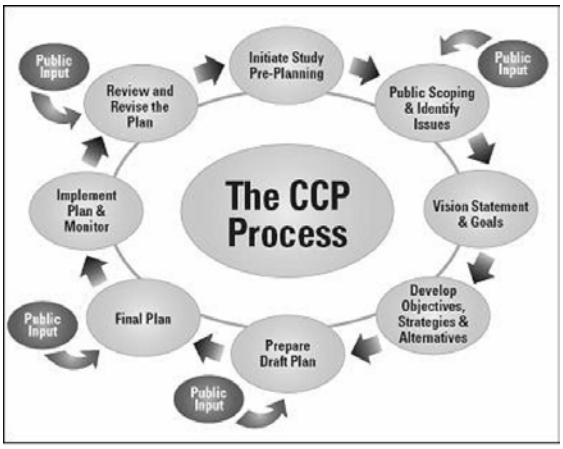
The purpose of the EA is to evaluate the environmental effects of the CCP on the quality of the human environment. NEPA also requires the Service to give serious consideration to all reasonable alternatives, including the "no action" alternative, which represents continuation of current conditions and management practices. Alternative management scenarios were developed as part of the planning process and can be found in Appendix C (Environment Assessment).

The Planning Process: How this CCP was Developed

Key steps in the CCP planning process are depicted in the following text (see Figure 4) and include:

1. Preplanning
2. Identifying issues and developing a vision statement
3. Gathering information
4. Analyzing resource relationships
5. Developing alternatives and assessing environmental effects
6. Identifying a preferred alternative
7. Publishing the draft plan and NEPA document
8. Documenting public comments on the draft plan
9. Preparing the final plan
10. Securing approval from the regional director
11. Implementing the plan

Figure 4. CCP Planning Process



The CCP may be amended as necessary at any time under an adaptive management strategy. Major revisions, if needed, will require public involvement and NEPA review.

The planning process for this CCP began in March 2006 with preplanning, which involved the collection of pertinent data and selection of team members. A core team and expanded team were formed to integrate stakeholders into the planning process. Refuge staff identified three primary areas of focus: wildlife management, habitat management, and public access and education. These focus areas helped shape comments received from the public during the scoping period into potential objectives for the Refuge.

The Planning Core Team

The planning team responsible for leading the CCP effort included Service biologists, planners, visitor services specialists, and environmental education specialists from the San Francisco Bay NWR Complex and the California/Nevada Refuge Planning Office. Appendix H lists the members of the planning core team.

The Planning Expanded Team

The expanded team is the advisory forum of the CCP process. Its role is significant because of the Refuge's history of networking and partnerships with local, State and Federal agencies, community groups, research institutes, and non-profit organizations concerned with the Refuge. Service staff identified several participants composed of State and Federal agency officials, local government officials, non-profit organizations, community groups, and other interested parties. The goal of the expanded team is to provide technical comments on the goals, objectives, and strategies of the CCP to improve the Service's decision-making process. Appendix H lists the members in the expanded team.

Public Involvement in Planning

Public involvement is an important and required component of the CCP and NEPA process. Public scoping meetings allow the Service to define the scope of the issues that need to be addressed and identify significant issues that may shape the proposed action. More importantly,

these meetings allow Refuge staff to hear public comments and concerns. Public meetings provide a forum for important discussion and identify important issues regarding the Refuge and its surrounding area.

The Refuge hosted a public scoping meeting on July 26, 2006. Public comments were generated from the public scoping meeting, and the Federal Register notice published on July 26, 2006. Two people from public attended the meeting. The Service also held individual meetings with stakeholders. A number of individuals provided comments at the meeting, via email, and by postal mail. The following paragraphs describe themes of the comments.

Issues, Concerns, and Opportunities Identified by the Public

Habitat Management

- Cullinan Ranch may affect restoration planning on Skaggs Island and may create nearby hydrological changes. Hydrologic modeling should be conducted on Skaggs to maximize the restoration efforts in the area.
- Revisit acquisition of the diked baylands in Marin and Sonoma Counties, Hamilton/Bel Marin Keys, and the St. Vincent's/Silveira Lands.
- Expand Refuge to include undeveloped baylands and some associated uplands in Marin and Sonoma Counties (as seen in the approved Refuge acquisition boundary). Lands in Sonoma County, on the east side of the Petaluma River remain under private ownership and should be included in the Refuge boundary.
- Study hydrology in the strip marsh to increase tidal flow.
- Tolay Lake and Creek should be returned to historical tidal flow.

Visitor Services and Environmental Education

- Assess the SF Bay Trail proposal for compatibility with the Refuge; it may not be biologically appropriate based on final restoration planning; the trail may need to be rerouted.
- Provide an auto tour through Skaggs Island; do not allow foot access due to enforcement limitations. Skaggs Island should be a place where the public can drive in, park, and see the Refuge's wildlife and plants.
- Public use should be secondary to habitat and species protection.
- Hunting should be discontinued; the CCP/EA should take into account the effects of hunting on other wildlife species, migratory birds, and non-hunting visitors. Hunting should also be assessed for its economic impacts to the Refuge and surrounding businesses. (HSUS)
- Sonoma County Regional Parks would like to work with the Refuge in aligning the SF Bay Trail through the existing Refuge Boundary and through Skaggs Island and west towards the Petaluma River.
- Sonoma County Regional Parks manages Hudeman Slough Boat Launch adjacent to Skaggs and would like to coordinate management of these remote facilities.
- Incorporate SF Bay Trail into Skaggs Island, Dickson, Cullinan, and the Haire properties to allow a continuous path through the Sonoma area, with expertise in trail planning and design.

Management Issues and Challenges Identified by Staff

The Refuge staff also identified the following management issues and challenges that would be important to reflect upon in the CCP.

Invasive Perennial Pepperweed and Non-Native Spartina Species
Currently, the primary invasive plant threat to tidal marsh of San Pablo Bay is perennial pepperweed (*Lepidium latifolium*) and non-native *Spartina* species. Pepperweed is a highly invasive herbaceous perennial in the *Brassicaceae* family and adapts to conditions of moderate salinity (Spenst 2006). Pepperweed can form complete monocultures and displace native species in riparian and wetland areas, where it is most aggressive (Eiswerth et al. 2005, Renz and Blank 2004). A survey of the San Francisco Bay Estuary found pepperweed in the following relevant locations to this CCP: northeastern marshes of San Pablo Bay, lower reach of Tolay Creek, and lower reach marshes of Petaluma (Grossinger et al. 1998). Pepperweed's invasion into pickleweed-dominated (*Sarcocornia* spp.) marshes also threatens habitat of the endangered salt marsh harvest mouse, California black rail (*Laterallus jamaicensis*), and California clapper rail (Howald 2000).

Non-native *Spartina* species also threaten tidal (marsh) and subtidal (mudflats) environments and the associated habitats of endangered species, migratory birds, and many other native estuarine organisms. Like pepperweed, non-native *Spartina* species (esp. Atlantic smooth cordgrass [*S. alterniflora*]) are highly invasive and threaten to cause the extinction of our native cordgrass species, choke tidal channels, and eliminate mudflats used by shorebirds (USFWS 2005). Control of this species (coordinated by the Invasive Spartina Project) is currently underway throughout the Estuary. The discovery of *S. alterniflora* and *S. densiflora* on Refuge lands in 2007 is of significant management concern.

Public Access and Safety
Highway 37 bisects the Refuge from east to west and provides the only roadway to all Refuge public access sites. It is a two-lane highway divided in the middle with a concrete K-rail to prevent head on collisions. No shoulder exists along most of its length to allow vehicles to safely pull out of the flow of traffic and enter the Refuge. Approximately 40,000 vehicles per day travel Highway 37 commuting from Solano to Marin County. Traffic flows at a range of speeds from 10 miles per hour during heavy commute times to 65 miles per hour. Safety is a key issue in accessing any portion of the Refuge.

Sea-level Rise and Climate Change
Increasing carbon dioxide and other greenhouse gas emissions from anthropogenic sources have undeniably altered the temperature more during the last century than any other time in history. Such temperature changes can have different consequences worldwide, from sea-level rise to greater meteorological fluctuations. The Service recognizes that a changing climate will affect natural resources on refuges and has been charged by Congress (109th Congress, 2d, H. CON. RES. 398) to address these impacts in CCPs. Anticipated impacts may include species range shifts, species extinctions, phenological changes, and increases in primary productivity. This challenge is especially important at San Pablo Bay Refuge, where most of the Refuge property lies below sea-level. Climate change will dramatically affect any activities to restore tidally-influenced wetland areas on the Refuge. Management planning for the Refuge will need to incorporate sea-level rise predictions and meteorological fluctuations (e.g., extreme tide events) into land management activities.

Endangered Species Habitat
Habitat loss is one of the primary threats to endangered species. Encroaching development or anthropogenic uses (e.g., grazing, agriculture) have reduced the amount of tidal environments

available to the listed California clapper rail and salt marsh harvest mouse. Poor circulation of tidal environments due to diking, berms, and levees has also resulted in poor quality habitat for endangered tidal marsh species.

Land Acquisition and Headquarter Site
San Pablo Bay NWR headquarters has been located at four different sites since it was initially staffed in 1994. The first two sites were buildings leased from the U.S. Navy on the former Mare Island Shipyard in Vallejo, California. The third site was located on the former military base Mare Island, which was proposed in a Federal-to-Federal land transfer of approximately 165 acres from the Navy to the Service. An impasse between the Service and the Navy arose in the early 2000s in regard to future liabilities of contaminants found on Navy lands. Since the Refuge could not accept the land in a Federal-to-Federal transfer, the Refuge was forced to find a new location. The Sonoma Land Trust offered a five-acre parcel at the Sears Point site, with an old farmhouse and several outbuildings, to the Refuge through a lease. In 2005, the Refuge was able to renovate a 950-square-feet farm house and shed for their use, as well as construct a greenhouse, headhouse (storage unit for related nursery supplies), and various other structures for Refuge use on the property. The Refuge hopes to acquire 860 acres of Sears Point Ranch from the Sonoma Land Trust for a permanent office location in 2011.

Development of the Refuge Vision

A vision statement is developed or reviewed for each individual refuge unit as part of the CCP process. Vision statements are grounded in the unifying mission of the Refuge System, and they describe the desired future conditions of the refuge unit in the long term (more than 15 years). They are based on the refuge's specific purposes, the resources present on the refuge, and any other relevant mandates. The vision statement for the Refuge is in Chapter 5.

Development of the Refuge Goals, Objectives, and Strategies

Refuge goals are necessary for outlining the desired future conditions of a refuge in clear and succinct statements. The Refuge System defines goals as a "descriptive, open-ended, and often broad statement of desired future conditions that conveys a purpose but does not define measurable units" (602 FW 1). Objectives and strategies are then developed to meet those goals. Objectives are defined as a "concise statement of what we want to achieve, how much we want to achieve, when and where we want to achieve it, and who is responsible for the work" (602 FW 1). Strategies are defined as a "specific action, tool, technique, or combination of actions, tools, and techniques used to meet unit objectives" (602 FW 1). Well-written goals, objectives, and strategies direct work towards achieving the Refuge's vision and purpose. Interim refuge goals were developed within the context of the authorities that established the Refuge, Refuge System mission and goals, the Service goals and policies, and ecoregion goals. The existing interim refuge goals are listed in Chapter 1. These goals will be modified through the CCP development process.

In addition, the goals of the San Pablo Bay NWR support the Service's urban refuge policy, which states that a primary purpose of urban refuges is ..."to foster environmental awareness and outreach programs to develop an informed and involved citizenry that will support fish and wildlife conservation." (Service Manual Chapter 341 FW 1)

Development of Alternatives

The CCP process includes the development of a range of alternatives that can be implemented to meet the goals of the Refuge System and the purpose of the Refuge. The Refuge System defines alternatives as "different sets of objectives and strategies or means of achieving refuge purposes and goals, helping fulfill the Refuge System mission, and resolving issues" (602 FW 1). The alternatives are developed based on comments from the scoping period, as well as input from the planning team and other Service staff. The EA (Appendix C) describes the development of alternatives, assessment of their environmental effects, and identification of the preferred management alternative (proposed action).

Alternative A: No Action. Under this alternative, the Refuge would continue current management actions, including habitat management, wildlife management, wildlife-oriented opportunities, and environmental education. The emphasis would continue to be focused on habitat management and biological aspects, including endangered species, shorebird, and waterfowl monitoring; invasive plant management; native plant restoration; tidal marsh enhancements and restoration; and developing an integrative pest management plan for mosquito populations. The Refuge would also continue to provide some limited wildlife-dependent (wildlife observation, photography, hunting, and fishing) and environmental education opportunities. Current staffing and funding would remain the same.

Alternative B: Develop an inventory and monitoring program; expand tidal restoration and enhancement activities; provide additional visitor access and limited environmental education. The Refuge would place greater emphasis on biological resource management, including developing an inventory and monitoring program for endangered species, migratory birds, and other wildlife and plants of the Refuge. Additional habitat management actions would be prescribed, including prioritization of tidal enhancements and restoration, expanded the invasive species management program, and climate change monitoring. The Refuge would also increase wildlife-oriented opportunities by opening additional access points and offering environmental education through on-site programs directed towards families. An administrative officer (shared with Marin Islands and Antioch Dunes NWRs), biological technician, outdoor recreation planner (shared with Marin Islands and Antioch Dunes NWRs), maintenance worker (shared with Antioch Dunes NWR), and law enforcement officer (shared with Marin Islands and Antioch Dunes NWRs) would be needed to fully implement this alternative.

Alternative C: Same as B; additionally, develop wildlife population goals; expand environmental education and interpretation opportunities. Under this alternative, the Refuge would conduct studies focused on developing long-term population goals to support the recovery of listed species, identify and enhance important migratory bird habitat, conduct upland grassland restoration, develop a early detection and rapid response plan for invasive plants, conduct subtidal resource conservation and restoration, and assess native and non-native predators that may affect endangered species and migratory bird populations. An administrative officer (shared with Marin Islands and Antioch Dunes NWRs), two biological technicians, biologist/range conservationist (shared with Antioch Dunes NWR), outdoor recreation planner (shared with Marin Islands and Antioch Dunes NWRs), maintenance worker (shared with Antioch Dunes NWR), and law enforcement officer (shared with Marin Islands and Antioch Dunes NWRs) would be needed to fully implement this alternative.

Selection of the Refuge Proposed Action

The alternatives were analyzed in the EA (Appendix C) to determine their effects on the Refuge environment. Based on this analysis, we have selected Alternative C as the proposed action because it best achieves the Refuge goals and purposes, as well as the Refuge System and Service missions. Alternative C relies upon existing and new partnerships in the community and increased Refuge staff levels to achieve its objectives.

Plan Implementation

The CCP will be reviewed by Refuge staff when preparing annual work plans and updating the Refuge Operational Needs System (RONS) database. This database describes the unfunded budget needs for each refuge and is the basis upon which the Refuge receives funding increases for operational needs. The plan may also be reviewed during routine inspections or programmatic evaluations. Results of the reviews may indicate a need to modify an integral part of the plan implementation, and management activities may be modified if the desired results are not achieved. If minor changes are required, the level of public involvement and NEPA documentation will be determined by the refuge manager. The CCP will be formally revised about every 15 years.

Chapter 3. Affected Environment

This chapter describes the environment that may be affected by the various management actions presented in Chapter 5 for the Refuge. The affected environment includes resources within and surrounding San Pablo Bay.

Ecoregion Setting

San Pablo Bay National Wildlife Refuge is located in the Northern California Coast ecological sub-region (Bailey 1995). This ecological sub-region encompasses mountains, hills, valleys, and plains in the northern California coast ranges and small parts of the Klamath mountains that are close enough to the Pacific Ocean for the climate to be modified greatly by marine influence (Bailey 1995). The San Francisco Bay Estuary is part of this sub-region, and the Refuge is within the Estuary. Within this sub-region, the Refuge is in the subsection San Pablo Bay Flats. This subsection is located on parts of the plain north and west of San Pablo Bay that are less than three meters above mean sea level. This subsection is characterized by tidal flat and is therefore tidally-influenced; the main geomorphic processes are coastal marine, with fluvial on the inner edges of the subsection.

Flyway Setting

The San Francisco Bay Estuary was declared as a Western Hemisphere Shorebird Reserve Network (WHSRN) site in 1989. During the height of migration, up to 1,000,000 shorebirds can be counted in the spring, and up to 375,000 in the autumn (Page et al. 1990). WHSRN is a voluntary, non-regulatory coalition that identifies and promotes conservation of crucial sites for shorebirds, no matter whether they are used in the breeding, migratory, or "winter" season. It was created in 1985 as an ambitious and visionary approach to addressing shorebird conservation needs at an enormous scale. WHSRN'S four goals are to:

1. use the best available scientific and other information;
2. implement shorebird conservation action at Network sites throughout the Americas;
3. create and maintain informed, involved, empowered, and interconnected human communities at Network sites; and
4. become the strongest network of sites possible.

Under this designation, landowners agree to make shorebird conservation a priority, protect and manage shorebird habitat, and keep WHSRN informed at least annually of any changes in the site's status, including contact information.

The Refuge was specifically established to support migratory birds that travel along the Pacific Flyway. The Pacific Flyway is a bird migration pathway that generally runs from Alaska and the Aleutian Islands south to Mexico and South America, paralleling the coast of Washington, Oregon, and California. This is one of four unique flyway regions that birds travel through in the United States. Millions of waterfowl and shorebirds migrate to wintering and breeding grounds along the Pacific Flyway. This Refuge is an important wintering area for waterfowl, particularly canvasbacks (*Aythya valisineria*), scaup *(Aythya* spp.*),* and scoters (*Melanitta* spp.). Shorebirds

also use the area to overwinter or as a stopover point during migration. The San Pablo Bay watershed, specifically the Napa-Sonoma Baylands within it, also qualifies as a Globally Important Bird Area in American Bird Conservancy's *United States Important Bird Areas* program. This area provides habitat for globally significant numbers of breeding California clapper rail and California black rail. The site is also designated as an Important Bird Area by Audubon California. The wetlands of San Pablo Bay encompass 31,566 acres of wetlands from San Rafael east to Vallejo.

Natural and Historic Context

At the end of the last glacial period, some 15,000 to 18,000 years ago, the seas began their most recent rise, and about 10,000 years ago, ocean waters began to flood the valleys now occupied by the San Francisco Bay Estuary (Atwater 1979). Between about 2,000 and 3,000 years ago, mudflats and tidal marshes began to form around the edges of western Suisun, North Bay, Central Bay, and South Bay (Atwater 1979). The evolution of these mudflats and tidal marshes, also called baylands, is closely related to the history of changes in sea level.

The San Francisco Bay Estuary includes many habitat types: deep bay, shallow bay, tidal flat, tidal marsh with channels, and shallow pans (Goals Project 1999). Each of these habitat types have been reduced, some drastically, from their original amounts (see Table 2). Beginning in the mid-1800s, following the Gold Rush in the Sierra Nevada, large areas of the Estuary's tidal marshes and mudflats were filled, diked, or drained (Perkins et al. 1991). Extensive portions of baylands were filled to provide land for ports, rail lines, and roads. Farmers then began diking and draining tidal marshes in the 1850s (Kelley 1989). Initial diking of tidal marsh in the North Bay was undertaken to develop grazing lands for livestock (Thompson and Dutra 1983). Livestock grazing was the sole agricultural practice in the North Bay for many decades, as the high water table and soil salinities discouraged the production of truck crops (Goals Project 1999). Hay and milk production still occur in the area. The locations of current habitat types may not represent their historical setting.

Table 2. Changes in Acres of Habitat Types in San Francisco Bay Estuary

Habitat Type	*Historical Acres*	*Present Acres*
Deep Bay	100,000	82,000
Shallow Bay	174,000	172,000
Tidal Flat	50,000	29,000
Tidal Marsh	190,000	40,000
Channels in Tidal Marsh	6,000 miles	1,000 miles
Shallow Pans	8,000	250

Source: Goals Project 1999

Physical Environment

Elements of the physical environment include topography, geology, soils, hydrology, sedimentation, water quality, climate and air quality, and hazardous materials and contaminants. These elements are described below as they relate to the Refuge.

Topography

Sonoma and Solano counties, where much of the Refuge is located, are low-lying areas bound by mountain peaks and separated by valleys. Sonoma is bound on the east by the main Coast Range,

of which Mount Diablo is best known (Munro-Fraser 1973). The Russian River Valley bounds the county in the north, and Sonoma Valley bounds the county on the west. The southwest section of the county is celebrated for rich swards of grass for dairy production. Solano County is historically swamp, overflowed land, and mudflats that are bare at low tide. Montezuma Hills occupy the southeast portion of the county, Townsend Hills bound the county in the southwest, and Potrero Hills cap the county in the north (Solano County Board of Trade 1887).

The Bay area topography can be generally categorized into subtidal, baylands, and uplands. The baylands are considered the historic and modern boundaries of the tides. The Refuge sits in bayland and subtidal areas. Much of the Refuge is tidally-influenced. Historically, the area was complex and contained extremely dense tidal channels. These channels separated the area into thousands of tidal pans, which were smallest and most numerous in saline areas and larger in the more brackish areas. Adjacent to Sonoma County on flatter portions of the region lie tidal marshes that are graded into low-lying moist grasslands with vernal pool complexes on ancient impervious clay soils (Goals Project 1999). These channels have since been altered and converted for navigation and agricultural pursuits (McKee et al. 2000).

Lake Tolay, in the hills between the Sonoma and Petaluma Baylands, once covered several hundred acres—many times more than the cumulative total area of all other North Bay perennial, non-tidal lakes and ponds. The lake no longer exists today, but plans to restore the lake are under consideration by Sonoma County Regional Parks. In the 1880s, Sonoma Creek was widened and deepened. By the 1930s, diking on the North Baylands was essentially complete; the main land uses were hay making and grazing. These natural marshlands became high-producing agricultural lands in the Lower Sonoma Valley. There are several managed diked wetlands near the hills of the northern periphery of the Sonoma Baylands and adjacent to Highway 37. Tidal marsh borders the sloughs, tidal channels, and Bay edge that ultimately feed into San Pablo Bay (e.g., Sonoma Creek, Napa River). Tidal marsh occurs both north and south of Highway 37. Tidal marsh of San Pablo Bay ranges from fully tidal to muted tidal and is comprised of historic tidal marsh, tidal marsh formed over the last century as a result of rapid sedimentation (centennial marsh), and newly restored tidal marsh (e.g., CDFG salt ponds).

Aerial view of the Strip Marsh Unit
USFWS

Geology and Soils

Ten thousand years ago, the sea level was lower, and the San Francisco shoreline lay at least 20 miles to the west. San Pablo Bay was a steep canyon carved by the combined flow of the San Joaquin and Sacramento Rivers. The end of the Ice Age raised mean sea level, eventually filling the canyons to create what is now San Francisco Bay and its surrounding baylands. Today, the San Francisco Bay Area is characterized by complex terrain consisting of coastal mountain ranges, inland valleys and bays. Elevations of 457 meters are common in the higher terrain of this area. The area where the Refuge is located has several active earthquake fault lines, including San Andreas, Healdsburg, and Rogers Creek (Drake 1978). Two distinct units comprise the geologic formations underlying the area: an older bedrock unit and a younger, unconsolidated sedimentary sequence. Alluvial material deposited on the bedrock consists of silty clay and loose to medium sand and gravel. The upper layer of bottom materials consists of soft, silty clay and is commonly called "younger bay mud." Bay mud varies in thickness, but reportedly ranges up to 60 meters deep in some areas (USFWS 1978). Sonoma and Solano Counties are described as silicious sandstone, shale, and volcanic tufa that are particularly beneficial to agriculture (Solano County Board of Trade 1887).

San Pablo Bay is underlain by deep sediments of alluvial derivation. Deposits consist of interbedded layers of sand, silt, clay, and gravel up to roughly 400 meters thick. The surface layer of mud may be over 30 meters thick in places. Soils are alkaline due to the influence of the salt-water estuary. Wherever diked and reclaimed, soils tend to be acidic. The Sonoma County portion of the Refuge has soils characterized by alluvium, coal, petroleum, quicksilver, borax and kaolin (Munro-Fraser 1973). The soils in the Solano County portion of the Refuge are characterized as red gravel and black sandy loam that is rich in alluvium (Solano County Board of Trade 1887).

Soils in marsh areas are generally representative of the Clear Lake-Reyes Association and are characterized as poorly drained, nearly level to gently sloping clays to clay loams. Specifically, wetland soils in the study area are classified as Reyes silty clay. This silty clay is stratified with muck and organic matter. Reyes silty clays are characterized as having a high shrink-swell potential and high available water capacity. The capability classification is IV w-9 (Solano County Board of Trade 1887).

Hydrology

The Refuge lies within the San Pablo Bay watershed, which is a major drainage basin for Marin, Sonoma, Napa, Solano, and Contra Costa Counties. The surface area of San Pablo Bay is approximately 90 square miles (60,000 acres). A unique feature of the watershed is the large tracts of historical baylands—diked and tidal—particularly along the perimeter of San Pablo Bay and adjacent to the Tolay Creek, Sonoma Creek, Petaluma River, and Napa River (U.S. Army Corp of Engineers 1999). Some of these diked baylands include what are now seasonal wetlands. Approximately one-half of the diked historic baylands are publicly owned, principally by wildlife agencies, military agencies, and special purpose districts such as flood control districts.

Tides are the major source of water and hydrologic change for San Pablo Bay and the larger San Francisco Estuary. In the Estuary, there is a mixed-diurnal type of tide, where there are two high tides and two low tides almost every day (Goals Project 1999). The highest tides tend to occur in January and June. The tides influence baylands in three basic ways: they carry nutrients, sediments, salts, and other materials to and from the baylands; they create gradients of

decreasing moisture and tidal action from lower to higher tidal elevations; and they provide the physical means for fish and other aquatic organisms to move across tidal flats and marshes at high tide (Goals Project 1999).

National Ocean and Atmospheric Administration operates long-term and short-term tide gauges along the coast and in the bays. The closest gauge to the Refuge is located at the Petaluma River entrance, which was in operation from May 1977 through February 1986. Tidal averages for this region of the area's tidal characteristics age during this period are provided in Table 3.

Table 3. Tidal Datum for Petaluma River Entrance

Mean Tidal Datum	Value (meters)	Value (feet)
Highest Water Level Measured (01/16/1978)	3.51	11.52
Mean Higher-high Water	2.85	9.35
Mean High Water	2.68	8.79
Mean Tide Level	1.99	6.53
Mean Sea Level	1.99	6.53
Mean Low Water	1.29	4.23
Mean Lower-low Water	0.99	3.25
Lowest Water Level Measured (06/03/1977)	0.52	1.71

Source: Published Tidal Datums for NOAA Tide Gauge No. 9415252

The Refuge is also impacted by freshwater inputs. More than 95 percent of the freshwater input of the Estuary comes from the San Joaquin and Sacramento Rivers (Goals Project 1999). The Refuge is also affected directly by the Napa and Petaluma Rivers that flank it, and by various sloughs and creeks running through the Refuge into San Pablo Bay. In Marin County, Las Gallinas, Miller, and Novato Creeks drain into San Pablo Bay. In Sonoma County, the drainage basins of the Petaluma River, Sonoma Creek, and Tolay Creek drain into the tidal flats of San Pablo Bay. The Petaluma River and its tributaries drain a total area of about 143 square miles. Sonoma Creek drains a 153-square-mile area. In Napa County, the Napa River, Carneros Creek, and Huichica Creek flow into San Pablo Bay. Napa River's basin encompasses 417 square miles. The western portion of Solano County is characterized by large expanses of diked baylands, bordering San Pablo Bay and Mare Island at its eastern edge. Contra Costa County bounds the southeastern edge of San Pablo Bay with San Pablo, Wildcat, Pinole, and Rheem Creeks draining into San Pablo Bay (U.S. Army Corp of Engineers 1999). The freshwater runoff from the land and these rivers mixes with salt water from the ocean creating a salinity gradient that varies throughout the Estuary, providing varied habitat types.

The San Pablo Bay watershed has experienced increased soil erosion, stream channel degradation, loss of riparian and oak woodland habitat, and declining groundwater values. Napa, Sonoma, and northern Marin Counties converted wetlands for grazing and cultivated croplands such as oat hay and wheat. Urbanized pockets in each county are continuing to grow, with Contra Costa having the highest concentration of commercial and industrial use, including petroleum refiners and chemical companies.

Sedimentation

There are two main sources of sediment for baylands: inorganic silts and clays that are generated by freshwater flows, tidal currents, and wind-driven waves; and organic sediments that are

created by the growth of plants within baylands (Goals Project 1999). More than six million cubic yards of inorganic sediment enter the Estuary annually from watersheds, mostly from the Sacramento and San Joaquin river system, and the local watersheds supply the remainder (Goals Project 1999). This sediment primarily settles out on the bottom of the Estuary or is carried to the ocean, with little transported to the baylands (Krone 1979 and 1985, Ogden Beeman and Associates 1992). Within the tidal marshes, inorganic sediments mostly occur within the channels and along their immediate margins (Leopold et al. 1993). Plant production and the accumulation of organic sediments account for most of the sedimentation on the tidal marsh plains (Collins et al. 1987).

Trends indicate that sediment availability is likely to decline in the coming decades given reductions in re-suspended sediment as sediment from Gold Rush hydraulic mining continues to pass through the Estuary (Jaffe et al. 1998). Studies over the last 10 years have detected a significant decline in suspended sediments, including a sudden decrease (40 percent) in 1999 (Schoellhamer 2009). Research also indicates that sediment provided to the Estuary by the Sacramento River has been declining as a result of dams and other water diversions (Krone 1979 and 1985, Schoellhamer 2009). These changes in suspended sediment will likely slow the pace of tidal marsh restoration and will affect the ecology of the Estuary.

Water Quality

The San Francisco Bay is made up of four interconnected embayments (Central, South, Suisun, and San Pablo Bays), each with different levels of urbanization and freshwater influences. The Bay Institute conducted a water quality evaluation of the San Francisco Bay Estuary that was published in 2003 (Bay Institute 2003). Five indicators were used to analyze the water quality of the Estuary based on State and Federal standards: trace elements (e.g., arsenic, metals), pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and dissolved oxygen. The study showed that several pollutants are present at levels of concern in San Pablo Bay and San Francisco Bay as a whole (see Table 4). Trace elements results for 2001 appear to be comparable to the 1993-2001 average, while fewer samples had pesticide concentrations that exceeded water quality standards for 2001 than the 1993-2001 average. PAH concentrations from samples appeared to improve for 2001 compared to the 1993-2001 average, while PCB and dissolved oxygen estimates were not available.

Table 4. Water Quality Contaminant Trends for the San Francisco Estuary

	1993-2001	2001
Trace Elements	An average of 10 percent of all water samples exceeded the standard for one or more trace elements; copper, mercury, selenium, and nickel concentrations were exceeded in some years; concentrations most severe in San Pablo Bay; and concentrations of mercury copper and selenium are declining.	10 percent of samples failed for at least one contaminant.
Pesticides	31 percent of all water samples exceeded the standard for one or more pesticides; Dieldrin, DDE Diazinon, and Heptachlor epoxide were exceeded in all or some years; concentrations most severe in San Pablo Bay.	17 percent of samples had pesticide concentrations greater than the water quality standard.
PCBs	Samples exceeded standards for PCBs found in the	N/A

	Bay; concentrations were moderate in San Pablo Bay; concentrations are declining.	
PAHs (polycyclic aromatic hydrocarbons)	Concentrations exceeded water quality standards during 1995-1997 and 2001; San Pablo Bay had the highest levels of PAH concentrations; concentrations have not changed	One sample from the South Bay exceeded standards for two PAH compounds.
Dissolved Oxygen (DO)	DO were generally above the minimum standard	N/A

Source: The Bay Institute. 2003. San Francisco Bay Water Quality Index. Available at: http://www.bay.org/publications/-ecological-scorecards

The Refuge is most closely affected by the water quality of San Pablo Bay and its tributaries. Table 5 lists waters in the San Pablo Bay region that have been designated as impaired and the pollutants for which they were so designated. The designations can be the result of pollutants, such as heavy metals or pesticides, or a physical property of the water, such as dissolved oxygen content or temperature. The Bay is impaired by persistent agricultural chemicals, such as DDT and Chlordane, which may have been used anywhere in the Sacramento and San Joaquin Rivers watersheds. Metals, PCB's, and mercury—remnants of past industrial and mining operations—also occur in the Bay. The tributaries, which include Sonoma Creek and the Petaluma and Napa Rivers, are impaired by sediment, nutrients, and pathogens that are related to the abundant agricultural activities found within the greater watershed. In addition, a health advisory for sport fish consumption was issued for the entire San Francisco Bay Estuary in 1994 and remains in effect because of persistently high PCB and other pollutant levels that have been found in aquatic organisms (Office of Environmental Health Hazard Assessment 1994).

Table 5. Impaired Water Bodies in the Vicinity of San Pablo Bay

Water Body/Waterways	*Listed Impairment/Pollutant*
San Pablo Bay	Chlordane, DDT, Diazinon, Dieldrin, Dioxin Compounds, Exotic Species, Furan Compounds, Mercury, Nickel, PCBs, Selenium
Napa River	Nutrients, Pathogens, Sedimentation/Siltation
Sonoma Creek	Nutrients, Pathogens, Sedimentation/Siltation
San Francisco Bay, Central	Chlordane, DDT, Diazinon, Dieldrin, Dioxin Compounds, Exotic Species, Furan Compounds, Mercury, PCBs, Selenium

Source: San Francisco Bay Regional Water Quality Control Board, Section 303(d) of the Clean Water Act, 2003.

Climate and Air Quality

The San Francisco Bay Area climate is characterized by moderately wet winters and dry summers. The summer climate of the West Coast is dominated by a semi-permanent high pressure cell, which is high-centered over the northeastern Pacific Ocean. Because this high pressure cell is quite persistent, storms rarely affect the California coast during the summer (BAAQMD 2004). In summer, the distribution of temperature near the surface over the Bay Area is determined, in large part, by the effect of differential heating between land and water surfaces. This process produces a large-scale gradient between the coast and the Central Valley, as well as small-scale local gradients along the shorelines of the ocean and bays. The temperature contrast between coastal ocean water and land surfaces 15 to 20 miles inland reaches 35 degrees Fahrenheit or more on many summer afternoons. At night, this contrast usually decreases to less than 10 degrees Fahrenheit. Air approaching the California coast, already cool and moisture-laden from its long trajectory over the Pacific, is further cooled as it flows across this cold bank of water near the coast, thus accentuating the temperature contrast across the coastline. This

cooling is often sufficient to produce condensation—a high incidence of fog and stratus clouds along the northern California coast in summer. These periods are characterized by winds that flow out of the Central Valley into the Bay Area and often include tule fog (BAAQMD 2004).

In winter, the Bay Area experiences periods of storminess, moderate to strong winds, and periods of stagnation with very light winds. Winter rains (November through April) account for about 90 percent of the average annual rainfall (BAAQMD 2004). The mean winter temperature maxima and minima reverse the summer relationship in that daytime variations are small, while mean minimum (nighttime) temperatures show large differences and strong gradients. The moderating effect of the ocean influences warmer minimums along the coast and penetrates the Bay. Coldest temperatures are in the sheltered valleys, implying strong radiation inversions and very limited vertical diffusion (BAAQMD 2004).

According to Bay Area Air Quality Management District, the Refuge is spread across the Cotati/Petaluma, Sonoma Valley, and Napa Valley regions. Air quality is affected by San Francisco Bay and the Pacific Ocean conditions. Air quality in the San Francisco Bay Area is managed by the Bay Area Air Quality Management District. There are both San Francisco Bay Area and National Ambient Air Quality Standards. To date, standards have been established for ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter (PM_{10}), particulate matter- fine ($PM_{2.5}$), sulfates, lead, hydrogen sulfide, and vinyl chloride. For the San Pablo Bay Area, carbon monoxide, nitric oxide, nitrogen dioxide, ozone, and sulfur dioxide are measured on a daily basis.

Black-necked stilt
USFWS

Geographic areas of the region are classified as “attainment” or “nonattainment” areas based on whether these areas meet the Bay Area and national standards. When an area is in compliance with national or Bay Area standards, they are designated “attainment”, and when they are not, they are considered “nonattainment” areas. For 2004, the San Pablo Bay region was designated an attainment area for national air quality standards for ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, PM_{10}, and $PM_{2.5}$. However, the region was classified as a nonattainment area for California State Standards for PM_{10} and $PM_{2.5}$ (BAAQMD 2004).

Hazardous Materials and Contaminants

A comprehensive analysis of hazardous materials and contaminants has not been conducted for the Refuge. Contaminants assessments are usually conducted in association with major construction or restoration activities. Past Refuge assessments are listed in the following text.

Cullinan Ranch

Cullinan Ranch is a historic tidal marsh that was diked and drained for oat hay farming in the late 1800s. Cullinan Ranch contained a variety of contaminants and heavy metals as a result of farming operations. A 1990 survey identified elevated levels of barium, copper, nickel, zinc, p,p'-DDT, p,p,'-DDE, and DDT (USFWS 1990). A 2003 survey of the pole barn and farmyard areas yielded similar results (Table 6) (Tetra Tech Em Inc. 2003). The farmyard area assessment resulted in high concentrations of zinc, nickel, DDTs, and chlordane that may pose unacceptable ecological risks. Various pesticides appear widespread throughout the farmyard area. Other contaminants found at Cullinan Ranch include arsenic, cadmium, copper, and mercury. However, the concentrations of these contaminants were not considered significant for action.

Table 6. 2003 Contaminants Survey at Cullinan Ranch

Sample Area	Potential Contaminant
Pole Barn Area	Zinc, Arsenic, Mercury, Nickel, Copper
Farmyard Area	Arsenic, Cadmium, Copper, Mercury, Nickel, Lead, Zinc
Pump Canal (area was submerged in water during soil sampling)	Iron, Nickel, Zinc, Mercury, DDD, DDT, DDE, Chlordane
East Pond Area	Arsenic, Copper, Mercury, Nickel
West Pond Area	Arsenic, Nickel, Mercury, Copper, Nickel

Source: Tetra Tech 2003

Contaminants at the pole barn area were delineated and removed in October 2006. Further delineation of contaminants of the farmyard area was conducted during summer 2007, and contaminant removal was completed during summer 2008.

Earlier surveys were conducted by U.S. Geological Survey (USGS) during March-April 1994. Samples were taken from the tidal marsh area, and results (arithmetic mean and standard deviations) are shown in Table 7. Samples were compared to recommended concentrations in reusable dredge materials. Based on the comparisons, the elements did not surpass the recommended amounts for beneficial reuse of dredge material.

Table 7. Arithmetic Means and Standard Deviations of Trace Elements (mg/kg dry wt) in Core Samples Taken from Cullinan Ranch Tidal Marsh Areas. Recommended Concentrations are Given for Comparison

Analyte	Cullinan Ranch (mg/kg dry wt.)	Recommended Sediment Screening Guidelines for Beneficial Reuse of Dredged Material[a] (mg/kg)	
		Surface Material[b]	Foundation Material[c]
(N)	27	N/A	N/A
AS	20.18 (5.11)	15.3	70
CD	0.11 (0.05)	0.33	9.6
CU	39.76 (4.42)	68.1	270
PB	20.13 (4.60)	43.2	218
HG	0.13 (0.05)	0.43	0.7
SE	0.62 (0.09)	0.64	N/A

[a] Values taken from SFRWQCB 2000; [b] surface material concentration recommendations based on ambient values in Bay sediments; [c] foundation material recommendations based on NOAA ER-M values.

Strip Marsh
Soil and sediment samples were collected in the Strip Marsh during March-April 1994 to permit comparisons to the adjacent diked Cullinan Ranch unit. Results of the samples are shown in Table 8 in comparison to recommended concentrations in reusable dredge materials. Arsenic, copper, and lead samples surpassed surface material guidelines. Many of the contaminant levels of the Strip Marsh exceed values found at the adjacent Cullinan Ranch unit. Much of the Strip Marsh unit tidal marsh developed over the last century ("centennial marsh") as a result of gold mining and other human actions that altered sediment flows (e.g., southern Mare Island rock spit built to divert sediments away from the Napa River).

Table 8. Arithmetic Means and Standard Deviations of Trace Elements (mg/kg dry wt) in Core Samples Taken from Strip Marsh Tidal Marsh Areas. Recommended Concentrations are Given for Comparison

Analyte	Strip Marsh	Recommended Sediment Screening Guidelines for Beneficial Reuse of Dredged Material[a]	
		Surface Material[b]	Foundation Material[c]
(N)	26	N/A	N/A
AS	18.97 (5.03)	15.3	70
CD	0.18 (0.08)	0.33	9.6
CU	70.89 (7.78)	68.1	270
PB	44.83 (15.76)	43.2	218
HG	0.33 (0.10)	0.43	0.7
SE	0.52 (0.06)	0.64	N/A

[a]Values taken from SFRWQCB 2000; [b]surface material concentration recommendations based on ambient values in Bay sediments; [c]foundation material recommendations based on NOAA ER-M values.

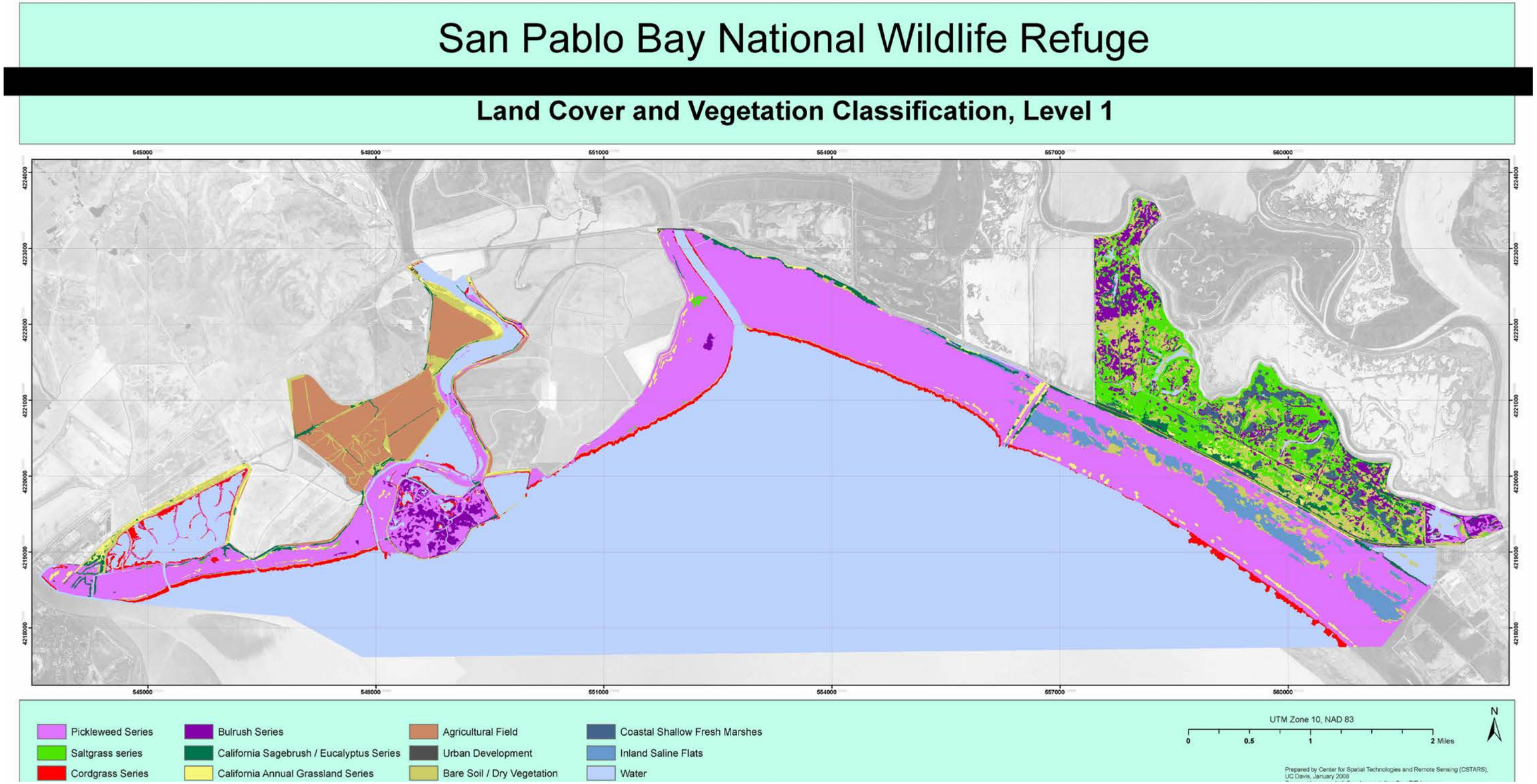
The Bay also has a considerable amount of contaminants for past and present activities. The water quality section earlier in this chapter provides detailed information on the contaminants found in the bay habitats of the Refuge.

There are no contaminants survey records for Lower Tubbs, Tubbs Setback, Tolay Creek, Figueras, Guadalcanal, Pritchett, and Sears Point units of the Refuge.

Habitat

The Refuge is made up of open bay water, upland, tidal marsh, seasonal wetlands, and muted tidal marsh mudflats. A vegetation mapping project was started in 2006 through the Center for Spatial Technologies and Remote Sensing at University of California, Davis. Limited field sampling and remote sensing analysis of hyperspectral data was used to develop the map. Figure 5 presents a preliminary map of the habitat types found of the Refuge. Habitat types are further described in the following text according to the Goals Project (1999). In general, mudflats make up much of the Refuge, followed by tidal wetland, diked wetland, and upland. Historical tidal marshes exhibited higher species richness and diversity of vascular plant species than today (Brewer et al. 1880; Greene 1891, 1894; Brandegee 1892, Jepson 1911, Howell 1949, Thomas 1961). By the early 20th century, most of San Pablo Bay tidal marshes had been diked for agriculture (Meiorin et al. 1991). Partial failures of dikes, failure of drainage systems, and tidal marsh restoration projects have

Figure 5. Preliminary Assessment of Habitat Types for San Pablo Bay NWR



since caused some agricultural baylands to revert to wetland conditions (USFWS, *unpub. rept.*). Tidal marsh vegetation has remained relatively intact where this habitat still exists, with few successful invasive plant introductions (Josselyn 1983; Atwater 1979). Non-native invasive *Spartina* species and perennial pepperweed are the major invasive plant threats to San Pablo Bay at this time. Both have colonized San Pablo Bay and are effective competitors with native tidal marsh plants, capable of altering the estuarine ecosystem. A description of tidal and subtidal habitats follows.

Shallow bay water and channels

Shallow bays and channels are characterized as the bottom being entirely between 18 feet below mean lower-low water and mean higher-high water. This environment includes eelgrass (*Zostera marina*) beds, oyster beds, and rock intertidal areas. Shallow bays and channels are important for many invertebrates, fish, and waterbirds. This rich environment is an especially productive feeding area for many fish, including Pacific herring (*Clupea pallasi*), Sacramento splittail (*Pogonichthys macrolepidotus*), northern anchovy (*Engraulis mordax*), and jacksmelt (*Atherinopsis californiensis*). It is also an important migratory corridor for anadromous fishes such as Chinook salmon, steelhead, and green sturgeon (*Acipenser medirostris*). A few of the many bird species that occur in this habitat include western grebe (*Aechmophorus occidentalis*), American wigeon (*Anas americana*), canvasback, Forster's tern (*Sterna forsteri*), and least tern (*Sterna antillarum*). Vegetation is limited to algal species and eelgrass, an important plant species founds in this habitat.

Tidal flat

The majority of the Refuge is made up of this habitat type. Tidal flats include mudflats, sandflats, and shellflats. It occurs from below mean lower-low water to mean tide level and supports less than 10 percent cover of vascular vegetation, other than eelgrass. These expanses of fine-grained silts and clay support an extensive community of diatoms, worms, and shellfish, as well as algal flora, including green algae, red algae, and sea lettuce. Eelgrass can also be a component of mudflats. This habitat type also supports feeding shorebirds and at high tide, seabirds.

Marsh at Tubbs Island Unit
USFWS

Tidal marsh

Tidal marsh, also known as salt marsh, is a vegetated wetland that is subject to the tidal and salinity influences of the Pacific Ocean. Tidal marsh typically occurs between mean sea level and mean higher-high water. Marsh pans are typical features of extensive, well-developed tidal marshes. These are natural ponds that form in the marsh plain. These ponds are usually less than one foot in depth and fill with tidal water only during very high tides.

Tidal salt marsh is generally dominated by Pacific cordgrass (*Spartina foliosa*) and pickleweed. Pacific cordgrass is usually the dominant species on broad tidal mudflats that fringe tidal marsh plains (Goals Project 1999). In middle tidal salt marsh, at elevations near and above mean high water, Pacific cordgrass yields to common pickleweed. Additional plant species on tidal marsh plains include fat hen (*Atriplex triangularis*), marsh- rosemary (*Limonium californicum*), alkali heath (*Frankenia salina*), jaumea (*Jaumea carnosa*), and gumplant (*Grindelia* spp.). At mean higher-high water, the tidal marsh transitions into upland. This ecotone, where one plant community transitions into another, is often referred to as the marsh-upland ecotone. The marsh-upland ecotone historically contained a unique mix of plant species, many of which are now rare or absent. The ecotone is an integral part of the tidal marsh ecosystem, providing many structural and functional services including refuge from predators during extreme tide events.

Muted tidal marsh is a subset of tidal marsh that occurs on the Refuge. Muted tidal marsh areas contain impediments to full tidal action such as internal berms and culverts. These impediments mute or dampen the tides, which can result in lower tidal marsh elevations and alter tidal marsh plant communities.

In the North Bay, tidal marshes support gobies, sculpins, and threespine stickleback (*Gasterosteus aculeatus*) (Goals Project 1999). Birds common to tidal marsh of the Refuge include northern harrier (*Circus cyaneus*), California clapper rail, California black rail, salt marsh common yellowthroat (*Geothlypis trichas sinuosa*), and San Pablo song sparrow (*Melospiza melodia samuelis*) and many species of shorebirds and waterfowl. Small mammal species that rely primarily on tidal marsh include salt marsh wandering shrew (*Sorex vagrans haliocoetes*), Suisun shrew (*Sorex ornatus sinuosis*), and salt marsh harvest mouse.

Diked baylands
Diked wetlands are areas of historical tidal marshes that have been isolated from tidal influence by dikes or levees, but which maintain primarily wetland features. One type of diked wetland is a managed marsh which is habitat managed for wildlife, primarily waterfowl. Diked marsh usually occurs in low areas adjacent to levees or dikes that have no or poor drainage. The Cullinan Ranch unit is considered diked bayland.

Biological Resources

The wildlife resources of San Pablo Bay are often described and studied within the larger context of the San Francisco Bay Estuary. A diversity of fish, plant, and wildlife species populate the San Francisco Bay Estuary. The Estuary served as a migration staging area and wintering area for a variety of waterfowl, shorebirds, and other waterbirds. During the spring and fall, thousands of shorebirds feed on the tidal mudflats in the area. Endangered species that use the Estuary include the California clapper rail, salt marsh harvest mouse, delta smelt (*Hypomesus transpacificus*), Chinook salmon, steelhead, and green sturgeon.

The wildlife of San Pablo Bay has been studied by many scientific entities including the USFWS, USGS, CDFG, PRBO Conservation Science, the San Francisco Estuary Institute, public universities, and many other organizations. Previous studies are often Estuary or Bay-wide in spatial scope with limited Refuge-specific data. In other cases, refuge-specific data is available

but analyses are done only at the Bay or Estuary level. Despite the limited amount of long-term refuge-specific data, there is a significant amount of knowledge about the ecology, status, and trends of biological resources of San Pablo Bay and the larger San Francisco Estuary. Long-term (more than 10 years) monitoring of Refuge biological resources has been collected but is primarily associated with tidal restoration planning and projects (e.g., Cullinan Ranch, Tolay Creek). During the last decade, regular (e.g., annual) monitoring of sensitive and invasive species populations throughout the Refuge began. These data are used in a variety of ways, including the support of an adaptive land management approach. The following sections describe the different species that are or may be present on the Refuge.

Invertebrates

Marine invertebrates occur in the deep bay, tidal channel, and shallow subtidal and intertidal habitats. The Bay is dominated by invasive non-native invertebrate species (Carlton 1979, URS 2001). San Pablo Bay is described as an estuarine habitat that supports zooplanktonic and benthic invertebrates. Zooplankton includes species assemblages such as rotifers, cladocera, copepods, tunicates, larval forms of annelid worms, gastropods, and bivalves. The introduced Asian clam (C*orbula amurensis*) and two introduced Asian mysid shrimp have profoundly affected the zooplankton community (URS 2001). Asian clam, green crab (*Carcinus maenas*), and Chinese mitten crab (*Eriocheir sinensis*) are invasive species that have also become well established in the San Pablo Bay. Table 9 lists common invertebrates that use San Pablo to hatch or rear young.

Table 9. Invertebrates that Hatch or Rear in San Pablo Bay

	Hatch	Rear
Cancer antennarius		Δ
Cancer gracilis		Δ
Cancer magister		▲
Cancer productus		Δ
Crangon franciscorum	Δ	▲
Crangon nigricauda	Δ	▲
Crangon nigromaculata		Δ
Heptacarpus stimpsoni		Δ
*Palaemon macrodactylus**	▲	Δ

▲ indicates peak, Δ indicates lesser amount
**indicates non-native*
Source: Orsi 1999

Several shrimp species are found in the Estuary. CDFG conducts otter trawls (survey of bottom dwelling fish) annually (San Francisco Bay Study). Results from 2000-2007 show that California bay shrimp *(Crangon franciscorum)*, is the largest common shrimp in the Estuary and usually the most abundant. In 2006, the juvenile abundance index was three times higher than the 2005 index and the highest index since 1998 (IEP 2008). Through April, most adult shrimp are collected in the Central Bay, with some distribution extending to channels of the South and San Pablo Bays. In the spring and summer, the highest juvenile catches were in San Pablo Bay. San Pablo Bay is an important nursery in high freshwater outflow years.

Blacktail bay shrimp (*Crangon nigricauda*) is usually the second most commonly collected shrimp in San Pablo Bay. Highest catches from San Pablo Bay occur in October. Blackspotted bay shrimp (*Crangon nigromaculata*) is the most common shrimp collected in the nearshore ocean

area adjacent to the Estuary. Stimpson coastal shrimp (*Heptacarpus stimpsoni*) is a small shrimp common over soft bottoms and eelgrass beds in higher salinity regions of the Estuary. This species is sometimes collected in San Pablo Bay, but none were collected in 2006, the first time since 1983. Oriental shrimp (*Palaemon macrodactylus*), introduced from Asia in the 1950s, is considered a minor component of total shrimp catch and can be found in San Pablo Bay. Siberian prawn (*Exopalaemon modestus*) is an introduced shrimp from Asia that is common in tidal brackish and freshwater areas of the Estuary, as well as the rivers and sloughs upstream of the delta. This was the most common *caridean* shrimp in the lower Sacramento and San Joaquin Rivers in 2006.

There are four common *cancer* crabs found in the Estuary. Dungeness crab (*Cancer magister*), historically abundant in the Bay (Skinner 1962), have cyclical productivity depending on ocean conditions. Dungeness crab reproduces in the ocean and rear in the nearshore coastal areas and estuaries. At the early post-larval stages, they can be found all over the bay and are most abundant in San Pablo Bay (Tasto 1983). In general, the greatest numbers of crabs were found throughout the year at North Bay survey stations, and station abundances remain fairly constant until the rainy season (Tasto 1983). Abundance in 2007 increased from the previous two years, but not nearly as high as from 2001-2004, which resulted in high commercial landings for the 2002-2003 to 2006-2007 fishing season. The most crab collected were from the Central Bay, with some movement up the channel over San Pablo Bay and western Suisun Bay shoals. All *cancer* crabs had a broader distribution in 2007 due to increased salinities and higher abundance.

Three other *cancer* species reproduce in both the nearshore ocean and higher salinity areas of the Estuary in the winter. Brown rock crab (*Cancer antennarius*) increased in 2007 from a low 2006 population index. This species was collected from the South Bay to San Pablo Bay. The 2007 abundance index for slender crab (*Cancer gracilis*) increased after three of the lowest annual indices in 20 years. Red rock crab (*Cancer productus*) is the least common of the four *cancer* crabs collected by otter trawl.

Chinese mitten crab was first collected in the Estuary in the early 1990s, but it is likely that it was introduced to the South Bay in the late 1980s. After several years of rapid population grown and expanding distribution, Chinese mitten crab peaked in 1998 and has steadily declined since 2001. Fall and winter 2007-2008 surveys resulted in no Chinese mitten crabs collected at fish facilities by the Bay Study or the UC Davis Suisun Marsh trawl in the northern part of the Estuary.

Fish

Fish species that use the Estuary and its tributaries can be categorized as migratory, estuary-dependent (need the estuary to complete at least one of their life stages), non-estuary dependent, and estuary resident (spending their whole lives in the estuary). A full species list is available in Appendix B.

Several long-term monitoring surveys have been conducted by several entities (e.g., CDFG, San Francisco Estuary Institute) in the San Francisco Estuary, including the Summer Townet Survey, the Fall Mid-water Trawl Survey (FMTS), the San Francisco Bay Study, the delta smelt 20-mm Survey, and the USFWS Beach Seine Survey. Total number of fish caught in surveys from 2000-2007 are shown in Table 10 and Table 11 for otter trawl (bottom) and mid-water trawl (middle of the water column) surveys. Averages are not available because numbers vary year to

year and averaging annual catch would not present an accurate depiction. Table 12 shows which fish commonly hatch or rear in San Pablo Bay.

Migratory Fish
Several anadromous fish species travel from the Pacific Ocean through the Estuary to freshwater spawning streams including Chinook salmon, steelhead, green sturgeon, longfin smelt (*Spirinchus thaleichthys*), American shad (*Alosa sapidissima*), and striped bass (*Morone saxatilis*). Chinook salmon, steelhead, and green sturgeon will be discussed in the section *Listed Fish Species.*

The longfin smelt is a short-lived species that spawns in freshwater and rears primarily in brackish water (IEP 2008). The 2007 survey indexes were some of the lowest on record (IEP 2008). Low outflow in the winter and spring of 2007 likely resulted in decreased longfin smelt abundance. American shad was introduced into the Sacramento River in 1871 and is now found throughout the Estuary. This species spawns in rivers, rears in freshwater, and migrates to the ocean. The 2007 FMTS index was only 24 percent of the 2006 index, the second lowest index on record (IEP 2008). The 2007 Bay Study trawl was also significantly lower than the previous year and the lowest index for the entire study period.

Striped bass was first introduced to the Estuary over 125 years ago (IEP 2008). Bass spend most of their lives in the San Francisco Bay Estuary (Herbold et al. 1992). Bass spawn in the rivers and juveniles rear in fresh and brackish waters (IEP 2008). The 2007 index surveys were all lower than previous years, with one index being the lowest in the 48-year history; they have continued their downward trend since the mid-1980s (IEP 2008).

Estuary-dependent Fish
Several fish species use San Pablo Bay as nurseries for larval or juvenile fish including starry flounder (*Platichthys stellatus*), jacksmelt, plainfin midshipman (*Poricthys notatus*), Pacific herring, and some perch species. Starry flounder is an estuary-dependent species that spawns in the ocean but rears in brackish and freshwater areas (IEP 2008). Throughout their time in the San Francisco Bay, juvenile starry flounder are commonly found in shallow water, including shoals, intertidal areas, and tidal marshes (Wood 1981, Moyle et al. 1986, Baxter 1999, CDFG, *unpub. data*). The 2007 survey for age-0 (under one year old) indicated that starry flounder was 57 percent higher than the 2006 index and nearly double the study period average (IEP 2008). However, age-1 and 2 classes were at least 60 percent of their study period average (IEP 2008).

Jacksmelt seasonally migrates from the nearshore coast to bays and estuaries to spawn and rear (IEP 2008). The 2007 age-0 index was nearly six times the 2006 index; it was also the highest index since 1985 and the second highest index on record (IEP 2008). Plainfin midshipman migrates from coastal areas to bays and estuaries to spawn. The 2007 age-0 index was 4.1 times the 2006 index and the highest on record (IEP 2008).

Larvae and young juvenile pacific herring are found in the shallow waters of San Pablo Bay between November and April, but there are no known spawning areas in San Pablo Bay (CDFG 1992). The 2007 age-0 index was more than three times the 2006 index—the first increase since 2002 (IEP 2008). However, the 2006-2007 commercial landings were the second lowest on record at 310 tons (IEP 2008).

Some perch species use the Bay as a nursery. However, their abundance has been drastically decreased. In 2007, the abundance index for Shiner perch (*Cymatogaster aggregata*) increased slightly from the 2006 index but was still only 37 percent of the study period average. The 2007 pile perch (*Rhacochilus vacca*) abundance was 0, showing no sign of recovery in the Estuary (IEP 2008). White seaperch (*Phanerodon furcatus*) are also found in the Estuary, but none were found in 2006 and 2007.

Table 10. CDFG Otter Trawl Survey Totals of Highest Recorded Number Species (combined) in San Pablo Bay, 2000-2007

Species	Total
Bay goby	5833
English sole	3675
Plainfin midshipman	3406
Longfin smelt	1651
Pacific staghorn sculpin	1226
Speckled sanddab	1018
Yellowfin goby*	645
White croaker	505
Shokihaze goby*	438
Cheekspot goby	432
Starry flounder	426
Striped bass*	384

Source: K. Heib, CDFG
** indicates non-native*

Table 11. CDFG Mid-water Trawl Survey Totals of Highest Recorded Number Species (combined) in San Pablo Bay, 2000-2007

Species	Total
Northern anchovy	142229
Pacific herring	10521
Longfin smelt	1383
Jacksmelt	904
American shad*	749
Striped bass*	456
Topsmelt	343
Chinook salmon	217

Source: K. Heib, CDFG
** indicates non-native*

Non-estuary Dependent Fish

A variety of fish have been present (neither spawning nor using the Bay as a nursery) in San Pablo Bay, including California halibut (*Paralichthys californicus*), longjaw mudsucker (*Gillichthys mirabilis*), tule perch (*Hysterocarpus traski*), white croaker (*Genyonemus lineatus*), threadfin shad (*Dorosoma petenense*), speckled sanddab (*Citharichthys stigmaeus*), northern anchovy, and some surfperch species. California halibut are occasionally found in San Pablo Bay (Ganssle 1966). They spawn in shallow coastal waters and rear in very shallow subtidal and intertidal areas of bays and estuaries. The 2007 combined age-0 and age-1 index was only two percent of the 2006 index (IEP 2008). The cooler ocean temperatures in the Gulf of the Farallones

likely resulted in the near absence of juvenile halibut. The 2007 age-2+ index was 55 percent of the 2006 index, but was twice the study period average (IEP 2008).

Longjaw mudsucker have been collected in San Pablo Bay (Goals Project 2000). Tule perch may be considered locally abundant in lower estuarine and riverine intertidal marsh and in portions of San Pablo Bay (Leidy, *unpub. data*). However, no current abundance information is available for this species. Several species are considered opportunists, using the Estuary as an extension of their nearshore distribution. These fish include northern anchovy, Pacific sardine (*Sardinops sagax caerulea*), and threadfin shad.

White croaker is a subtropical fish and a common coastal species that frequents bays and estuaries. Since 1995, age-0 indices have been below the survey average. Catch was sporadic in 2007 and most common in the Central Bay. The 2007 age-1+ index was approximately 2.5 times the 2006 index, but the third lowest on record. Threadfin shad was introduced into reservoirs in the Sacramento-San Joaquin watershed in the late 1950s. It is found throughout the Estuary, but prefers oligohaline to freshwater dead-end sloughs and other low-velocity areas (Wang 1986). The 2007 FMTS index for threadfin shad was 1.4 times the 2006 index but still below average (IEP 2008).

Speckled sanddab is the most abundant flatfish in the Estuary, spawning along the coast and rearing in the Estuary. The 2007 indexes were twice the 2006 index—the highest since 2004 (IEP 2008). It is surmised that cooler ocean temperatures were a likely factor in the increase.

Northern anchovy is the most abundant fish in the San Francisco Bay but is generally more abundant downstream of the Carquinez Strait (Goals Project 2000, Herbold et al. 1992). It is an important prey species for many fishes and seabirds. The 2007 abundance index for this species was 38 percent of the 2006 index (IEP 2008). Even though the index was the second highest since 2001, it remained below the study period average.

Some surfperch species are transient, migrating to bays and estuaries to give birth to fully formed young and return to the ocean for their lifespan. Walleye surfperch (*Hyperprosopon argenteum*) abundance index decreased to just 15 percent of the 2006 index and was the lowest since 1997 (IEP 2008). The 2007 age-1+ index was 46 times the 2006 record low index. The 2007 barred surfperch (*Amphistichus argenteus*) is also present in the Estuary but not easily sampled because they are commonly associated with eelgrass beds (IEP 2008). Black perch (*Embiotoca jacksoni*) was the only surfperch common in the Estuary that did not show a distinct decline but remained relatively low throughout the study period.

Estuary Resident Fish

Several species of gobies are found in the Estuary, including the Shokihaze (*Tridentiger barbatus*), yellowfin (*Acanthogobius flavimanus*), bay (*Lepidogobius lepidus*), arrow (*Clevelandia ios*), chameleon (*Tridentiger trigonocephalus*), and cheekspot goby (*Ilypnus gilberti*). Other resident fish species include delta smelt (discussed in the following subsection), splittail (discussed in the following subsection), dwarf perch (*Micrometrus minimus*), and Pacific staghorn sculpin (*Leptocuttus armatus*).

Shokihaze goby is an Asian fish first collected in the Estuary in 1997 (Greiner 2002). The 2007 survey for Shokihaze goby was identical to the 2006 results, which was the highest for the study

period (IEP 2008). Yellowfin goby are also introduced from Asia, spawning in brackish water. Juveniles migrate upstream to lower salinities and freshwater habitat (Moyle 2002). The 2007 index was slightly higher than the 2006 index but only 27 percent of the study period (IEP 2008).

Bay goby is native and one of the most common fish in the Estuary, with densities of young-of-the-year bay gobies highest in South or San Pablo bays (CDFG 1987 and Fleming 1999). The 2007 index decreased slightly from 2006 and was 91 percent of the study period average. In the Estuary, larval arrow gobies are most abundant in South and San Pablo Bays (Wang 1986, CDFG 1987). Juveniles and adults are common in shallow subtidal and intertidal areas of South, Central, and San Pablo Bays (CDFG 1987). A few arrow gobies were collected in the Petaluma River marshes and in Napa-Sonoma marsh (CDFG, *unpub. data*, ANATEC Laboratories 1981, CH_2M Hill 1996, Matern et al. 1996).

Chameleon goby were introduced to the Estuary in the 1960s, and the 2007 age-0 index was 44 times the 2006 index and 10 times the previous record high (IEP 2008). Its distribution is centered in the South Bay. However, the 2007 age-1+ index declined slightly from the 2006 index and was 83 percent of the study period average. Cheekspot goby are native fish that are common prey for a variety of fish and shorebirds. The year 2007 was the highest index on record and was more than three times the previous high in 2005.

Dwarf perch is considered a resident species to the Estuary. The 2007 dwarf perch index was very similar to the 2005 and 2006 indices, which were all below the study-period mean. Pacific staghorn sculpin have been collected in all four sub-regions of the Bay (Goals Project 2000). Juveniles and adults are most frequently captured in central and San Pablo Bays. Pacific staghorn sculpin rears in high salinity areas but is also found in brackish and occasionally freshwater. The 2007 age-0 index was almost four times higher than the 2006 index; it was the first year the index increased since 2002 (IEP 2008).

Table 12. Fish Species that Hatch or Rear in San Pablo Bay

	Hatch	Rear
arrow goby	Δ	Δ
bat ray	Δ	Δ
bay goby	▲	Δ
big skate	Δ	Δ
brown rockfish		Δ
brown smoothhound	Δ	Δ
California halibut		Δ
California tonguefish		Δ
cheekspot goby	▲	▲
Chinook salmon (fall run)		▲
delta smelt		Δ
diamond turbot	▲	
dwarf perch	▲	Δ
English sole		▲
*inland silverside**	Δ	Δ
jacksmelt	▲	▲
leopard shark	Δ	Δ
longfin smelt		▲

northern anchovy	▲	▲
Pacific herring	Δ	▲
Pacific staghorn sculpin	▲	▲
Pacific tomcod		Δ
pile perch	Δ	Δ
plainfin midshipman	▲	▲
shiner perch	▲	▲
speckled sanddab		Δ
starry flounder		▲
*striped bass**		▲
topsmelt	Δ	Δ
walleye surfperch		Δ
white croaker	Δ	▲
white seaperch		Δ
white sturgeon		Δ
*yellowfin goby**	▲	Δ

▲ indicates peak, Δ indicates lesser amount
** indicates non-native*
Source: Orsi 1999

Listed Fish Species
Listed fish species are discussed in the section *Federally Listed Wildlife Species at the Refuge* towards the end of this chapter.

Birds

Bird populations have clearly declined in abundance and diversity during the last 150 years (SFEP 1991). Despite significant reductions in population numbers of avian fauna, the San Francisco Estuary supports more than 57 percent of the total diving ducks in California (USFWS 1990 in SFEP 1991) and is considered a site of hemispheric importance for shorebirds by the WHSRN. The Refuge supports the federally listed California clapper rail and many other sensitive bird species, such as the state-listed California black rail, the salt marsh common yellowthroat, and the San Pablo song sparrow. Several bird species rely on the North Bay and the Refuge's habitats for roosting, foraging, or breeding, including shorebirds, waterbirds, waterfowl, terns, gulls, and passerines.

Shorebirds
San Francisco Bay holds higher proportions of the Southern Pacific region's total wintering and migrating shorebirds than any other coastal wetland within the Pacific coast wetland system (Page et al. 1999). Roughly 31 species of shorebirds are encountered regularly in the San Francisco Bay Estuary, relying primarily on tidal flats but also on salt ponds, managed wetlands, and other habitats for foraging invertebrates (Goals Project 2000). For 11 species (see Table 13), the Bay holds over 50 percent of the individuals found on surveys of the Pacific Coast wetlands in at least one season (Hickey et al. 2003). The San Francisco Bay Estuary provides refuge for shorebirds during their migration and wintering (August through April) and provides breeding habitat for a few species (Goals Project 2000). The Estuary is recognized as a Western Hemisphere Shorebird Reserve Network site of international importance for more than a million shorebirds in migration (Goals Project 2000, PRBO, *unpub. rept.*). However, loss of more than 90 percent of wetlands in the past 150 years has greatly altered the ecosystem, resulting in the

proposed listing or protection of more than 100 species, many associated with tidal salt marsh habitats (Goals Project 2000).

Table 13. Dominant Shorebird Species of the San Francisco Bay Wetlands

Species
black-bellied plover
semipalmated plover
black-neck stilt
American avocet
willet
long-billed curlew
marbled godwit
red knot
western sandpiper
least sandpiper
dowitcher spp.

Source: Page et al. 1999

San Francisco Bay holds the second largest known wintering concentration of marbled godwits (*Limosa fedoa*) in the world (Goals Project 2000). In the North Bay, 30 percent of the San Francisco Bay population is found in San Pablo Bay, where it winters and forages (Goals Project 2000). Thirty percent of western sandpipers (*Calidris mauri*) in the Bay area are in the North Bay, but only half of this percentage was found in San Pablo Bay, as they prefer salt ponds, followed by mudflats (Goals Project 2000). Long-billed dowitchers (*Limnodromus scolopaceus*) are present in the North Bay for wintering or during migration; they prefer freshwater habitats over brackish and intertidal areas (Campbell et al. 1990, Cogwell 1977, Pitelka 1950, Takekawa and Warnock 2000). Black turnstones (*Arenaria melanocephala*), red knots (*Calidris canutus*), and Wilson's phalarope (*Phalaropus tricolor*) minimally use the San Pablo Bay area (Goals Project 2000). Western snowy plovers (*Charadrius alexandrinus nivosus*) have only been seen in small numbers in diked, seasonal wetlands in the North Bay (Goals Project 2000).

Least sandpiper
USFWS

A shorebird survey of the San Francisco Bay was conducted in November 2006; prior to that a survey has not been conducted since 1993. For 2006, 31 shorebird species were recorded, totaling

355,774 individuals (See Table 14) (Warnock et al., *unpub.*). The 2006 survey was the second to largest of previous counts (1990: 357,754; 1991: 342,504; and 1992: 325,449) (Warnock et al., *unpub.*). Forty percent of total shorebirds counted occurred in the North Bay. The five most abundant species in the North Bay were western sandpiper, dunlin (*Calidris alpina*), least sandpiper (*Calidris minutilla*), American avocet (*Recurvirostra americana*), and willet (*Catoptrophorus semipalmatus*). More than one-third of all shorebirds found were roosting in the North Bay.

Table 14. Results of the November 2006 Shorebird Survey of San Francisco Bay

Species	Surveys in the North Bay Region			
Area	*A**	*B**	*C**	*J**
American avocet	18023	468	155	405
black-necked stilt	1149	41	27	151
Wilson's snipe	9	0	0	0
dowitcher spp.[1]	7770	75	747	213
stilt sandpiper	0	0	0	0
red knot	0	0	0	0
sharp-tailed sandpiper	1	0	0	0
pectoral sandpiper	0	0	0	0
least sandpiper	7675	100	820	1239
dunlin	41743	379	3019	170
western sandpiper	32843	101	2298	0
sanderling	75	0	203	0
marbled godwit	3567	205	485	95
greater yellowlegs	287	20	12	42
lesser yellowlegs	1	0	0	0
willet	4875	1899	1121	756
ruff	0	0	0	0
Spotted Sandpiper	0	3	13	23
Long-billed Curlew	1163	9	194	31
Whimbrel	1	0	26	0
Black-bellied Plover	3546	362	520	232
American Golden-Plover	0	0	0	0
Pacific Golden-Plover	1	0	0	0
Killdeer	165	10	31	91
Semipalmated Plover	1565	0	0	0
Snowy Plover	0	0	0	4
Surfbird	0	0	16	0
Ruddy Turnstone	0	0	3	0
Black Turnstone	0	0	98	17
Black Oystercatcher	2	0	34	0
Totals	**124461**	**3672**	**9822**	**3469**

**A: west side of San Pablo Bay north of the Petaluma River to just north of the Napa River. B: east side of San Pablo Bay from the mouth of the Carquinez Strait to the Richmond Bridge. C: east side of the Bay from Richmond Bridge to Bay Bridge. J: west side of Bay from Bay Bridge to south side of Petaluma River.*
(*Source: Warnock et al., unpub.*)

The largest negative difference was found in the marbled godwit (15 percent reduction from the 1992 survey). Also, the 2006 count suggested a decline in ruddy turnstone, dunlin, and western

sandpiper numbers from the counts conducted in the 1990s. However, due to the lack of surveys conducted during the last decade, it is difficult to assess whether these differences reflect a real population decline.

Waterbirds

Waterbirds here include herons, egrets, grebes, and rails. Waterbirds in the San Francisco Bay Estuary rely on the bay, tidal habitats and salt ponds for foraging, roosting, and breeding. Not all birds rely on the Estuary for breeding. Grebe species primarily rely on the Bay for foraging and roosting, but they are not known to breed there. The eared (*Podiceps nigricollis*), Western, and Clark's (*Aechmophorus clarkii*) grebe roost and forage in a variety of habitats in San Francisco Bay Estuary, including lakes, ponds, marsh sloughs, open bay, tidal habitats, and subtidal habitats, but they mostly frequent salt ponds (Goals Project 2000).

Several waterbird species reside in the Bay year round, including herons and egrets. Great egrets, snowy egrets (*Egretta thula*), great blue herons (*Ardea Herodias*), and black-crowned night herons (*Nycticorax nycticorax*) are a common to abundant year-round resident on the Refuge and in the San Francisco Bay Estuary that rely on fresh, brackish, and salt-water habitats to survive. These species are most abundant on the Refuge during the winter season. They use habitats of the Refuge primarily for roosting and foraging, and they nest in habitats immediately adjacent to the Refuge (e.g., eucalyptus groves, freshwater wetlands).

The federally endangered California clapper rail is a year-round resident of tidal marsh. Detail about clapper rails is provided in a subsequent section titled *Federally Listed Wildlife Species at the Refuge*.

California clapper rail
©B. Moose Peterson

California black rail is a state threatened species that occurs on the Refuge. The species is low to moderately abundant in the San Pablo Bay area, foraging and nesting on the Refuge (Evens et al. 1991). They have been detected in all units of the Refuge where tidal marsh is present. They are primarily restricted to tidal marshlands, preferring pickleweed habitat (Cogswell 1977). Winter and early spring clapper rail surveys conducted annually since 2002 show black rails occur throughout the Refuge (Block 2007b). Virginia rails (*Rallus limicola*) have also been detected during clapper rail surveys.

Waterfowl
The San Francisco Bay region is identified as one of the 34 waterfowl habitat areas of major concern in the North American Waterfowl Management Plan (USFWS 1989). More than 250,000 birds have been counted in waterfowl surveys in the San Francisco Bay Estuary (Steere and Schaefer 2001). More than 30 species of waterfowl are found in the San Francisco Bay ecosystem, divided into dabbling ducks, diving ducks, and swans and geese (Goals Project 2000). The Bay is recognized for its large population of diving ducks, both bay and sea ducks (Goals Project 2000). The San Francisco Bay Estuary was historically the primary wintering area for the Pacific Flyway canvasback population. The Refuge was established, in part, for its importance as wintering habitat for migratory waterfowl, particularly canvasbacks. Historically, more than 50 percent of canvasbacks surveyed in the Estuary were located in the North Bay and Napa-Sonoma ponds. More recently, canvasback numbers have declined as indicated in Figure 6. Scaup, ruddy duck (*Oxyura jamaicensis*), and dabbling ducks also use the area. Mallards (*Anas platyrhynchos*), a dabbling duck relying on seasonal wetland habitats, winters most often in great numbers in both the North and South Bays (Goals Project 2000).

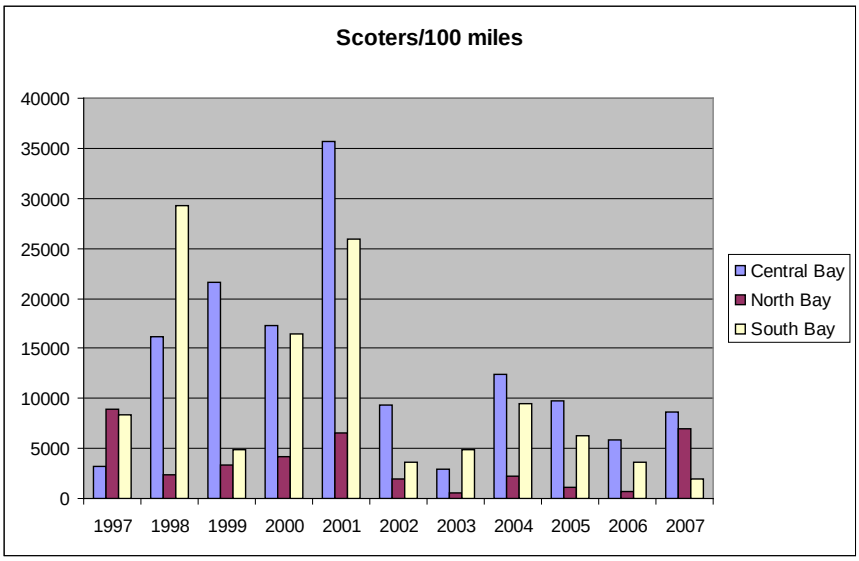
Eighteen migratory or resident waterfowl species have been observed at the Refuge (see Appendix B for Species List). These include the canvasback, redhead (*Aythya americana*), scaup, ruddy duck, American wigeon (*Anas americana*), mallard, northern pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), surf scoter (*Melanitta perspicillata*), and bufflehead (*Bucephala albeola*). Total peak waterfowl populations have been estimated at 60,000. Northern pintail commonly use CDFG managed open water ponds (formerly salt ponds) north of Highway 37 and subtidal open waters of San Pablo Bay. The majority of canvasbacks wintering in the San Francisco Bay occur in the CDFG managed tidal ponds and subtidal open waters of San Pablo Bay. Surf scoters are the second most abundant waterfowl species on San Francisco Bay (Accurso 1992) and tend to be more common throughout the open waters of the Bay. Up to 80,000 individuals have been counted during a single winter season in the Estuary by USGS Western Ecological Research Center (WERC). In the North Bay, flocks are widespread in mid- to late-winter. This species has experienced significant declines during the last decade that may be related to contaminants on wintering or breeding grounds. Studies by the USGS WERC and others are underway to examine possible reasons for decline of surf scoters. A more recent survey from 2007 showed Estuary-wide numbers of wintering scoters increased to levels not seen since 1997.

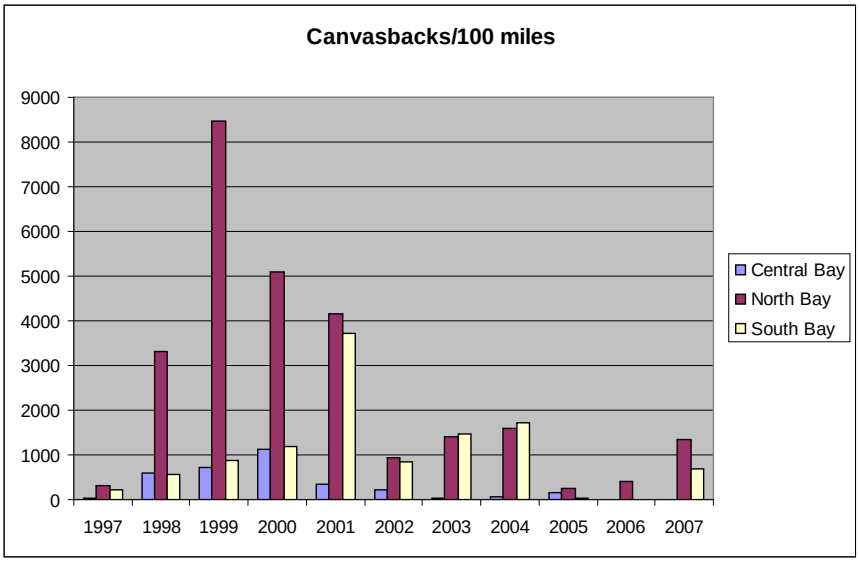
Scaup
USFWS

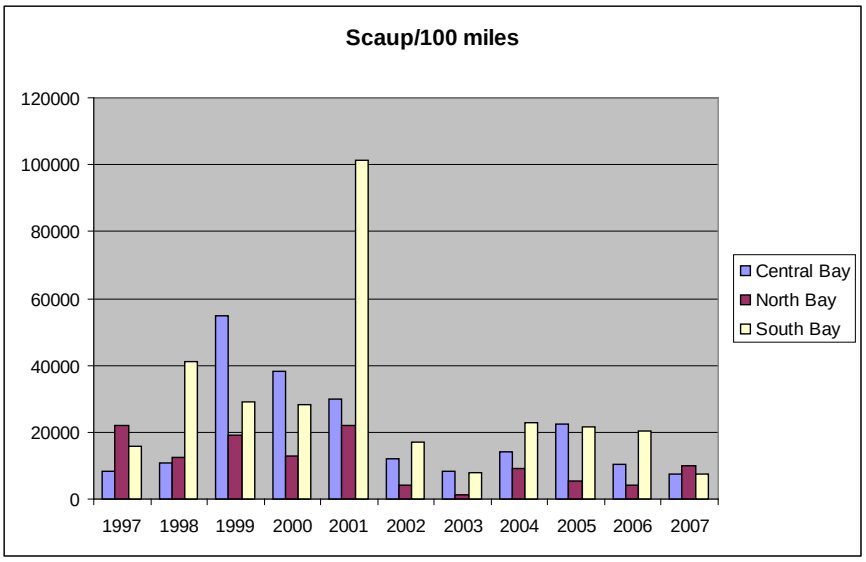
More than half of the ruddy ducks in North America winter at or near the Pacific Coast from southern Canada to Mexico (Goals Project 2000). The majority (85 percent) of these winter in

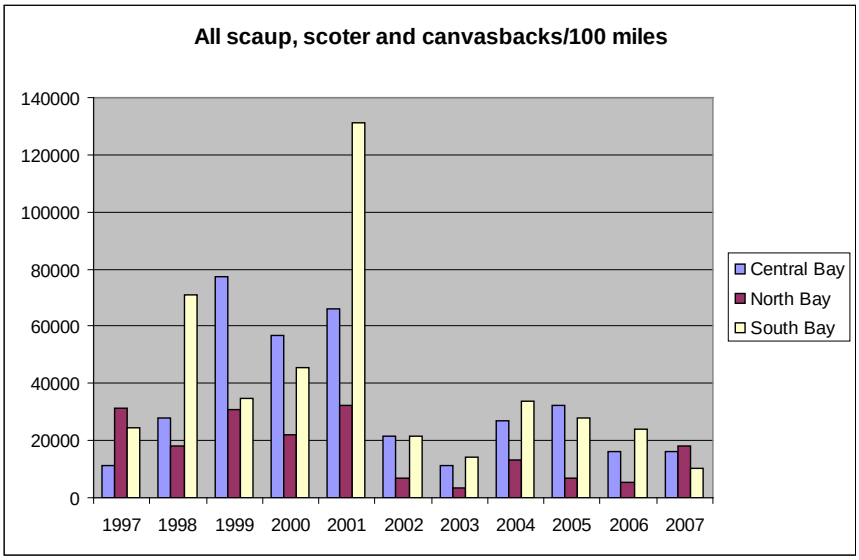
California, primarily at San Francisco Bay. Shallow managed open water ponds (formerly salt ponds) in the northern part of the Bay area support the second highest numbers of ruddy duck in the San Francisco Bay region (Accurso 1992), but smaller flocks numbering in the hundreds were observed in the nearshore, northernmost, and northwestern waters of the North Bay. Diving ducks make up most of the waterfowl found in the open San Pablo Bay area. Annual waterfowl surveys indicate a downward trend for diving ducks when comparing 2007 North Bay survey results to 1997 results. Major species such as scoter, canvasback, and scaup also showed a declining trend (See Figure 6) during the last decade. Scoters have increased during the last six years but are down for the last decade. Canvasbacks have increased in the North Bay during the past three years but are still well below numbers observed in the late 1990s. Scaup numbers have fluctuated in the North Bay, but the general 10-year trend is negative. Reasons for these changes could be related to conversion of the North Bay salt ponds (CDFG) to managed open water and tidal marsh and longer-term climatic cycles and trends.

Figure 6. 1997–2007 Waterfowl Survey Results in North Bay in the San Francisco Bay Estuary (number of birds surveyed per 100 transect miles)









Source: USFWS

Terns and Gulls
Caspian terns (*Sterna caspia*) are present in the San Francisco Bay area. First breeding accounts found colonies in the South Bay, but since 1990, the majority of birds nest at colonies in the Central and North Bays. The only known North Bay breeding colony is located at Knight Island in the Napa River Marsh (R. Leong, pers. comm.). Caspians forage on the open bay, salt ponds, marshes, freshwater ponds, rivers, and reservoirs, and at sea (Sibley 1952, SFBBO *unpub. data*), and therefore may frequent the Refuge.

Passerines
Passerines (songbirds) occur throughout the Refuge and its varied environments (see Appendix B for species list). Dominant songbird species that are year-round residents of tidal marsh on the Refuge include the San Pablo song sparrow, salt marsh common yellowthroat, and marsh wren (*Cistothorus palustris*). Common migratory songbirds that occur in the marsh-upland ecotone and adjacent upland habitats include western meadowlark (*Sturnella neglecta*), white-crowned sparrow (*Zonotrichia leucophrys*), savannah sparrow (*Passerculus sandwichensis*), and golden-crowned sparrow (*Zonotrichia atricapilla*).

Raptors
Various raptor species occur throughout the Refuge's upland environments, and are also found foraging in tidal marsh habitats. Primary raptor species include osprey (*Pandion haliaetus*), red-tailed hawk (*Buteo jamaicensis*), Cooper's hawk (*Accipiter cooperii*), sharp-shinned hawk (*Accipiter striatus*), Swainson's hawk (*Buteo swainsoni*), northern harrier, golden eagle (*Aquila chrysaetos*), peregrine falcon (*Falco peregrinus*), white-tailed kite (*Elanus leucurus*), rough-legged hawk (*Buteo lagopus*), American kestrel (*Falco sparverius*), and red-shouldered hawk (*Buteo lineatus*).

Mammals
Several mammal species are present in San Pablo Bay. Little is known about the distribution and abundance of mammal species on the Refuge. Studies have focused primarily on rodent and shrew species in an effort to monitor endangered salt marsh harvest mouse populations. Presence of several medium and large mammal species is known based on incidental observations and knowledge of habitat associations.

Small mammal species that are distributed throughout tidal and marsh-upland ecotone include the salt marsh harvest mouse (discussed in more detail in the following text), California vole (*Microtus californicus*), house mouse (*Mus musculus*), deer mouse (*Peromyscus maniculatus*), Norway rat (*Rattus norvegicus*), and the ornate shrew (*Sorex ornatus*). Only the salt marsh harvest mouse, California vole, and ornate shrew are native tidal marsh species, although non-native rodent species can inhabit tidal marsh. Studies conducted on the Refuge in 2003 and 2004 suggest non-native rodent species become less abundant beyond 80 meters from the marsh-upland interface or where there is increased channel complexity (density and configuration) (USFWS, *unpub. data*). Shrews are the rarest small mammal species encountered during small mammal surveys on the Refuge. Only three shrews have been captured over thousands of trap nights since 2003 (Block 2009). The low capture rates may represent a true rarity of this species, or it may be that current methods are not able to detect shrews. Shrews are very small, weighing an average of 5.2 grams (Owen and Hoffman 1983), and may not trigger traps traditionally used to capture small mammals (e.g., small Sherman live traps). The Suisun shrew (*Sorex ornatus sinuosus*) is a

relatively rare inhabitant of the salt marsh ecosystem of San Pablo and Suisun Bays (WESCO 1986). Johnston and Rudd (1957) estimate that shrews represent approximately 10 percent of the mammalian fauna present in marsh habitats. This species is currently limited in its distribution to the scattered, isolated remnants of natural tidal salt and brackish marshes surrounding the northern borders of Suisun and San Pablo Bays (WESCO 1986). Ornate shrews are present in San Francisco Bay except for the southwestern portion of San Pablo Bay. The ornate shrew may hybridize with the Suisun shrew in particular parapatric zones in North San Pablo Bay marshes. Rudd (1955) described populations at Grizzly Island and Sears Points that exhibited intermediate morphological characters between Suisun and ornate shrews.

Black-tailed deer (*Odocoileus hemionus*) is the only large "game" mammal found on the Refuge, using both tidal and upland areas. Jackrabbits (*Lepus californicus*) and raccoon (*Procyon lotor*) are considered common throughout the tidal areas, especially in units containing internal berms and levees. Other less commonly detected mammal species of the Refuge over the last decade include beaver (*Castor canadensis*), skunk (M*ephitis mephitis*), coyote (*Canis latrans*), opossum (*Didelphis virginiana*), feral house cats, and muskrat (*Ondatra zibethicus*). Refuge surveys have focused on detection of small rodent (e.g., salt marsh harvest mouse) and shrew species; abundance of medium to large mammals is unknown. In addition, surveys specific to bats have not been conducted, and their presence on the Refuge (likely only to forage) is unknown. Bats are known to occur in San Pablo Bay (e.g., China Camp).

Marine mammals
Harbor seals (*Phoca vitulina*) and river otters (*Lontra canadensis*) have been observed on the Refuge. Historic haul-out sites for harbor seals occurred at the Lower Tubbs Island muted marsh area (Long Point). More recently (December 2009), harbor seals have been observed hauling out along the western mouth of Tolay Creek.

River otter
USFWS

Reptiles and Amphibians

There is no detailed information on reptile and amphibian species on the Refuge. Pacific tree frogs (*Pseudacris regilla*), western pond turtles (*Actinemys marmorata*), California alligator lizard (*Elgaria multicarinata*), and coast garter snake (*Thamnophis elegans terrestris*) are present in the Bay Area (Stebbins 1959). These species are presumed to be distributed in the area where the Refuge is located (Goals Project 2000).

Federally Listed Wildlife Species at the Refuge

California Clapper Rail

The California clapper rail was added to the Federal endangered species list in 1970 (35 FR 16047) and the California state endangered species list in 1971 (California Code of Regulations, Title 14, Section 670.5). The clapper rail was listed as endangered primarily as a result of human-related factors such as hunting, habitat loss, habitat fragmentation, introduction of invasive species, and increased predation (Goals Project 2000). Rails were historically abundant in all tidal salt and brackish marshes in the San Francisco Bay vicinity (Cohen 1895). Newberry (1857) reported clapper rails as very common in the marshes of Petaluma. However, DeGroot (1927) suggested declines in the North Bay around the turn of the century, while Grinnell and Wythe (1927) continued to report that rails were still common in the South Bay. In Solano and Sonoma Counties, Gill (1979) and Harvey (1980) observed rails at numerous locations in the Napa Marsh complex.

General habitat characteristics of clapper rail include tidal areas dominated by pickleweed and extensive Pacific cordgrass (Grinnell et al. 1918, DeGroot 1927, Harvey 1988, Collins et al. 1994). The highest quality habitat for clapper rails on the Refuge occurs within Lower Tubbs Island, a unit of the Refuge which contains high channel complexity and large contiguous expanses of *S. foliosa* intermixed with American tule/bulrush (*Scirpus americanus*). These areas have exhibited the highest rail detection rates on the Refuge since 2005. Estuary-wide surveys conducted in 2005 show San Pablo Bay populations are variable and represent some of the lowest densities (200-meter radius average/marsh area surveyed) in the Estuary, ranging from 0.0 (Skaggs Island, Sonoma Creek) to 2.8 (Gallinas Creek) individuals per hectare (Herzog et al. 2005). Clapper rails have not been detected in the Strip Marsh unit of the Refuge, which occurs east of Sonoma Creek, despite previous survey efforts (2002, 2008). Absence of clapper rails here is likely due to the absence of natural tidal channels and low density of Pacific cordgrass. Cordgrass of the Strip Marsh unit is limited to small isolated patches along the bay edge.

The California clapper rail population was first estimated at 4,200-6,000 birds from 1971-1975, of which 55 percent occurred in the South Bay, 38 percent in the Napa marshes, and the remaining 8 percent in other North Bay and outer coast marshes (Gill 1979). In response to predator management, the South Bay rail population has since rebounded (Harding et al. 1998). The highest population densities for clapper rails continue to be located in the tidal salt marshes of south San Francisco Bay.

Surveys conducted by the CDFG and the Service estimated the Estuary-wide population of clapper rails at 1,500 birds in the mid-1980s (Harvey 1988). In 1988, the total rail population was estimated to be 700 individuals, with 400 to 500 rails in south San Francisco Bay (Foerster 1989). In 1990-1991, the Bay-wide population was estimated at 300-500 individuals, followed by a rebound in 1993 to over 800 individuals due to predator management (USFWS, *unpub. data*). The population increased in the mid- to late 1990s to an estimated 1,040 to 1,264 individuals (Albertson and Evans 2000) following predator control efforts focused in the South Bay. The most current population estimate for the San Francisco Estuary, based on an average of Estuary-wide surveys conducted from 2005-2008, is approximately 1,425 individuals (Liu et al. 2009). This recent Estuary-wide effort suggests 33 percent of the total clapper rail population occurs in San Pablo Bay, with the highest densities at Gallinas Creek (western San Pablo Bay). Clapper rail populations showed a negative (-21 percent) Estuary-wide trend from 2005 to 2008 (Liu et al. 2009). A significant negative trend (-57 percent) was detected in the South Bay during 2007-2008

(Liu et al. 2009). Many factors could be contributing to this decline, including predation during extreme tide events and invasive *Spartina* control. Despite the recent negative trend, clapper rail populations appear to have slightly increased during the last decade.

Clapper rail distribution in the North Bay is patchy and discontinuous, primarily located in small, isolated habitat fragments (Collins et al. 1994). No population estimates for the Refuge are available at this time. The most recent available population estimates of the area between the Golden Gate Bridge and the western margin of Suisun and Grizzly Bays from large-scale surveys of the North Bay in 1992-1993 (Collins et al. 1994) resulted in a conservative estimate of 195-282 pairs. Small populations of clapper rails are widely distributed throughout tidal creek systems of San Pablo Bay tidal marshes. Clapper rails have been detected in the Tolay Creek, Lower Tubbs Island, Sonoma Creek, and Sonoma Baylands units of the Refuge. In San Pablo Bay, clapper rails currently occur at Gallinas Creek and Hamilton Marshes, at the mouth of Novato Creek, along the Petaluma River as far north as Schultz Creek, Lower Tubbs Island, Sonoma Creek area, and along most major tidal sloughs that empty into the Napa River (Evens 2000a, Evens 2000b, Collins and Evens 1992, Liu et al. 2009). They have also been detected at Wildcat and San Pablo Creeks in Contra Costa County. Clapper rails are sparse in the linear strip marsh between Highway 37 and San Pablo Bay, most likely due to the lack of tidal channels. Rail numbers detected in the Sonoma Creek/Napa Slough area have declined since the early 1990s, from estimates of 13 pairs in 1992 (Evens and Stallcup 1994) to two birds detected in 2000 (Evens 2000a). Surveys conducting during 2004-2009 show clapper rails occur in Sonoma Creek, Skaggs Island, Tolay Creek, Lower Tubbs Island, and Sonoma Baylands units of the Refuge (Block 2009b). Clapper rails have not been detected at Cullinan Ranch or the Strip Marsh unit.

Salt Marsh Harvest Mouse

The salt marsh harvest mouse is a rodent species endemic to salt marsh of the San Francisco Estuary. There are two subspecies: the northern salt marsh harvest mouse (*Reithrodontomys raviventris halicoetes*) is present in the marshes on the San Pablo and Suisun Bays, and the southern salt marsh harvest mouse (*Reithrodontomys raviventris raviventris*) is found in the marshes of Corte Madera, Richmond, and south San Francisco Bay (USFWS, *unpub. report*). *Haliocoetes* was first identified in 1909 after two years of intermittent collecting on the salt marshes of San Pablo Bay (Dixon 1909). *Haliocoetes* has been subject to a greater range of salinity in the North Bay than its counterpart (Fisler 1965).

The salt marsh harvest mouse was listed as a Federal Endangered Species (35 FR 16047) in 1970 and was listed as a California State Endangered Species in 1971. Habitat loss has been the primary factor for the listing. Approximately 810km^2 (80 percent) of the historic tidal marshes inhabited by salt marsh harvest mouse have been destroyed through filling, diking, or subsidence (Shellhammer et al. 1982, Goals Project 1999).

Salt marsh harvest mouse
USFWS

By the time the salt marsh harvest mouse was distinguished as a species in 1908, extensive tidal marshes throughout its range had already been reclaimed for agriculture, salt ponds, and urban development (USFWS, *unpub. report*). Therefore, there are no historical records of its abundance or distribution in the Estuary as a baseline. The salt marsh harvest mouse probably occupied most of the tidal middle, or pickleweed-dominated, marsh plains and high marsh zones of San Francisco Bay, San Pablo Bay, and the Suisun Marsh prior to the significant marsh reclamation of the 1840s.

Several studies have shown that the dominant large-scale feature of salt marsh harvest mouse habitat is "middle" and "upper" marsh where dense pickleweed is intermixed with other halophytic plants such as gumplant (*Grindelia stricta*), alkali heath, and fat hen (Fisler 1965, Shellhammer 1982). Previous studies have also suggested that interspecific interactions with other rodent species may affect habitat quality and hence abundance and distribution of salt marsh harvest mouse. Rodents and other small mammal species known to co-occur with salt marsh harvest mouse include California vole, house mouse, deer mouse, western harvest mouse (*Reithrodontomys megalotis*), and Suisun shrew. Other factors that likely affect habitat quality of salt marsh harvest mouse include the presence and configuration of high tide refuge, abundance and type of predators, invasive species, contaminants, and human disturbance (e.g., mosquito surveillance, restoration monitoring).

The fringing salt marshes along northern San Pablo Bay (Petaluma River to Mare Island Strait) support what is considered to be the largest population of the northern subspecies of salt marsh harvest mouse in San Pablo Bay (USFWS, *unpub. report*). Outside of the Highway 37 and Mare Island Marsh areas, there are other major centers of stable or large populations, including some parts of the Contra Costa County coastline (Duke et al. 1990, Duke et al. 1991), Petaluma Marshes, and the Calaveras Point Marsh in south San Francisco Bay (Duke et al. 1990). The northern subspecies is more widespread and patchy in distribution in both diked and tidal marshes than the southern subspecies, although its densities may be very low outside of the Highway 37 and Mare Island marshes and the marshes of the Contra Costa County shoreline (Duke et al. 1990, Duke et al. 1991). Many northern subspecies populations have been displaced from tidal marshes to unstable diked pickleweed marshes, primarily in Suisun Bay. Historically, this subspecies has been limited to salt marsh habitat (Dixon 1909). Fisler (1965) found salt marsh harvest mice in areas where grass and pickleweed mixed. Salt marsh harvest mice may become abundant in portions of diked brackish marshes, where extensive tall, dense cover of pickleweed

vegetation and various species of brackish vegetation develops (Finfrock 2000) because of effective and consistent water management. The salt marsh harvest mouse is generally restricted to saline or subsaline marsh habitats around the San Francisco Bay Estuary.

Salt marsh harvest mice have been recorded at several salt marsh sites bordering San Pablo Bay. Surveys from 1974 and 1975 indicated presence of harvest mice in San Pablo Creek (Cummings 1975). A survey in 1982 found presence of salt marsh harvest mice at Sears Point, Tubbs Island, and the Sonoma Creek area (Newcomer 1982). Surveys conducted since 1999 in the Tolay Creek and Tubbs Island Setback units of the Refuge suggest moderate to high abundance relative to other sites samples in the Estuary (Takekawa et al. 2004, Block 2009, McGinnis 1999). No studies to date have provided estimates of salt marsh harvest mouse within a given marsh area. Abundance of salt marsh harvest mouse is represented as a capture index. Recovery of the salt marsh harvest mouse is also based on a capture index. The lack of density estimates is likely related to the difficulty in estimating density and extrapolating from trap data.

From 2003-2005, surveys for salt marsh harvest mouse were conducted at nine sites throughout tidal marshlands of the Refuge. Surveys were conducted to examine landscape level variables that may affect distribution of salt marsh harvest mouse. The study area encompasses the northern portion of San Pablo Bay and extends from Mare Island (Vallejo) west to the mouth of Tolay Creek. Study sites ranged from 2–91 hectares (ha) in size (mean = 27 ha).

Listed Fish Species

Five federally- and/or state-listed fish species may occur within the boundaries of the Refuge: Sacramento splittail, delta smelt, Chinook salmon, steelhead, and green sturgeon. However, surveys conducted at the Refuge have not detected these species; often surveys are conducted as a result of post-monitoring for restoration projects (see Appendix B for Species List). Sacramento splittail and delta smelt are Estuary residents, while Chinook salmon, steelhead, and green sturgeon are anadromous.

The Sacramento splittail was federally delisted in 2003 but remains state-listed as threatened. Splittail are abundant in two tributaries to San Pablo Bay, the Napa and Petaluma rivers, and therefore may be present in the open waters of the Refuge, especially in wet years (Goals Project 2000). Splittail is endemic to the Estuary and its watershed. They spawn on inundated floodplains and river margins. The 2007 survey indexes were low compared to the year prior, likely as a result of low winter-spring outflow (IEP 2008).

The delta smelt was federally- and state-listed as threatened in 1993 and is under a high degree of threat, especially in drought years (USFWS 1986). Delta smelt are endemic to the upper Sacramento-San Joaquin Estuary, but during high outflow periods, they may be washed into San Pablo Bay (USFWS 1996). However, delta smelt do not establish permanent populations in San Pablo Bay. Their exact presence on the Refuge is not known, but the open water portions of the Refuge should be considered potential delta smelt habitat. Causes for decline in delta smelt include reduction in river outflows, water diversions, high outflows, changes in food organisms, toxic substances, disease, competition, predation, and loss of genetic integrity (USFWS 1996). The 2007 Summer Townet Survey index was 0.4, the same as the 2006 index and comparable to the low indices observed since 2001 (IEP 2008). The 2007 FMWT delta smelt index was 68 percent of the 2006 index and the second lowest on record (IEP 2008). The 2007 Bay Study also showed similar low results.

The Chinook salmon is the most abundant salmon in California (McGinnis 1984). The distribution in San Francisco Bay is not well known, but they have been found throughout the Bay. Sacramento River winter-run Chinook salmon may be supported by the subtidal Refuge habitat. This species is federally listed and state-listed as endangered. Central Valley spring-run Chinook, federally listed as threatened, are also believed to migrate through San Pablo Bay. Chinook migrate through the lower Napa River and San Francisco Bay from November through June (G. Stern, NOAA Fisheries, pers. comm.).

The steelhead makes spawning runs through the Napa River and several of its tributary streams; Huichica Creek, Petaluma River, and Sonoma Creek and several of their tributary streams (Leidy 2007). Steelhead fish are the anadromous form of resident rainbow trout. The San Francisco Estuary and its tributaries are thought to support Central California Coast and Central Valley distinct population segments which are federally listed as threatened. Reliable estimates of steelhead in tributaries to San Francisco Bay are not available but guesstimates place the size of steelhead runs well below 10,000 fish based on run sizes in other nearby tributaries (Goals Project 2000).

The southern distinct population segment of green sturgeon was listed as threatened on April 7, 2006. Several threats contributing to the risk of extinction of the Southern DPS were identified, including the loss of spawning habitat; concentration of spawning into a single spawning river (i.e., the Sacramento River, CA); entrainment or impingement by water project operations, dredging, power plant operations, or other in-water activities; bycatch of green sturgeon in fisheries; and poor water quality conditions (NOAA Fisheries 2010). Adult green sturgeon are found in the Delta and bays from March, or earlier, through October (Kelly et al. 2006), with some individuals outmigrating from the Sacramento River in December and February (NOAA Fisheries 2010). Juvenile green sturgeon (≤ 3 years old) occurs in the Delta and the Suisun, San Pablo, and San Francisco bays throughout the year (CDFG 2002; Bay Delta and Tributaries Project 2009). Green sturgeon juveniles rear in the Sacramento River and the Delta and bays for one to four years before migrating out to sea as subadults (Emmett et al. 1991; Nakamoto et al. 1995). No population estimate for this species is available.

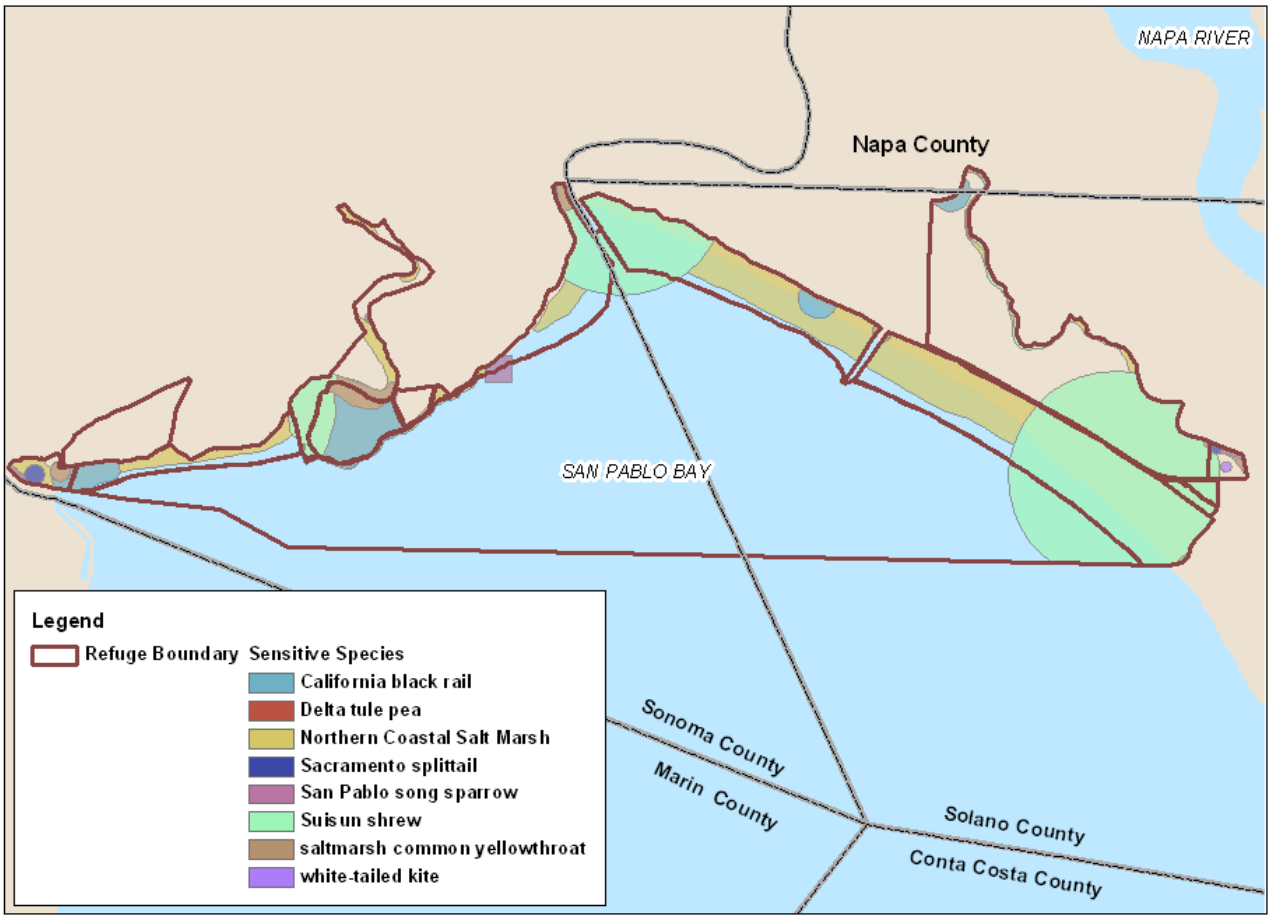
Federally Listed Plant Species at the Refuge

No known colonies of endangered plants exist on the Refuge. Soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*) is restricted to salt and brackish tidal marshes within the San Francisco Bay area in northern California. This species was listed as endangered on December 22, 1997. Specifically, soft bird's-beak is predominantly found in the upper reaches of saltgrass-pickleweed marshes at or near the limits of tidal action (USFWS 1997). Because of this plant's habitat requirements, the Refuge may potentially have individual plants. Habitat conversion, water pollution, changes in salinity, indirect effects of urbanization, competition with non-native vegetation, insect predation, erosion, and other human-caused actions threaten this species. Soft bird's-beak was observed in 1982 near the confluence of South Slough and Dutchman's Slough near the Cullinan Ranch unit (CNDDB 2007). Surveys conducted the following three years after discovery has not resulted in detection of the species, and it is believed to be extirpated. However, according to the California Natural Diversity Database (CNDDB) (accessed December 2008), they are presumed to exist in the Cullinan Ranch unit (Figure 7).

Other Sensitive Species

Several state species of concern may use the Refuge for roosting, foraging, or breeding based on the CNDDB. Figure 7 shows the current extent of Species of Concern identified by the state of California. In some cases, a species is more widespread than shown based on current Refuge data.

Figure 7. Sensitive Species on San Pablo Bay NWR

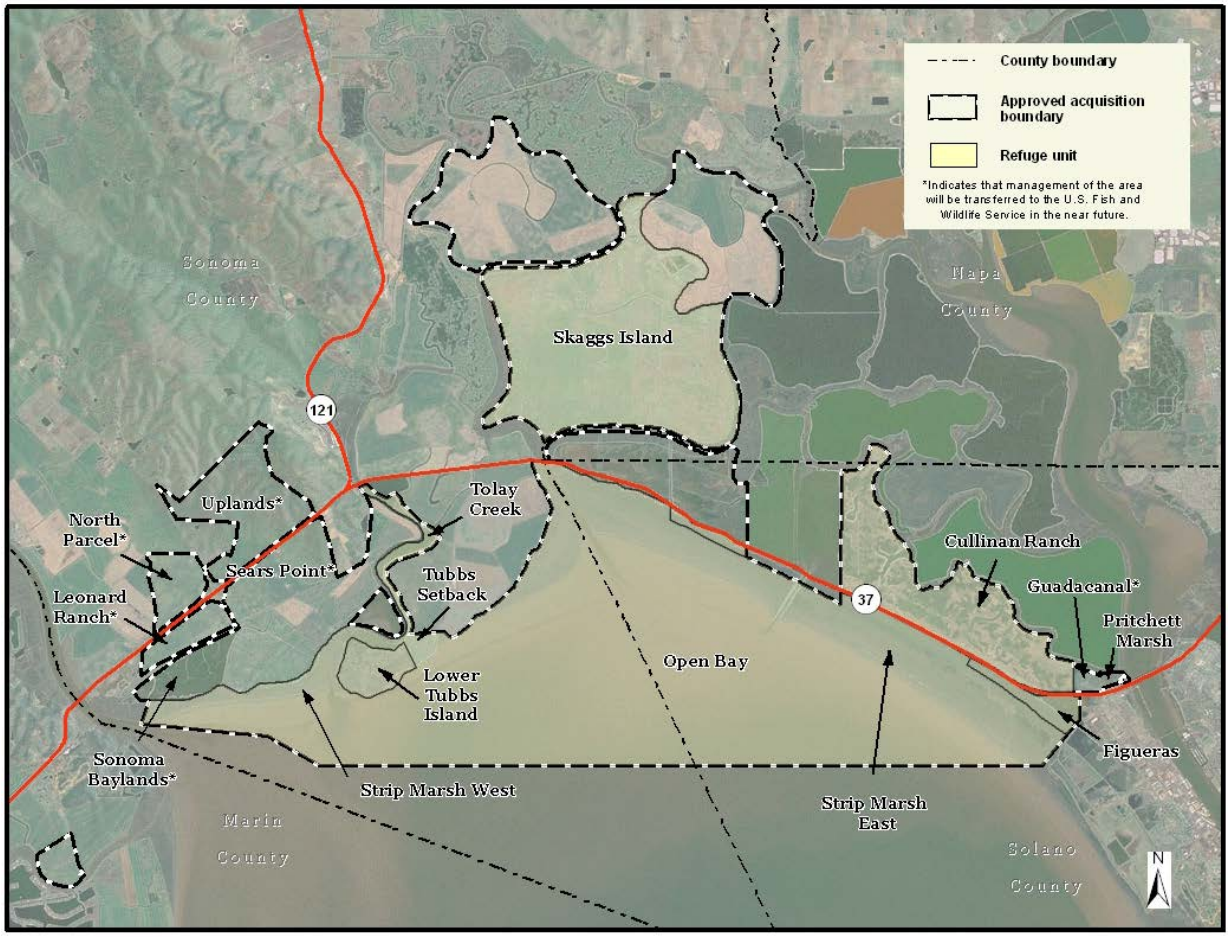


Source: California Natural Diversity Database. Accessed in December 2008 at http://www.dfg.ca.gov/biogeodata/cnddb.

Description by Unit

Several units make up the Refuge and are delineated by boundaries that include major roads, levees, railways, or hydrological features (e.g., Tolay Creek). Size, location, history, and environmental characteristics of each unit are shown in Figure 8.

Figure 8. Map of Refuge Units



Sears Point

Sears Point is a 2,327-acre parcel located between the Petaluma River and Tolay Creek. It is currently owned by the Sonoma Land Trust (SLT). The Refuge's office headquarter is located at Sears Point under a lease agreement. Adjacent to the headquarters is the Refuge native plant nursery, which supports habitat restoration on Refuge lands. This unit is described as agricultural upland, made up mostly of grasses where cattle still continue to graze through a lease agreement with a local rancher. Sonoma Land Trust plans to restore portions of this parcel to tidal, seasonal and riparian wetlands, streams, and upland habitats for a variety of native plants and wildlife. Approximately 970 acres south of the rail line will be restored to tidal marsh. Over 400 acres north of the rail line will see seasonal wetlands enhancements, while retaining oat haying and cattle grazing. A 40-acre seasonal wetland will be enhanced on the baylands north of Highway 37, while 15.5 acres in the upland watershed will be enhanced to benefit the endangered California red-legged frog (*Rana draytonii*). Lastly, over 1,000 acres of upland grassland will be enhanced or restored to high quality seasonal wetlands and native perennial grassland communities. The Refuge plans to provide environmental education and public access opportunities at the headquarters site. Currently, a restoration plan is being developed for this area by SLT. Almost 860 acres of Sears Point, including the 400 acres north of the rail line, will be

transferred to the Refuge in the next few years. This area will serve as the first permanent headquarters site for the Refuge.

Lower Tubbs Island

Lower Tubbs Island is located in Sonoma County, California, on the shores of San Pablo Bay. Once a duck hunting club, this 249-acre unit was transferred to the Service from The Nature Conservancy in 1978 (USFWS 1998). In 1971, the area was used as a special rehabilitation area for waterbirds injured by a major oil spill under the Golden Gate Bridge. The unit was acquired to provide habitat for endangered species and other wildlife. A hunting lodge, a museum, and associated outbuildings once located on the unit have since been removed. Hydrology of Lower Tubbs Island is characterized as muted tidal. Because of the muted nature of this site, the elevation of tidal marsh here is below that found in adjacent tidal marsh (e.g., Tolay Creek) (Wetlands and Water Resources 2009). Tidal waters are conveyed to and from this unit through five culvert arrays: two along the southern perimeter of San Pablo Bay, one east in the Tubbs Island Setback unit, and two along the western border, which connect the unit to Tolay Creek. In December 2009, natural hydrological links (channels) to Tolay Creek were restored. The interior of the site contains several berms and culverts that were used by the duck club to manage hydrology for waterfowl. These features are not maintained by the Refuge. Despite past human influences on Lower Tubbs Island, the tidal marsh here contains the highest density of channels on any unit of the Refuge. This hydrological complexity is reflected in the vegetation and wildlife that use this area.

The vegetation of Lower Tubbs Island is dominated by native tidal marsh-adapted species such as pickleweed, saltgrass (*Distichlis spicata*), Pacific cordgrass, and gumplant. Non-native weed species such as fennel (*Foeniculum vulgare*) and yellow starthistle (*Centauria solstitialis*) are scarce but do occur on some interior levees and berms. Invasive perennial pepperweed has colonized interior berms and tidal marsh of the unit but remains at low-density levels (e.g., <0.1 acre) relative to other areas of the Refuge.

Small mammal surveys conducted across the Refuge in 2003 and 2004 suggest this unit supports some of the highest densities of salt marsh harvest mice and clapper rails on the Refuge (Block 2009, Block 2009b). Other common bird species that use tidal marsh here include the California black rail, Virginia rail, San Pablo song sparrow, salt marsh common yellowthroat, and marsh wren. Another unique feature of Lower Tubbs Island is the presence of interior tidal marsh mudflats. These tidal flats provide foraging and roosting habitat for shorebirds, especially during high tides.

A levee surrounds the perimeter of this unit. This levee has provided public access by foot or (non-motorized) bicycle with interpretive signs for environmental education. A levee trail along the eastern border of Tolay Creek provides access to the Lower Tubbs Island trail. The Tolay Creek trail occurs on lands owned and managed by the Vallejo Sanitation District, and they permit Refuge and public access under an informal agreement with the Refuge. No hunting or fishing activities are allowed in this unit, but pheasant hunting occurs in the adjacent Tolay Creek Unit, and waterfowl hunting is permitted in the open bay and navigable sloughs of San Pablo Bay.

Tubbs Island Setback

Historically, Tubbs Island Setback was a tidal wetland but was diked and reclaimed for agriculture (hay) in the early 1900s. This 72-acre area later came under ownership of the

California State Land Commission. In 1981, the Service acquired a 66-year lease to manage the property as part of the Refuge (USFWS 1998). Haying continued through another lease agreement with adjacent landowners until 1984.

In 1985, the Service contracted with Sverdrup and Associates to prepare a marsh restoration project plan (USFWS 1989). However, it was not until 1997 that funds were acquired to implement the plan. The goal was to restore tidal influence to the area without affecting adjacent landowners. The plan included construction of a new dike to protect adjacent upland areas from tidal action, construction of a 2,000-foot levee to isolate the area from adjacent landowners and prevent flooding, breaching the existing outboard dike, and placement of water control structures to provide improved water circulation.

Planting at Tubbs Island Setback
USFWS

Efforts to restore the site to tidal marsh were initiated in 2002 with the 150-foot wide breach of the outer dike to provide tidal flow from San Pablo Bay. Since the breach, sedimentation has rapidly raised the base elevation resulting in tidal mudflats, formation of tidal channels, and colonization by native tidal marsh plants (Woo et al. 2006). Monitoring of the restoration began pre-breach (PRBO Conservation Science, USGS) and continues today. Monitoring elements include hydrology, water quality, sediment, vegetation, fish, mammals, and birds.

Twenty-eight plant species have been detected in the levee areas during monitoring surveys (Woo et al. 2006). Dominant tidal marsh plants following restoration are pickleweed, gumplant, saltgrass, Pacific cordgrass, and alkali heath (Woo et al. 2006). The surrounding levees are dominated by ruderal species including coyote brush (*Baccharis pilularis*); yellow starthistle; fennel; mustard (*Brassica* spp.); wild radish (*Raphanus sativus*); and several species of non-native grasses such as perennial ryegrass (*Lolium perenne)*, ripgut brome (*Bromus diandrus)*, and wild oat (*Avena fatua)*. Invasive plants such as perennial pepperweed have been detected at the site but were removed in 2007 as part of an active pepperweed control program on the Refuge. Invasive *Spartina* species have not been detected at this unit. The Refuge has been restoring native plant species to the marsh-upland ecotone of this unit since 2006. Several species are used in restoration, including coyote brush, western goldenrod (*Euthamia occidentalis*), and creeping wild rye (*Leymus triticoides*).

Monitoring results show an increase in wildlife diversity since restoration in 2002. Over 50 bird species have been recorded, compared to only 19 pre-breach (Woo et al. 2006). At least 14 shorebird species are known to use this site and adjacent tidal marsh units (Perlmutter et al. 2010, Woo et al. 2006). Bird abundance has increased, and this is likely in response to increased sedimentation in the project's interior and resulting formation of tidal mudflats. Passerines such as song sparrow use the perimeter vegetation of the site. As low- and higher-marsh vegetation continues to colonize the site, the abundance of shorebirds is expected to decrease, while passerine and rail use is expected to increase. Rail species have not been detected, although they occur in adjacent marsh areas. Rails are expected to colonize Tubbs Island Setback as marsh plant communities develop here.

Trapping for small mammal species has been conducted at the site since 1999. Pre-breach results show endangered salt marsh harvest mice were present (N = 8) but limited to a narrow ditch along the western edge dominated by pickleweed. Since the breach in 2002, the number of salt marsh harvest mouse captures has risen from 0 (2003) to 24 in 2008 (Block 2009, Woo et al. 2006). Other species captured during trapping efforts since 1999 include deer mouse, California vole, house mouse, and Norway rat.

Fish and aquatic invertebrate species have shown mixed results since the breach. Sampling in 2002 identified 16 fish species, whereas only four species were found in both June and December 2005. Sensitive fish species were not detected. Invertebrate sampling was conducted in mudflats, mudflat transition zones, and vegetated margins in August 2004 (Woo et al. 2006). Invertebrate abundance was higher at Tubbs Island Setback than the lower lagoon of Tolay Creek (USGS, *unpub. data*).

Tolay Creek

Tolay Creek is located south of Highway 37 in the center of the Refuge. Historically, Tolay Creek was part of a series of tidal sloughs that surrounded marsh islands. The creek received freshwater input from Tolay Lake and intermittent streams in the Sonoma Mountains (USFWS 1997). During the early 1900s, much of the area west and east of Tolay Creek and south of Highway 37 were partially diked and drained for agricultural use. Prior to 1999, the 3.2-kilometer stretch of Tolay Creek south of Highway 37 consisted of a fallow field with large cracks in the substrate that created mosquito habitat (Takekawa et al. 2005). The creek was channelized over time, and the majority of the surrounding marsh was lost or degraded. The extent of tidal influence also decreased as a result of siltation in the upper reaches of the creek (Ducks Unlimited Inc. 1997a). The result of these human activities has dramatically altered the landscape of Tolay Creek, decreasing the size of the tidal flood plain and associated marsh (Takekawa et al. 2005).

Tolay Creek was acquired by the California State Lands Commission in 1981 and is currently managed by the Service through a lease. The "upper" and "lower" lagoons along Tolay Creek are owned and managed by CDFG. The Service and CDFG began restoration of portions of Tolay Creek beginning in the 1980s with the last major effort in 1999. All efforts have been focused on providing habitat for shorebirds, waterfowl, and sensitive species through restoration of tidal hydrology.

Today, the 17-kilometer creek enters San Pablo Bay along a remnant wetland corridor on the northwest shore between the Petaluma River and Sonoma Creek, 16 kilometers west of Vallejo on the south side of Highway 37. There are three habitat types in Tolay Creek: open water/tidal

creek channel, tidal mudflat, and tidal marsh. The open water and tidal creek channel areas contain little vegetation, except for pacific cordgrass and patches of big bulrush (*Scirpus robustus*) in the transition zones. The salt marsh areas are dominated by pickleweed but are also populated by saltgrass, jaumea, marsh rosemary, big bulrush, Pacific cordgrass, alkali heath, fat hen, California bee plant (*Scrophularia californica*), bristly ox tongue (*Picris echioides*), yarrow (*Achillea millefolium*), and coyote brush. Since the completion of restoration actions in 1999, increased sediment deposition has resulted in mudflats at low tide. Invasive plant cover has declined from 38 percent (1998) to 2 percent (2002) (Takekawa et al. 2002). Following a major winter storm event in 2005, the upper lagoon exhibited mudflats at low tide for the first time since restoration in 1999. Channels are now forming, Pacific cordgrass is colonizing the edges of the mudflats, and thousands of shorebirds and waterfowl are observed here during winter and migratory periods (Perlmutter et al. 2010, Takekawa et al. 2002).

Fish sampling conducted from 1999-2003 yielded a variety of native and non-native aquatic species along Tolay Creek, including the species listed in Table 15. A list of fish species on the Refuge is provided in Appendix B. Sensitive fish species have not been detected during these surveys.

Table 15. Aquatic Species Found at Tolay Creek, 1999-2003 Surveys

Common Name	*Scientific Name*
American shad	*Alosa sapidissima*
Arrow goby	*Clevelandia ios*
Bay goby	*Lepidogobius lepidus*
Bay pipefish	*Sygnathus leptorhynchus*
Inland silverside	*Menidia beryllina*
Mosquito fish	*Gambusia afinis*
Pacific herring	*Clupea pallasi*
Pacific staghorn sculpin	*Leptocuttus armatus armatus*
Prickly sculpin	*Cottus asper*
Rainwater killifish	*Lucania parvu*
Shimofuri goby	*Tridentiger bifasciatus*
Speckled sanddab	*Citharichthys stigmaeus*
Starry flounder	*Platichthys stellatus*
Striped bass	*Morone saxatilus*
Threespine stickleback	*Gasterosteus aculeatus*
Topsmelt	*Atherinops affinis*
Wakasagi goby	*Hypomesus hipponensis*
Yellowfin goby	*Acanthogobius flavimanus*

Figueras Unit

The 185-acre parcel known as the Figueras Tract, located along the eastern side of the Refuge, was the first land acquired for the Refuge in 1974. Figueras, the previous owner, originally intended to build a fish propagation facility on the property. This land was once farmed and receives some tidal influence but is highly muted. The vegetation is dominated by pickleweed. Limited biological monitoring has been conducted here. The site is surveyed during regional shorebird monitoring efforts and is known to support high densities of shorebirds (e.g., American avocets) and acts as shorebird refuge during high tides.

Cullinan Ranch

Cullinan Ranch is a 1,525-acre diked bayland that was added to the Refuge in 1991. The ranch is northeast of San Pablo Bay and located in Solano and Napa Counties. South and Dutchman Slough bound this unit from the north, while Highway 37 bounds it from the south. The unit is bound by Guadalcanal Village from the east and CDFG Pond 1 from the west. Historically, Cullinan Ranch was part of a network of tidal marshes and sloughs along the Napa River (USFWS 1989). The first permanent dikes were constructed in the early 1900s, and more were added in the 1940s to prevent flooding and isolate the ranch as reclaimed wetland. Cullinan Ranch was farmed (primarily for oat and hay) into the 1980s (Ducks Unlimited 2007). In 1987, several conservation groups defeated the proposed development of Cullinan Ranch into a residential marina community (USFWS 1989). Subsequently, it was acquired by the Service to protect endangered species, as well as to provide habitat for migratory shorebirds, waterfowl, and other wildlife, fish, and plants.

The ranch topography is as much as 3-8 feet below sea level (Towill Inc. 2000) due to a century of subsidence since it was first diked. Swales and ditches contribute to the topography, some of which are old sloughs and channels (USFWS 1989). Seasonal ponding occurs throughout the unit and supports a seasonal freshwater wetland. Five habitat types are found on Cullinan Ranch: emergent marsh, seasonal wetland, tidal marsh, open water, and upland (Ducks Unlimited 2007). Wetland acreage was estimated and is shown in Table 16. Restoration activities are currently being planned so that the area will eventually be tidally influenced and elevations will reach marsh plain level. Restoration is expected to provide additional habitat for salt marsh harvest mouse and other threatened and/or endangered species, enhance production of estuarine dependent fish species, and reduce the effects of flood events (Ducks Unlimited Inc. 1997b).

Table 16. Cullinan Ranch Wetland Acreages

Wetland Type	Acres
Emergent Marsh Wetland	227
Seasonal Wetland	626
Tidal Marsh	5
Remnant Tidal Marsh	3

(Source: Ducks Unlimited Inc. 2007)

Cullinan Ranch has the potential to support habitat for a number of special status wildlife, bird, and plant species. Salt marsh harvest mice have been found on levees at Cullinan Ranch (Hulst 2000). Soft bird's-beak was observed in 1982 near the confluence of South Slough and Dutchman's Slough (CNDDB 2007). Surveys conducted the following three years after discovery has not resulted in detection of the species, and it is believed to be extirpated. However, according to the California Natural Diversity Database (CNDDB) (accessed December 2008), they are presumed to exist in the Cullinan Ranch unit. Surveys for biological resources have been conducted since 1993 by USGS, Ducks Unlimited, and Dr. Mike Bias to document baseline conditions prior to tidal restoration (Ecosystem Restoration Sciences 2004). These results showed:

- Prior to 1997, plant species such as wild oat, perennial rye grass, and *Spergularia* species dominated the site. Once pumping of the ranch ceased in 1994, the site quickly reverted to cattail (*Typha latifolia*) and other seasonal wetland plant species.
- Formal bird surveys began in 1993. Point counts and area surveys showed Cullinan did not support rail species. As a result of pumping cessation, birds associated with seasonal

wetlands became abundant, including red-winged blackbirds (*Agelaius phoeniceus*) and waterfowl species.

Non-native and invasive plant species are located throughout Cullinan Ranch. Invasive species of management concern at this time include perennial peppergrass and New Zealand spinach (*Tetragonia tetragonioides*).

Strip Marsh

The 63-acre Strip Marsh is owned by the California State Lands Commission but leased to the Service. This unit sits between the north shore of San Pablo Bay and Highway 37. It is bounded by Sonoma Creek along its western border and Mare Island to the east. The Strip Marsh is tidally-influenced and considered a "centennial" tidal marsh in that it formed rapidly over the last century as a result of sediment loads from the gold rush period. Unique geomorphic features of this marsh are (1) the absence of tidal channels except along a narrow (<10-meters) fringe of San Pablo Bay, (2) the formation of a natural berm approximately 50 meters from bay edge and running parallel to it, and (3) the formation of a large swale in the northern half of the unit that traps tidal water following high tides and winter rain. These features have strongly influenced biological resources of the marsh.

The rapid expansion of this marsh resulted in few channels and is primarily made up of pickleweed, while nearer to the edge of San Pablo Bay there is a mixture of pickleweed and pacific cordgrass. Historically, this area was once open water, but diking of Cullinan Ranch and the subsequent construction of the Sears Point Road, known now as Highway 37, created levees that led to sediment build-up in the Strip Marsh. This unit provides endangered species habitat for salt marsh harvest mice and California clapper rail. It is currently closed to the public, and management consists of biological surveys, mosquito monitoring and control, water circulation and habitat improvements, and law enforcement of hunting and fishing regulations.

Guadalcanal

Guadalcanal Village was once a naval housing site affiliated with the Mare Island Naval Shipyard in Vallejo, California. This site is located east of Mare Island and north of Highway 37. The California Department of Transportation (Caltrans) purchased this 53-acre unit as a mitigation site in 2000. Caltrans conducted site remediation and highly engineered the site to facilitate tidal wetland restoration. The unit is primarily made up of tidal marsh. The site is to be transferred to the Service after a monitoring and mitigation period of eight years. Once the property is transferred, an endowment from Caltrans will be used to maintain the property. Currently, the area has a parking lot and a wildlife observation point but is closed to the public because of mitigation activities. Additional wildlife viewing is accommodated nearby from a Caltrans pedestrian skywalk over Highway 37. The USGS San Francisco Bay Estuary Field Station has been monitoring biological resources of the site since pre-breach in 1999 (Bias et al. 2002).

Guadalcanal
USFWS

Sonoma Baylands

Sonoma Baylands consists of 348 acres of recently restored tidal marsh. It is located immediately adjacent to the Refuge on the west side of San Pablo Bay in the San Francisco Bay. The California Coastal Conservancy currently owns the property, and it is managed by the Sonoma Land Trust. It was under Coastal Conservancy direction that the site became one of the first tidal restoration projects completed in San Francisco Bay in 1996. The Sonoma Baylands is a remarkable example of tidal bayland restoration and is today considered by State and Federal conservation agencies and environmental groups a success in terms of both habitat development and wildlife use. The site is dominated by tidal mudflats and developing channel systems. Colonization by native tidal marsh-dependent plant species has begun and occurs primarily along the perimeter of the site. Physical and biological parameters of the site were monitored to evaluate tidal marsh evolution (PWA 2004).

Native plant restoration at Sonoma Baylands
USFWS

The Refuge is actively restoring plants native to the marsh-upland ecotone of Sonoma Baylands through an environmental education and habitat restoration partnership between the Refuge, Friends of the San Pablo Bay, The Bay Institute, Sonoma Land Trust, and the State Wildlife

Conservation Board. This effort augments the Service's previous partnership with the Sonoma Land Trust and the CDFG to manage invasive pepperweed populations.

A portion of the SF Bay Trail is located on this site, which provides safe, convenient public access from State Route 37.

Skaggs Island

Skaggs Island is located on the north side of Highway 37 and east of Highway 121. Approximately 3,300 acres of this property was recently transferred from the Navy to the Refuge on March 31, 2011. The entire 4,390-acre island is below sea level. In the 1920s, the island was drained and separated from the surrounding wetlands by flood levees to enable agricultural production. The Navy purchased 3,300 acres of Skaggs Island in 1941 for use as a military base operating a high frequency, direction-finding antenna facility, as well as a training facility; it closed in 1993. Of the 3,310-acre facility, only 60 acres were developed with extensive infrastructure to support the military mission, including utilities and maintenance for about 160,000 square feet of building space with water and sewer systems. The remaining open space was used for farming operations.

The habitat on Skaggs Island has not been surveyed by Refuge staff but generally consists of non-native grasses and forbs. It is the keystone unit within 30,000 acres of existing and restorable wetlands in the north San Francisco Bay Area. Skaggs Island was historically tidal marshland, comprising part of the delta of the Napa River and Sonoma Creek, which are integral parts of the larger San Francisco Bay-Delta Estuary. Sensitive wildlife and habitat known to occur at Skaggs Island include the California clapper rail, the salt marsh harvest mouse, a great blue heron rookery, and a black-crowned night heron rookery (Morrison 1993, USFWS *unpub. data*). Skaggs Island also supports a wintering burrowing owl (*Athene cunicularia*) population and is a major stopover site for migratory raptors. More than 13 species of raptors have been observed at Skaggs Island since 2003.

Leonard Ranch, North Parcel, and Uplands

Leonard Ranch, North Parcel, and the Uplands were recently added to the approved acquisition boundary. These parcels are currently privately owned.

Open Bay and Mudflats

Approximately 8,356 acres of the Refuge is open bay. The northern edge of San Pablo Bay is owned by the California State Lands Commission but managed by the Service. Fishing and waterfowl hunting from a boat are allowed in this area. A variety of fish species rely on the open bay near the shore as a nursery or use it as a migratory route to freshwater rivers and channels to the North. Several species of shorebirds also forage on the mudflats as they migrate through the Pacific Flyway.

Cultural Resources

Several Native American tribes are known to have inhabited the area, including Pomo (central and western Sonoma County), Miwok (southern Sonoma County), Yukia (northern Sonoma County), Sotoyome (northern Sonoma County), and Suysune (eastern Sonoma County) (Drake 1978). The Suisun and Wappo tribes inhabited the area that is now Solano County (Hunt 1926). However, the area where the Refuge is located was once open water and marsh, making it difficult

to locate physical evidence of human activity. Moreover, archaeological sites also tend to be situated on higher land than the Refuge (N. Valentine, pers. comm.). The earliest available written records indicate that Spain claimed ownership of California in 1542. Mexico later ruled California in 1822, and General Vallejo ruled the area that is now the Refuge (Hunt 1926). Following the Mexican-American War, California joined the United States in 1850. The city of Vallejo was named in honor of the general and became the new state capital in 1852. However, the capital was moved to Sacramento a few weeks later because members of the legislature became unhappy with the living and working conditions of the city (www.visitvallejo.com). In 1854, the United States Navy created a naval installation on Mare Island that revived the city when the state legislature left. Mare Island grew into the largest ship construction and repair facility in the world during World War II.

The possibility of prehistoric sites within the Refuge is minimal because of the drastically altered landscape due to gold washing activities (N. Valentine, pers. comm.). There are known shell middens near the Refuge upland areas, but most of the lowland and/or marsh areas would have been open water and/or marsh. Near the existing Refuge boundary are two historic resources noted in California's Register of Historic Places. The Tubbs Ranch and a hunt club were located in the area prior to the Refuge's establishment.

Social and Economic Environment

Transportation

The Refuge units are bound on different sides by Highway 37, which is a major two-lane highway connecting the East Bay with the North and West Bays and the Pacific Coast. Other major transportation routes in the vicinity of the Refuge include Interstates 80, 101, and 580. Highway 37 is the primary access road to all units of the Refuge. However, this major roadway is traveled at high speeds, and there is no shoulder or turn lanes, making it difficult for the public to visit the Refuge. Traffic volumes on Highway 37 for 2001 were 2,300 for the peak hour and 28,500 for the average daily total (Chuck Morton, CalTrans, pers. comm.). There is no direct public transportation system available to provide access to the Refuge units. Alternatively, the public can access Refuge units bordering San Pablo Bay by boat. Boating activities in San Pablo Bay are regulated by State and Federal Laws.

Employment

Employment in Sonoma and Solano counties, where the Refuge is primarily located, was researched. Jobs are found in various sectors, but the top sectors are retail, services, and government (see Table 17 and Table 18). The 2008 unemployment rate was 6.5 percent for Solano County and 5.1 percent for Sonoma County (EDD 2008).

In Solano County, the 2006 per capita income averaged $25,785, and the median household income was $61,533 (ABAG 2003). In Sonoma County, the 2006 per capita income averaged $30,294, and the median household income was $60,821 (ABAG 2003).

Table 17. Employment Demographics for Sonoma County (2002)

Industry	*Jobs Provided*	*Percent Total*
Agriculture and Mining	12,223	4.4
Construction	21,061	7.6

Manufacturing	27,989	10.1
Transportation and Public Utilities	5,501	2.0
Wholesale Trade	7,583	2.7
Retail Trade	31,197	11.2
Finance, Insurance and Real Estate	26,247	9.4
Services	89,593	32.2
Government and Public Administration	30,410	10.9
Tourism	26,410	9.5
TOTAL		100.0

Source: U.S. Department of Commerce, Bureau of Economic Analysis

Table 18. Employment Demographics for Solano County (2002)

Industry	*Jobs Provided*	*Percent Total*
Agriculture and Mining	3,030	2
Construction	13,000	10
Manufacturing	11,100	9
Transportation, Public Utilities and Communication	6,020	5
Wholesale Trade	3,580	3
Retail Trade	27,100	22
Finance, Insurance and Real Estate	5,200	4
Services	30,070	24
Government and Public Administration	26,200	21
TOTAL		100

Source: Association of Bay Area Governments and Solano Economic Development Corporation

Local Economy

The Refuge is relatively rural compared to the rest of the San Francisco Bay area. Solano and Sonoma Counties are surrounded by open farmland and flanked by San Pablo Bay on one side. Dairies, hay farms, and cattle ranches were predominant in the area prior to the Refuge. Ranches and farms still remain in the area; 65 percent of Solano County land is dedicated to agriculture, with field crops and pasture lands dominating the purpose (Solano County Administrator's Office 2003). Sonoma County economy is diversified but anchored by food and wine production. Sixty percent of Sonoma County land is used for agricultural purposes (Sonoma county indicators 2006).

Land Use

The Refuge is primarily wetland, grassland, mudflats, and open water. The two-lane Highway 37 cuts through the Refuge and can be seen or heard from much of the Refuge. Adjacent lands in the area include grasslands, vineyards, ranches, and farms. There are few residential homes in the immediate areas bordering the refuge, but high density residential communities are a short drive away.

Native plant nursery and shadehouse
USFWS

Demographics

The Refuge is primarily located in Sonoma and Solano counties; it is within the San Francisco Bay area. Solano County's population was estimated at 411,680 in 2006 (ABAG 2003). Sonoma County's population was estimated at 466,981 in 2006 (ABAG 2003). The racial demographics are shown in Table 19 and Table 20.

The largest age group distributions in Solana County are: 18–64 years old (63.3 percent); 5–17 years old (19.3 percent); 65 years old and older (10.5 percent); and under 5 years old (7 percent). The largest age group distributions in Sonoma County are: 18–64 years old (64.4 percent); 5–17 years old (16.7 percent); 65 years old and older (12.8 percent); and under 5 years old (6.2 percent).

Table 19. Solano County Demographic (2006 estimate)

Ethnicity	*Percentage*
White	43.9
Hispanic	22.0
Asian	13.9
Black	14.6
American Indian	0.7
Native Hawaiian or Other Pacific Islander	0.7
Other	0.5
Two or more races	3.6

Source: ABAG 2003

Table 20. Sonoma County Demographic (2006 estimate)

Ethnicity	*Percentage*
White	69.3
Hispanic	22.0
Asian	3.9
Black	1.5
American Indian	0.6
Native Hawaiian or Other Pacific Islander	0.3
Other	0.1
Two or more races	2.3

Source: ABAG 2003

Public Use

Current visitor activities in the Refuge include bird watching, limited seasonal hunting, fishing, hiking, and photography. Fall, winter, and spring offer the best opportunities to observe concentrations of migratory waterfowl, shorebirds, wading birds, and raptors.

Wildlife Observation and Photography

An established trail at the Tolay Creek unit provides the best wildlife observation and photography opportunities. A parking lot and interpretive kiosk are located at the Tolay Creek unit. Further down the Tolay Creek trail is Lower Tubbs Island, one of the best places to see wildlife. This area also provides a spectacular view of San Pablo Bay, its wildlife habitat, and numerous tidal marsh species. Restrooms and drinking water are available at the Refuge office on Sears Point during regular office hours. No restrooms, picnic areas, campgrounds, drinking water, or other facilities are available at the Tolay Creek or Cullinan Ranch Units. Due to the sensitive nature of the wildlife living on the refuge, and for protection of endangered species, pets are not allowed.

Boating

Boat access to the open water and navigable sloughs of San Pablo Bay provides opportunities for fishing, wildlife observation, and wildlife photography on the Refuge. Boat launching is not available on the Refuge, but boat ramps are available at the Vallejo public marina near Brinkman's Marine and at Port Sonoma on the Petaluma River.

San Pablo Bay NWR Headquarters
USFWS

Fishing

The Refuge has never been officially opened to fishing, but fishing by boat has occurred on the open bays and navigable sloughs prior to the Refuge's establishment. Fishing from shores of the Refuge is not allowed. Analysis of compatibility for fishing on the Refuge is included in the Appendix E of this CCP.

Hunting

Hunting is allowed on designated areas of the Refuge subject to both State and Federal regulations during respective seasons. Boat access to the open water and navigable sloughs of San Pablo Bay provides opportunities for waterfowl hunting on the refuge. Boat launching is not available on the Refuge, but boat ramps are available at the Vallejo public marina near Brinkman's Marine and at Port Sonoma on the Petaluma River. There is limited upland game hunting by foot for the month of December at the Tolay Creek unit (domesticated pheasant escapees). See Chapter 4 for a hunt map. Analysis of compatibility for hunting on the Refuge is included in the Appendix E of this CCP.

Chapter 4. Current Refuge Management and Programs

The Refuge is managed as a satellite refuge within the San Francisco Bay NWR Complex. Staff for San Pablo Bay Refuge also manages Marin Islands and Antioch Dunes Refuges. Law enforcement staff assigned to the overall complex provides intermittent patrols of the Refuge. Current staffing consists of one part-time administrative assistant and four permanent full-time positions including a refuge manager, biologist, maintenance worker, and one wildlife refuge specialist. Staff split their time between the four refuges.

Habitat Management, Enhancements, and Restoration

Tidal marsh restoration and enhancement projects have been conducted on the Refuge, and more are planned. These projects focus on restoring hydrology and associated estuarine-dependent plant and animal communities. Restoration of tidal marsh plant communities dominated by pickleweed and Pacific cordgrass provide key habitat components for endangered species, including the endangered salt marsh harvest mouse and California clapper rail. Existing and planned enhancement or restoration projects on the Refuge include Cullinan Ranch, Sonoma Creek, Tolay Creek, and Tubbs Island.

Cullinan Ranch Restoration

Cullinan Ranch, historically a tidal wetland marked by slough channels, was diked in the late 1800s and again in the 1940s for agricultural purposes. An Environmental Impact Statement/Environmental Impact Report was completed in 2009, and a Record of Decision was signed in April 2010. A restoration plan has been completed for the 1,500-acre unit to restore tidal influence that will support migratory birds and salt marsh-dependent species. A component of the plan includes public access in the form of a non-motorized boat launch and fishing pier. Permitting is underway, and construction is expected to begin in 2010.

Sonoma Creek Enhancement

The fringing tidal marshlands along the western bank of Sonoma Creek south of Highway 37 impound water for long periods following spring tides and storms. Interior berms and historic mosquito ditches, combined with rapid marsh expansion over the last century, have likely contributed to the expansion of these impoundments. The impoundment of water leads to high mosquito production rates and reduced health of marsh vegetation. These conditions reduce habitat quality for a number of tidal marsh species, especially those that primarily inhabit the pickleweed plain, such as salt marsh harvest mice, black rails, and San Pablo song sparrows. The Refuge is working with the Marin-Sonoma Mosquito and Vector Control District to develop long-term solutions to improving drainage to this area in an effort to reduce mosquito management efforts (e.g., treatment with pesticides). This enhancement project is in the design and engineering phase, with construction proposed for 2011. The primary approach to this enhancement would involve creating large channels within the marsh that would drain impoundments to Sonoma Creek.

Tolay Creek Restoration

Tolay Creek is a tidal slough with associated tidal marsh that outflows to San Pablo Bay. This unit was historically connected to the Tolay Creek watershed and received freshwater input from Tolay Lake, Sonoma Creek, and intermittent streams in the Sonoma Mountains. Human activities

such as levee construction and conversion to agricultural lands have decreased the size of the tidal flood plain, and the watershed connections have been eliminated (e.g., siltation). Restoration projects were completed in the early 1980s and again in 1999 to expand tidal marsh areas and improve tidal flow to and along Tolay Creek (south of Highway 37). The purpose of these efforts was to improve habitats for endemic tidal wetland and subtidal species (USFWS 1997). Post-restoration monitoring has indicated that tidal marsh composition and function are developing in these areas (Takekawa et. al. 2004).

Lower Tolay Creek and Lower Tubbs Island Enhancement
An 87-acre area of lower Tolay Creek and Lower Tubbs Island contain remnant berms, levees, and culverts that cause water to impound following high tides and winter precipitation. The lack of drainage results in poor vegetation health and anoxic soils, while contributing to increased mosquito populations. The project goal is to improve the flow of tidal waters through this area to enhance tidal marsh composition and function, as well as reduce future need for mosquito control. Enhancement of this area is expected to provide benefits to the larger surrounding tidal marsh. Construction of the project was completed in December 2009. Monitoring by the Refuge and Audubon California began in 2007 and will continue until 2015.

Water control structures at Lower Tubbs Island
USFWS

Tubbs Island Setback Restoration
The Refuge initiated the Tubbs Setback Restoration Project in 1985 with funding support from the United Heckathorn Trustee Council. Ducks Unlimited engineered and constructed the restoration work, including a fortified setback levee to protect adjacent baylands. Prior to restoration, the site was a heavily subsided, fallow agricultural field. In 2002, the outer levee was breached to tidal influence. Since that time, tidal marsh plant assemblages have colonized the perimeter of the site, and mudflat is present at low tides. Monitoring results show the site has been colonized by many native wildlife and plant species that are native to the Estuary (Takekawa et al. 2005).

Climate Change
The Refuge is currently working with a researcher to assess climate change effects on Refuge resources to help Refuge management make informed decisions on habitat and wildlife resources. A modeling effort was also conducted in 2010 to assess habitat changes as a result of climate change on the Refuge (Clough and Larson 2010). The Sea Level Affecting Marsh Model identified habitat changes on the Refuge units that may be expected as a result of sea-level rise. The model

predicts that the Refuge will incur a conversion of irregularly flooded marshes into regularly flood salt marshes (and even tidal flats) under higher rates of sea-level rise. The model also predicted a conversion of dry lands to open water on the Refuge. However, a number of assumptions were made, suggesting the need to consider other modeling efforts to confirm these findings. Staff is currently reviewing this modeling to determine management implications.

Acquisitions

Acquisitions are also a method of increasing habitat for Refuge wildlife and habitat resources. In addition, global warming and impending sea-level rise may require that the Refuge seek lands adjacent to its current holdings to provide wildlife and habitat resources into the future. The Refuge has been involved with several ongoing acquisition opportunities.

Sonoma Baylands. Efforts are underway to facilitate the transfer of Sonoma Baylands to the Refuge. This restored tidal wetland habitat has the potential to provide safe public access, environmental education, waterfowl habitat, and endangered species habitat. If successful, the Refuge will take advantage of providing safe public access directly to the Refuge and to the Bay. Portions of the trail surface will be repaired and upgraded, while an additional section of trail will be mowed to allow access directly to the Bay.

Additional information and interpretive kiosks will be constructed on site, and volunteers will be sought to provide docent led tours. Restoration of the transition habitat along the levee will continue, as will other habitat enhancement activities. Waterfowl hunting is currently permitted on the site. A compatibility determination will be conducted for this unit when acquired to determine if hunting should be continued and if fishing can be permitted.

Sears Point. The Refuge currently leases this property for its headquarter and nursery site. This property of uplands and seasonal wetland habitat will provide the Refuge with a permanent headquarters site that does not fall within current sea level inundation predictions. The area's pasture and infrastructure continues to allow for grazing of cows and can provide the Refuge with an opportunity to showcase the agricultural history of the area.

Staff and volunteers building the nursery greenhouse
USFWS

Guadalcanal. This restored tidal wetland habitat already provides shorebird and endangered species habitats, as well as the potential to provide safe public access (recreational fishing) and environmental education.

Mosquito Population Management

Mosquito management activities occur throughout the San Francisco Bay region, where a large (more than 6 million people) human population occurs and where there is a long history of mosquito management and documented mosquito-borne disease transmission to humans and wildlife. Mosquitoes can be vectors of disease to both humans and wildlife and, in some cases, can cause death. Ten California species of mosquito that are known vectors of arboviruses or as major pests were evaluated for West Nile Virus (WNV) transmission in 2002. All 10 species were infected with WNV and were able to transmit the disease at some level (Goddard et al. 2002). The mosquito species *Culex tarsalis* is considered one of the most efficient laboratory vectors of WNV tested from North America and is abundant in California and much of western North America, where it is involved in the maintenance and amplification of western equine encephalomyelitis virus and Saint Louis encephalitis virus (Goddard et al. 2002). *Culex tarsalis* larvae are typically found in irrigation ditches, ponds, storm sewers, and other areas that usually contain abundant organic material. Of the 10 mosquito species studied by Goddard et al. 2002, *Culex tarsalis* showed the greatest potential to amplify and maintain WNV in California. Mosquito species most abundant on the Refuge in 2005 were *Aedes dorsalis*, *A. squamiger* and *Culiseta inornata* (E. Hawk, MSMAD, pers. comm.). Based on a 2005 report provided by the Marin-Sonoma mosquito abatement districts, small populations of *A. washinoi* and *Culex tarsalis* were also found on the Refuge. In 2010, there were three human cases of WNV reported in Contra Costa County (pers. comm., Solano County MAD). Positive WNV results have been reported in 2010 for birds and mosquitoes within the nine-county bay area region.

As of 2011, 326 bird species have been listed in the Center for Disease Control WNV avian mortality database (http://www.cdc.gov/ncidod/dvbid/westnile/birdspecies.htm, accessed May 2, 2011). The list includes wildlife that inhabit tidal marshes of the Refuge, such as waterfowl, grebes, heron, egrets, cormorants, songbirds (wrens, yellowthroats, song sparrows), and rails (Virginia rail, common moorhen, American coot). Other vertebrates known to be infected by WNV include horses, bats, chipmunks, skunks, rabbits, and squirrels.

With the spread of West Nile Virus WNV and the potential for spread of other mosquito-borne disease across the country, there is increasing pressure to manage mosquito populations that occur on lands of the NWRS, especially in urban areas such as the San Francisco Bay region. The NWRS understands that mosquitoes are a natural component of wetlands, but we also recognize that they may pose a threat to human and/or wildlife health. As a result, mosquito control has long been an existing action on the Refuge. Prior to and since establishment of the San Pablo Bay National Wildlife Refuge in 1974, mosquito control on the Refuge has been monitored and regulated through annual USFWS Pesticide Use Proposals for consistency with departmental, Service, regional, and state policies. Refuge staff works cooperatively with three mosquito abatement districts to manage mosquito populations on the Refuge: Solano County Mosquito Abatement District, Napa County Mosquito Abatement District, and Marin-Sonoma Mosquito and Vector Control District.

A mosquito management plan (Appendix G) has been developed to describe the precise character, extent, and level of abatement activity. The Plan is consistent with the Service's interim guidance issued by the U.S. Fish and Wildlife Service for mosquito-borne disease management pursuant to the NWRS (USFWS 2004). Staff have developed this plan and required NEPA analysis in coordination with the Marin-Sonoma, Solano, and Napa County mosquito abatement districts. The Marin-Sonoma, Solano, and Napa County Mosquito Abatement Districts will continue to adhere to a set of best management practices (BMPs) already required under the applicable Special Use Permits issued by the Refuge. These BMPs are based on integrated pest management (IPM) principles and allow use of pesticides only after evaluation of a range of alternatives, including physical and cultural methods (e.g., wetland enhancement), biological controls, and no action; and full consideration of safety, environmental effects, efficacy, specificity, and cost.

Vegetation Management

Invasive species

Several non-native plant species can be found on the Refuge. In most cases, non-native plants do not pose a threat to native plant and animal communities of the Refuge, although a few non-native plant species are considered invasive. Executive Order 13112 defines an invasive species as "a species that is non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health"(1999). The California Invasive Plant Council (Cal-IPC) defines invasive non-native plants as "plants that are not native to, yet can spread into, wildland ecosystems, and that also displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes" (CalIPC 2006). Using these definitions, invasive plant species on the Refuge at this time include perennial pepperweed and non-native cordgrass species.

Pepperweed is a highly invasive herbaceous perennial in the *Brassicaceae* family. This Eurasian herb was introduced into the U.S. in the 1930s and is now found throughout the western United States. Pepperweed appears to be adapted to conditions of moderate salinity (Spenst 2006) but is not an obligate halophyte. It has been known to grow in freshwater, brackish, saline, and alkaline environments and across a wide range of habitats, including riparian areas, wetlands, marshes, meadows, and floodplains (Young et al. 1995, Bossard et al. 2000, Renz and Blank 2004, Howald 2000). The U.S. Bureau of Land Management and 10 western states classify pepperweed as a noxious weed (Chen et al. 2005). It is ranked "high" (a composite scoring of ecological impact, invasive potential, and distribution) by the California Invasive Plant Council (2006), and is listed among the Class B noxious weeds by the California Department of Food and Agriculture due to its highly invasive and ubiquitous nature.

Pepperweed can form complete monocultures and displace native species in riparian and wetland areas, where it is most aggressive (Eiswerth et al. 2005, Renz and Blank 2004). Monocultures and the dense thatch they produce can inhibit emergence of annual plants by blocking the penetration of light to the soil surface (Renz 2000). Progressive invasion of pepperweed since 1975 onto the berms, levees, and creek banks of Petaluma Marsh (north of San Pablo Bay) has resulted in the replacement of coyote brush (Grossinger et al. 1998), a common species on the Refuge. Pepperweed is found growing in pickleweed-dominated plains adjacent to tidal channels (May

1995). Although pepperweed generally prefers higher elevations than pickleweed, marsh accretion over time has resulted in increased habitat suitable for pepperweed.

The Refuge conducted a census of pepperweed in tidal marsh areas of the Refuge in 2005 and 2006 (Figure 9). Mapping results, conducted largely by volunteers, show pepperweed occupies approximately 60 acres of tidal marsh between the Petaluma River and Sonoma Creek. This data was analyzed in relation to other features on the Refuge (e.g., levees, channels). These results, in combination with the best available scientific information on pepperweed control, were used to develop a pepperweed control plan (Hogle et al. 2006). Control actions began in 2007 and continued through 2009. Results from monitoring will be used to adapt control techniques through time. The goal of the Refuge control plan is to reduce pepperweed cover by 90 percent of baseline (2005) within five years. Eradication is unlikely given the prevalence of this species throughout the San Francisco Estuary.

Figure 9. Mapping Results for 2005-06 Invasive Pepperweed Census

Non-native invasive *Spartina* species also pose a threat to tidal marsh and mudflats of the Refuge, particularly Atlantic smooth cordgrass and hybrids (*S. alterniflora*) with our native Pacific cordgrass. Atlantic smooth cordgrass is extensive in the southern and central areas of the San Francisco Estuary. The first observations of invasive *Spartina* on the Refuge occurred during summer 2007. A small population of *S. densiflora* (0.5m^2) and *S. alterniflora* (5m^2) were discovered in the Strip Marsh unit and have also been discovered along Sonoma Creek. These populations were treated in 2008 and 2009.

Invasive Spartina
USFWS

Studies on the effects of invasive cordgrass suggest an eventual extinction of native Pacific cordgrass, tidal channel degradation, and spread into tidal mudflats (key shorebird foraging habitat) without active control efforts. In the absence of control efforts, this species is likely to spread to other estuaries along the California coast. In 2004, non-native invasive cordgrasses occupied over 1,000 acres in the Estuary, with the highest densities occurring in the southern part of the Estuary (www.spartina.org/invasion.htm). The California Coastal Conservancy initiated the Invasive Spartina Project (ISP) in 2000 to study and control existing populations and reduce the further spread of invasive *Spartina* species. The ISP is a regionally coordinated effort of Federal, State, and local agencies; private landowners; and other interested parties. The ISP has conducted surveys for invasive *Spartina* species on the Refuge for several years. The ISP is expected to end in 2011. At this time, individual land managers, including the Refuge, will be responsible for monitoring and control of these highly invasive species.

Early Detection

The Refuge, in cooperation with the USFWS National Invasive Species Program, the National Invasive Species Council, the Center for Invasive Plant Management, and USGS is developing an early detection and rapid response program focused on invasive plant species. The following actions are currently underway:

- Establish an early detection and rapid response (EDRR) program. The Refuge is testing protocols for early detection of invasive plant species. Preliminary sampling was conducted in 2007 using USGS methods. An EDRR protocol developed by the National Park Service is also being evaluated.
- Partnership with the Marin-Sonoma Weed Management Area. A forum of local, State, Federal, and non-profit partners for sharing information and tools.
- Active participation in the Bay Area Early Detection Network. A network of agencies and groups established in 2007 for sharing data, information, and resources related to early detection and rapid response for invasive plants.
- Monitoring and control of invasive *Spartina* species on the Refuge with the ISP.

The goal of these activities is to reduce the likelihood that colonizing invasive plant species spread throughout the Refuge. Rapidly responding to early invaders will significantly reduce future control costs and conserve existing native plant and wildlife populations.

Plant Restoration

The Refuge established a native plant nursery at the Refuge headquarters in 2006. The nursery supports native plant restoration at San Pablo Bay and Marin Island NWRs. The focus of propagation is native species that occupy the marsh-upland transition zone along levees and berms. This zone typically receives little attention in tidal marsh restoration projects and is the most difficult to restore (relative to lower elevation tidal zones). In addition, these areas often support high densities of non-native species and can act as colonizing sites for invasive non-natives. One of the functions of native plants in the transition zone is the provision of high-tide refuge for estuarine-dependent species such as the salt marsh harvest mouse and rails. Native plants are propagated from seed collected within the San Pablo Bay region. Typical species include creeping wild rye, saltmarsh baccharis (*Baccharis douglasii*), western goldenrod, and yarrow.

Saltmarsh Baccharis (*Baccharis douglasii*)
USFWS

The Refuge has partnered with the Friends of the San Pablo Bay and other non-profit organizations to develop and encourage community participation through native plant restoration. Volunteers assist with seed collection, nursery propagation, weeding, and planting.

Fish and Wildlife Management

Migratory Bird Management

Refuge biologists from the San Francisco Bay Complex participate in the annual Pacific Flyway Waterfowl Survey conducted annually in January. These surveys monitor populations and allow annual comparisons of wintering waterfowl populations within and across sites along the Pacific Flyway, which includes the San Francisco Bay area. A comparison of surveys 1997 and 2007 conducted in the San Pablo Bay area showed declines in most waterfowl species.

Refuge biologists also participate in an estuary-wide shorebird survey conducted by PRBO during the last two years and one other survey 10 years ago. The survey's results and trends were discussed in Chapter 3.

Threatened and Endangered Species Management

The primary tools used by the Refuge to conserve or improve endangered species populations or habitat include restoration or enhancement of estuarine environments, and promotion of research that provides new information about particular species or habitats and associated management implications. Restoration and enhancement efforts include reintroduction of tidal waters to diked baylands, removal of tidal water impoundments, invasive plant control, and native plant restoration.

Surveys for salt marsh harvest mice and other small mammal species are conducted using standard small mammal trapping techniques (e.g., Sherman live traps) within trapping grids or at random point locations. Surveys for small mammals have been conducted throughout the Refuge in relation to regional or local scientific studies or as part of restoration monitoring programs. Current surveys are conducted annually at the Tubbs Island Setback and Tolay Creek restoration sites (Takekawa et al. 2004, Woo et al. 2006). Results from all previous trapping efforts show salt marsh harvest mice occur throughout tidal marsh of the Refuge.

Conducting weight measurement of salt marsh harvest mouse
USFWS

Surveys for the California clapper rail on the Refuge were initiated in 2002. Annual surveys began in 2004 and include Cullinan Ranch, Sonoma Creek, Tolay Creek, Tubbs Island, and Sonoma Baylands. These surveys indicate presence and absence; no population estimates are available at this time. PRBO Conservation Science conducts annual rail surveys along the western edge of the Refuge (Petaluma River mouth). The most recent surveys were conducted during the winter-spring season of 2009-2010.

Fish and Invertebrate Management

Subtidal monitoring of the Refuge is not conducted by Refuge staff. The CDFG conducts several long-term studies (See Table 21) monitoring fish and invertebrates in the San Francisco Bay Estuary (IEP 2008). The San Francisco Bay Study conducted by CDFG samples demersal (bottom-dwelling) fish, pelagic fish, shrimp, and crabs from South Bay to the western Delta. Delta

smelt and striped bass are considered focus species of concern. USFWS also has an annual beach seine survey, which samples intertidal and shallow subtidal habitats from Central San Francisco Bay through the delta. U.S. Geological Survey conducts a survey of phytoplankton, California Department of Water Resources conducts a survey of benthic resources, and the CDFG conducts a survey of zooplankton in the San Francisco Bay Estuary that includes San Pablo Bay stations (K. Hieb, pers. comm.). These studies provide presence, indexes, and trends for a variety of subtidal species, including listed delta smelt, Chinook salmon, Sacramento splittail, and steelhead (see Chapter 3 *Fish* subsection).

Table 21. Examples of Recent and Long-term Monitoring, Research, and Investigations that Occur Within San Pablo Bay

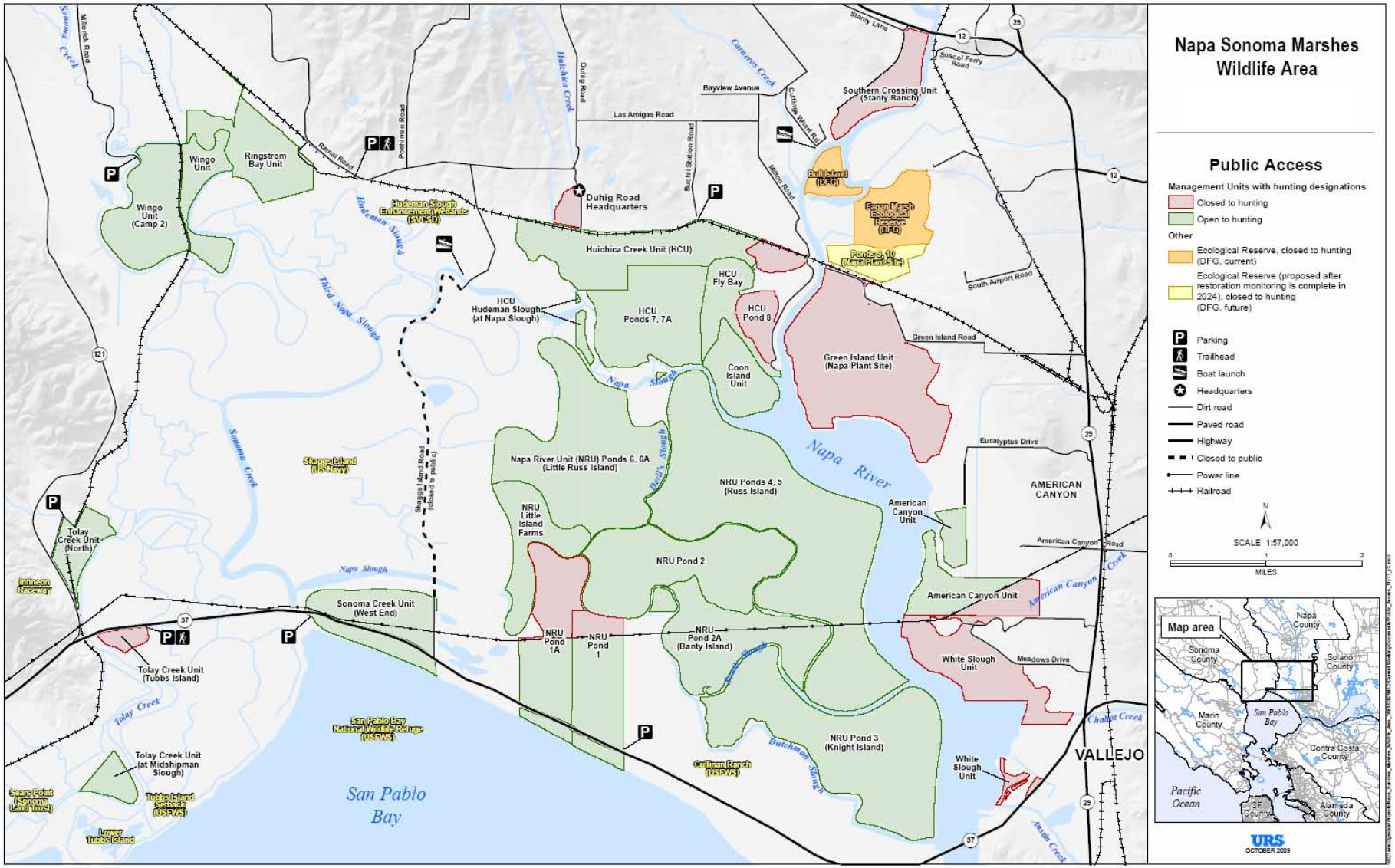
Type	Focus	Subject	Location	Conducted By	Time period
Abiotic	Tidal marsh topography	Habitat Effects of climate change on tidal species	Refuge	U.C. Davis	2008-present
	Sediments and water quality	Tidal marsh restoration	Refuge/San Francisco Estuary	USFWS, USGS, SFEI, Audubon CA	1998-present
Plant	Lepidium latifolium	Ecology, control methods	Refuge	USFWS, U.C. Davis	2005-present
	Invasive species	Early detection methods	Refuge	USFWS/USGS	2007-present
	Invasive Spartina species	Control methods, ecology	San Francisco Estuary	Invasive Spartina Project	2000-present
Bird	Marsh-upland ecotone	Native plant restoration	Refuge	USFWS, The Bay Institute	2006-present
	Shorebirds	Population status, restoration monitoring	Refuge/San Francisco Estuary	USFWS, PRBO, USGS, Audubon CA	2006-present
	Waterfowl	Flyway population status, restoration monitoring	Refuge/San Francisco Estuary	USFWS, USGS, Audubon CA	1981-present
	CA clapper rail	Population monitoring	Refuge/San Francisco Estuary	USFWS, PRBO	2002-present
	Surf scoters	Population monitoring, habitat studies	San Francisco Estuary	USGS, CDFG	n/a-present
	Song sparrow	Reproduction, habitat	San Francisco Estuary	PRBO	1998-present
	Tidal marsh songbirds	Restoration monitoring	Refuge	USFWS, Audubon CA, USGS	n/a-present
Fish and Invertebrates	Summer Townet Survey	Population monitoring	San Pablo, Sacramento River, and San Joaquin River	CDFG	1959
	Fall Mid-water Trawl Survey	Population monitoring	San Pablo Bay, San Joaquin River, and Sacramento River	CDFG	1967
	San Francisco Bay Study	Population monitoring	San Francisco Bay Estuary	CDFG	1980
	Delta Smelt	Population monitoring	San Francisco Bay	CDFG	1995

20-mm Survey		Estuary		
Beach Seine Survey	Population monitoring	San Francisco Bay Estuary, Sacramento River, and San Joaquin River	USFWS	1992

Recreational Fishing and Hunting Management

Fishing is an existing use in the open bay sections, creeks, sloughs, and channels of the Refuge, but it is regulated by the CDFG. Fishing has never been formally opened on the Refuge, but when opened, will only be allowed on the Refuge from a boat in all navigable sloughs and open waters where fishing currently exists and from designated angling sites located on specific units of the Refuge shoreline. There are no launch facilities on the Refuge; therefore, boats are not permitted to launch from the Refuge and must enter via the open bay or other waterways outside of the Refuge. Waterfowl and upland game hunting is allowed in certain areas of the Refuge (see Figure 10), but hunters must comply with CDFG and Federal regulations.

Figure 10. Hunting Areas in the North Bay



Other Management Activities that Affect the Refuge

The Refuge continually works with adjacent landowners in conducting biological programs, environmental education, and outreach. The Refuge realizes that our efforts may affect our neighbors, so we make every effort to seek their input for all aspects of programs that could have implications beyond our boundaries. Conversely, actions that take place on adjacent lands may affect the Refuge. The Refuge has succeeded in maintaining open communication and partnering on projects to reduce negative impacts, to reduce effort for all involved parties, to fulfill the Refuge mission, and to promote good stewardship on neighboring lands. Some adjacent landowners include the CDFG, California Coastal Conservancy, Sonoma Land Trust, Fred Dickson, Norm Yenni, Vallejo Sanitation District, City of Vallejo, United States Navy, Caltrans, Paradise Winery, and Infineon Raceway.

The Refuge and CDFG have a specific relationship to manage a patchwork of lands across the North Bay bordering the north and south sides of Highway 37. Current partnerships with CDFG include several tidal restoration and research projects. Productive relationships with our neighbors have resulted in the upcoming transfer of several pieces of land into the Refuge: Guadalcanal Village by Caltrans, Sonoma Baylands by California Coastal Conservancy, and Sears Point by Sonoma Land Trust.

Fire Prevention and Hazard Reduction

The Refuge completed a Fire Management Plan in 2004. Overall fire risk of the Refuge has increased with the move to Sears Point, which introduced several hundred acres of grasslands to the matrix of existing wetlands that are managed. The plan will be updated during the life of the CCP to include these grasslands.

Law Enforcement and Resource Protection

Two full-time Refuge officers patrol the San Francisco Bay NWR Complex. Refuge officers are able to patrol San Pablo Bay periodically to ensure public uses (e.g., wildlife observation, hunting, and fishing) are in compliance. Law enforcement patrols also conserve endangered species habitat by reducing or eliminating human disturbance in sensitive habitat. The officers receive some support from CDFG during waterfowl season.

Facilities Maintenance

Facilities maintenance on the Refuge is currently more in the construction mode than in the maintenance mode. The headquarters is located at an old dairy farm, and as such, many of the structures are in the process of being demolished, replaced, or renovated. As one construction project ends, another begins; and when water lines or other infrastructure fail, repairs are made until such time that they can be upgraded or replaced. The goal of facilities maintenance is to renovate the site to maintain the ranch aesthetic and recycle materials on site for construction and renovation purposes.

Maintenance throughout the remainder of the Refuge currently consists of mowing levees, parking areas, and fields; trash collection, weed control through herbicide applications; and sign

replacement and repair. Fencing is a new addition to the maintenance list, since an active cattle operation is part of the Sears Point property.

Safety

The Refuge has an approved Safety Plan, and audits are conducted annually. In the event of an emergency, numbers for fire, police, sheriff, or other emergency contacts are readily available.

Public Uses

The number of visitors to the Refuge in 2008 and 2009 are estimated at 7,000 and 5,550, respectively. The majority of these visitors participate in special events held at the Refuge, but the numbers also include participants in the interpretation and environmental education programs. Several wildlife-oriented recreational uses are allowed on the Refuge. These include wildlife observation, photography, hunting, and fishing. Participation numbers are not well known because these activities take place away from the headquarter site. Waterfowl hunting and sport (or recreational) fishing are allowed in the open bay waters (approximately 8,000 acres) of San Pablo Bay. Fishing numbers are not available because fishermen enter areas by boat from launches outside of the Refuge. Pheasant hunting occurs on some segments of the Tolay Creek Unit (less than five acres) and it is estimated that 15 hunters annually participated in this activity in 2007-2009. The Tolay Creek Unit also has a public trail for walking and bicycling for wildlife viewing, hiking, photography, and wildlife interpretation. Precise figures for wildlife observation visits are not available because the trailhead is not located at the headquarter site, but staff estimate that there are 100 visits each year.

Staff and volunteer docent-led wildlife observation and interpretive hikes are offered at the Tubbs Island and/or Tolay Creek unit. Volunteers are being sought to lead bird and plant walks on other portions of the Refuge, including newly acquired properties. Most walks occur during the annual Flyway Festival throughout Tubbs Island and/or Tolay Creek, as well as other closed areas of the Refuge. From counts taken during the Flyway Festival and other tours, we estimate a total of 5,500 to 6,000 people visit the Refuge each year.

Environmental Education and Outreach

The Refuge had a longstanding environmental education program with local schools when the headquarters was located in Vallejo. The goal of the program was to develop natural resource, curriculum-based, education programs tied to applicable California State Standards (Language Arts, History/Social Science, and Science) for formal (schools) and non-formal (youth) groups. The program also sought to provide high quality training and curriculum materials for educators and youth professionals that focus on bay and watershed ecology as relevant to the resource management issues of the Refuge and U.S. Fish and Wildlife Service. This program was phased out after the Refuge headquarters relocation to Sears Point in 2005 due to the unavailability of safe access onto the Refuge for school buses and other transport vehicles.

Currently, the Refuge relies on partners to conduct environmental education-based activities, yielding approximately 980 and 650 participants (on and off the Refuge) in 2008 and 2009, respectively. The Bay Institute conducts an environmental education program focused on habitat restoration that brings schoolchildren to the Refuge.

Environmental education activities conducted by partners
USFWS

The Refuge's environmental education staff has focused on outreach that provides information about the Refuge and its resource management objectives and issues through hand-on materials, brochures, displays, and other materials at local environmental education fairs. The Refuge already participates in several local community events, including the Napa Earth Day Fair, Heron Festival at Clear Lake, and the annual San Francisco Bay Flyway Festival, which is held on Mare Island in January or February. Through interpretative walks, spotting scope observations, children's hands-on activities, and staffing the San Pablo Bay NWR booth, the outreach program has served approximately 9,000 participants annually at these three events. Refuge staff also participates at the Bay Area Environmental Education Fair each January, where they interact with and serve approximately 6,000 teachers.

Outreach at a local festival
USFWS

Existing Partnerships

Partnerships are critical to the success and progress of any refuge. San Pablo Bay Refuge has greatly benefited from the support of several entities and individuals. These partners contribute funding, personnel, data, and a variety other resources to the management and conservation of the Refuge.

- Audubon California
- Audubon National

- California Coastal Conservancy-Invasive Spartina Project
- California Department of Fish and Game
- California State Lands Commission
- California Wildlife Conservation Board
- Friends of San Pablo Bay NWR
- Marin-Sonoma Mosquito and Vector Control District Abatement
- Marin-Sonoma Weed Management Area
- Napa-Solano Mosquito Control District
- National Park Service
- PRBO Conservation Science
- ConocoPhillips
- Infineon Raceway
- Save the Bay
- SF Bay Joint Venture
- Sonoma Land Trust
- Sonoma State University
- The Bay Institute
- The Bay Trail
- Citizen's Committee to Complete the Refuge
- The Wildlife Society of SF Bay NWR Complex
- Barbara's Bakery
- University of California, Davis
- United States Geological Survey

These entities work cooperatively or separately with the Refuge to pursue funding or in-kind opportunities for various Refuge projects, planning and permitting efforts, and—in some cases—expertise or physical labor. Overall they are vital to the Refuge for their ability to provide expertise, advice, and political support.

Chapter 5. Refuge Management Direction: Objectives and Strategies

One of the most important parts of the CCP process is the development and refinement of the Refuge vision and goals. This section contains the primary goals that will define the management direction of the San Pablo Bay Refuge for the next 15 years. In addition, as part of the CCP, refuges are expected to develop objectives and strategies that, together, will help achieve the goals. Goals are broad statements of the desired future conditions for refuge resources. Refuge goals may or may not be feasible within the 15-year time frame of the CCP. Whenever possible, objectives are quantified statements of a standard to be achieved or work to be accomplished. They should be specific, measurable, achievable, results oriented, and time fixed;, they should be feasible within the 15-year lifespan of the CCP. Strategies are specific actions, tools, or techniques that contribute toward accomplishing the objectives. In some cases, strategies describe specific projects in enough detail to assess funding and staffing needs.

Goals, objectives, and strategies may evolve to adapt to changing environmental conditions or needs. Also, staffing and funding are necessary to complete these goals, objectives, and strategies in the stated timeframe.

The following vision statement and eight goals of the San Pablo Bay National Wildlife Refuge provide a context for the proposed management direction.

San Pablo Bay NWR Vision Statement

San Pablo Bay National Wildlife Refuge lies within the larger San Francisco Estuary, one of the largest estuaries along the Pacific Coast. The location of San Pablo Bay relative to freshwater influences of the Sacramento and San Joaquin Rivers and saline waters of the Pacific Ocean result in a unique and rich array of physical and biological conditions. Large contiguous expanses of pickleweed-dominated tidal marsh support high densities of the endangered salt marsh harvest mouse, as well as provide habitat for the endangered California clapper rail and other sensitive estuarine-dependent species. This Estuary is of hemispheric importance to shorebirds. Hundreds of thousands of shorebirds and waterfowl use this area to overwinter or rest and feed as they migrate along the Pacific Flyway.

Through history, humans have altered San Pablo Bay, resulting in high levels of contaminants and conversion of tidal environments to agricultural lands, salt ponds, and other non-tidal conditions. Despite these changes and the proximity to a highly urbanized environment, lands immediately surrounding the Refuge are dominated by open space. These open spaces provide opportunities to restore historic tidal and upland environments, directly linking them to adjacent uplands and freshwater seasonal wetlands, a rare historic feature of the larger San Francisco Estuary and a condition that will enhance and sustain populations of native flora and fauna.

The Refuge, working with partners, will play an important role in protecting, enhancing, and restoring tidal and upland environments of San Pablo Bay, especially where opportunities exist to expand or link tidal wetlands to uplands and freshwater seasonal wetlands. Our efforts will focus on the use of natural processes, where possible, to achieve desired environmental structure

and function. An adaptive management framework will be used to respond to changing environmental conditions, especially with respect to invasive species, enhancement and restoration projects, and projected climate-related events.

Although humans have had negative impacts on San Pablo Bay, a century of agricultural uses has resulted in the preservation of open spaces where tidal wetlands and native grasslands can be restored. This environment links people to open space and their agrarian past. The Refuge will be an open space resource where wildlife and people connect—where people belong with nature and are immersed in it. The Refuge will be inclusive of all age groups, backgrounds, and skill levels by providing a variety of opportunities, including fishing, hunting, trails, interpretive signs and guided tours, and off-refuge environmental education to facilitate that connection, that belonging, that immersion.

GOAL 1: Support and contribute to the recovery and protection of threatened and endangered species and related ecosystems of the San Francisco Estuary.

GOAL 2: Protect, enhance, and restore high quality roosting and foraging environments for overwintering and migratory shorebirds and waterfowl.

GOAL 3: Acquire, protect, enhance, and restore functioning tidal marsh and associated upland systems to benefit all native wildlife and plants that use environments of the Refuge.

GOAL 4: Protect and enhance subtidal systems for the benefit of marine and subtidal dependent species.

GOAL 5: Identify, assess, and adapt to current and future climate change impacts to Refuge resources.

GOAL 6: Develop a supportive relationship with the surrounding community to foster understanding and stewardship of the Refuge and the National Wildlife Refuge System mission.

GOAL 7: Provide visitors and the local community with compatible wildlife-oriented outdoor recreation opportunities to enjoy, understand, and appreciate the resources of the Refuge.

GOAL 8: Provide a quality environmental education and interpretation program that enriches the local community with the history and purpose of the natural habitats of North San Pablo Bay and the mission of the National Wildlife Refuge System.

Wildlife Management

GOAL 1: Support and contribute to the recovery and protection of threatened and endangered species and related ecosystems of the San Francisco Estuary.

Objective 1.1 Within five years of the Plan, develop and begin to implement an inventory and monitoring (I&M) program that addresses native and non-native species, habitats, and ecosystems of San Pablo Bay.

Rationale: Federally listed threatened, endangered, and candidate species are trust responsibilities under the jurisdiction of the Service. Threatened and endangered species, as well as those proposed for Federal listing, are likely to become extinct due to environmental factors. Listed species known to occur on the Refuge, the California clapper rail and the salt marsh harvest mouse, are dependent on tidal wetlands. As much as 90 percent of wetlands around the San Francisco Bay have been lost to development (Goals Project 1999). The Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (Draft Tidal Marsh Recovery Plan) (USFWS 2009) identifies the need for monitoring to assess status, trends, habitat use, and threats to develop appropriate recovery actions. Refuge management strategies will support these objectives. Furthermore, understanding how listed species interact with their environment and other wildlife will support their recovery.

In addition, documentation of the occurrence of plants, fish, wildlife, habitats, abiotic components, ecological communities, and invasive species will meet management needs. Monitoring changes in biotic and abiotic resources will help management make informed decisions or develop, refine, and evaluate achievement of fish, wildlife, and habitat management objectives. Inventory and monitoring data may also support management of abiotic and biotic resources by other agencies or organizations at broader spatial scales than the Refuge. Development of an I&M plan will permit prioritization of I&M activities given available resources, relate I&M activities to refuge management goals, document standardized protocols, describe methods for data storage and archiving, and provide templates for summarizing results.

Strategies

- Identify partners and funding to develop and implement an I&M program.
- Develop I&M program based on best available information and guidance from local, regional, and national conservation plans and policies.
- Integrate, collaborate, and contribute data to existing I&M and other scientific efforts at the local, regional, and national scale where feasible.
- Consider short-term (e.g., 1-year, 5-year, 10-year) and long-term (e.g., 100-year) survey data needs (e.g., endangered species population monitoring, climate change evaluations).
- Prioritize species, habitats, ecosystems, and processes that should be included in the I&M program. Prioritization should include specificity of ecological requirements, rarity, status and trends, and assessment of climate change impacts and adaptations.
- Develop detailed methods for implementation (e.g., protocols, metadata, tools, frequency, etc.).

<u>Objective 1.2</u> Within life of the Plan, evaluate population health, develop population goals, and identify and implement management actions that will preserve or enhance existing populations of priority species identified in the I&M program (see Objective 1.1).

Rationale: The Draft Tidal Marsh Recovery Plan identifies several actions needed to achieve recovery of the California clapper rail and salt marsh harvest mouse.

Actions include evaluating and monitoring existing populations, protecting, managing, and restoring habitat, and conducting research necessary to promote recovery. Refuge management strategies will directly support the actions identified in the Plan.

Strategies

- Identify partners and funding to address information needs.
- Review scientific literature and work with other scientific organizations to evaluate health and viability of populations that occur in San Pablo Bay and the processes that drive them (e.g., hydrology, reproduction).
- At a minimum, assess population viability and develop population goals for endangered species that occur in San Pablo Bay, including the salt marsh harvest mouse and the California clapper rail.
- Through funding and partners, study ecological and demographic processes that affect populations in San Pablo Bay.
- Prepare habitat management plans for priority species, including the salt marsh harvest mouse and the California clapper rail.
- Support recovery activities identified in the Tidal Marsh Recovery Plan.
- Support management-oriented research on threatened and endangered species, including studies about the effects of management treatments thought to promote recovery.

Objective 1.3 Within the life of the Plan, continue and expand enhancement and restoration of the marsh-upland ecotone by establishing a dominance of native plants along at least two-kilometers of levee or transitional uplands of the Refuge.

Rationale: Historic tidal marsh of the Estuary encompassed a gradual transition to uplands and, in many places, included gradual slopes. Today, these "transition" areas, commonly referred to as the marsh-upland ecotone, are dominated by levees with a very steep, narrow transition to uplands. The Refuge tidal marsh ecotones consist only of levees, and they are dominated by non-native plant species. The ecotone is an important functional component of the tidal marsh ecosystem, including provision of the Refuge from predators during extreme high tides.

The Goals Project (1999) identifies the importance of restoring the San Francisco Bay marsh-upland ecotone. The Draft Tidal Marsh Recovery Plan identifies the ecotone as essential to the viability of endangered species populations.

Strategies

- Prepare and implement a marsh-upland ecotone restoration plan that identifies:
    - priority areas for restoration
    - priority species to restore
    - timelines for restoration
    - detailed propagation and restoration methods
    - weed management methods
    - further research needs
    - monitoring protocol

- Develop new or alternative methods that efficiently restore the marsh-upland ecotone at larger spatial scales (e.g., hydroseeding, hydrosprigging).
- Review literature and incorporate native plant species known to improve habitat of estuarine species.
- Remove non-native plants from levees.
- Use partnerships and volunteers to support the propagation program.

Objective 1.4 Throughout the life of the Plan, maintain native plant communities in at least the 100-foot buffer around trails and other public areas using mechanical and chemical methods to prevent the introduction of invasive vegetation beyond the buffer.

Rationale: Invasive and non-native species have become the primary threat to the Refuge System and the Service's wildlife conservation mission. Invasive species have the potential to alter foraging, nesting, and roosting habitat of endangered species and migratory birds that occur on the Refuge. The biological integrity policy identifies the need to control non-native vegetation. The Refuge's proximity to urban environments also highlights the importance of vigilant monitoring of Refuge units. The National Strategy for Management of Invasive Species (April 2003) was developed within the context of the National Invasive Species Management Plan [EO 13112], which functions as the internal guidance document for invasive species management throughout the Refuge System. The Plan identifies four goals: 1) increase the awareness of invasive species issues, both internally and externally; 2) reduce the impacts of invasive species to allow the Refuge System to more effectively meet its fish and wildlife conservation mission and purpose; 3) reduce invasive species impacts on the Refuge System's neighbors and communities; and 4) promote and support the development and use of safe and effective integrated management techniques to deal with invasive species.

Strategies

- Develop Adaptive Weed Management Plan, which will include prioritization methods, weed ecology, available treatment methods, monitoring methods.
- Conduct frequent and routine mowing at regular intervals to minimize seed development of non-native invasive species.
- Use herbicides to treat non-native invasive weeds along levees and trails to prevent further weed spread.
- Routinely remove human-related trash and debris from levees, trails, and roadways that would impact native plants and wildlife.
- Investigate methods other than chemical and mechanical treatments to reduce non-native and invasive weeds within endangered species habitat.

Objective 1.5 Within the life of the Plan, assess native and non-native predators' relation to listed species, migratory birds, and other species of concern of San Pablo Bay, including population levels, access to prey, impacts to refuge resources, and thresholds for management action.

Rationale: The presence, distribution, and potential impacts of native and non-native predators are not well understood on the Refuge. As mentioned in

Objective 1.4, invasive species are a primary threat and priority for the Refuge System. The strategies will meet the objectives in the Refuge System's National Strategy for Management of Invasive Species.

Strategies

- Gather information from agencies and other organizations on current and potential predator populations of concern in the San Pablo Bay region.
- Identify and obtain resources required to implement baseline assessments, monitoring, and control programs.
- Conduct baseline assessments of predators of concern using available methods.
- Develop predator population thresholds that will trigger control actions.
- Consult with USFWS and U.S. Department of Agriculture Wildlife Services to develop a predator management plan as needed.
- Assess implications of restoration projects and public access to predator movement.

GOAL 2: Protect, enhance, and restore high quality roosting and foraging environments for overwintering and migratory shorebirds and waterfowl.

Objective 2.1 Within five years of the Plan, prepare a summary of migratory bird survey data pertinent to the Refuge (local, regional, Pacific Flyway).

Rationale: Migratory birds are Federal Trust Species under the jurisdiction of the Service. The Refuge provides wintering, migration, and breeding habitat for waterfowl and shorebirds. The North American Waterfowl Management Plan (USFWS et al. 1986, USFWS et al. 1998), Restoring the Estuary: Implementation Strategy of the San Francisco Bay Joint Venture (Steere and Schaefer 2001), U.S. Shorebird Conservation Plan, and Southern Pacific Shorebird Conservation Plan (Hickey et al. 2003) address population and habitat objectives for healthy waterfowl and shorebird populations. Refuge management strategies will support these objectives. The data summary will assist Refuge planning and evaluation of management actions and will identify data gaps and future research needs.

Strategies

- Summarize San Francisco Estuary winter waterfowl survey data for San Pablo Bay and develop recommendations from these data for waterfowl management actions.
- Obtain shorebird and waterfowl data from USFWS Migratory Birds Division and identify additional data needs.
- Obtain data from Estuary-wide surveys for shorebirds from PRBO Conservation Science, Audubon, and other data sources.
- Review and summarize monitoring data (i.e., physical and biological changes) for existing restoration projects (e.g., Tolay Creek) to inform wildlife management decisions.
- Populate relevant Refuge Lands Geographic Information System (RLGIS) layers.

Objective 2.2 Within the life of the Plan, identify all high shorebird and waterfowl use areas and enhance, where feasible, low quality migratory bird habitat on the Refuge.

Rationale: Migratory birds are Federal Trust Species under the jurisdiction of the Service. The Refuge was also established under the Migratory Bird Conservation Act, particularly for its large numbers of waterfowl. The Refuge provides wintering, migration, and breeding habitat for waterfowl and shorebirds. The Baylands Ecosystem Habitat Goals Project (1999) identifies the importance of restoring the North Bay tidal marshes for shorebirds and waterfowl, especially high tide roost areas. The North American Waterfowl Management Plan (USFWS et al. 1986, USFWS et al. 1998), Restoring the Estuary: Implementation Strategy of the San Francisco Bay Joint Venture (Steere and Schaefer 2001), U.S. Shorebird Conservation Plan, and Southern Pacific Shorebird Conservation Plan (Hickey et al. 2003) address population and habitat objectives for healthy waterfowl and shorebird populations. Refuge management strategies will support these objectives.

Strategies

- Identify distribution and high use areas of the Refuge.
- Identify and protect existing high tide roost environments as priority conservation areas (e.g., develop map).
- Where appropriate, implement recommendations from appropriate management plans such as the Pacific Shorebird Plan and the Baylands Ecosystem Habitat Goals Project.
- Enhance existing high tide roost environments through seeding or planting native plants.
- Limit disturbance to priority conservation areas, especially during key periods (e.g., migration, breeding).
- Control or eliminate invasive species populations in high use areas using chemical or mechanical controls.
- Conduct studies on interior tidal ponds (formation, persistence, shorebird use).
- Identify low use areas and mimic characteristics of high use areas at these sites.
- Support and participate in regional shorebird and waterfowl monitoring efforts.
- Support shorebird and waterfowl research that informs refuge management.
- Evaluate effects of wetland restoration or enhancement projects on shorebird and waterfowl habitat. Reduce or mitigate negative effects of management actions and improve habitat when possible.
- Use data summarized under Objective 2.1 to inform decision making.

Habitat Management

GOAL 3: Acquire, protect, enhance, and restore functioning tidal marsh and associated upland systems to benefit all native wildlife and plants that use environments of the Refuge.

Objective 3.1 Within five years of Plan completion, develop and begin to implement a planning tool (e.g., database, work prioritization scheme) to annually prioritize and guide restoration and enhancement projects on the Refuge.

Rationale: Several restoration projects have been ongoing or planned prior to the CCP, and many other projects are expected in the future. A project prioritization tool and associated spatial database will improve the ability of Refuge management to allocate a limited amount of resources to meet Refuge objectives, work with partners on and off the refuge, and adapt to a changing climate. A dynamic spatial project database will help prioritize our projects on the Refuge and regionally. Developing parameters for prioritizing projects, including those related to climate change, will provide a consistent and well-documented protocol for decision making. The Refuge Lands Geographic Information System was developed to assist USFWS managers and biologists in the collection, organization, and use of spatial data for their day-to-day management activities and in the development and implementation of biological programs.

Strategies

- Evaluate and prioritize USFWS national and regional restoration and conservation goals in relation to San Pablo Bay (e.g., endangered species recovery goals, San Francisco Bay Joint Venture, Tidal Goals Project, Subtidal Goals Project).
- Identify parameters that may assist with project prioritization, such as habitat quality, presence of sensitive species, climate change (refer to Objective 5.2), adjacent landowner actions, mosquito reduction, invasive species, wildlife disease, and levee and erosion risks.
- Prepare timelines that identify when projects could occur and their duration.
- Estimate and update costs of potential projects.
- Develop RLGIS layer of proposed and completed projects.
- Develop and implement annual work plan that flows from the larger long-term work plan.
- Develop monitoring criteria and protocols for measuring criteria to determine restoration success.

Objective 3.2 Restore or acquire at least 1,500 acres of tidal environments by the end of this Plan.

Rationale: Significant numbers of waterfowl, waterbirds, shorebirds, mammals, listed species, and other wildlife rely on tidal environments on the Refuge. According to the San Francisco Bay Area Wetlands Ecosystem Goals Project (1999), only 10 percent of historic wetlands remain. The Goals Project, as well as the Draft Tidal Marsh Recovery Plan, identifies wetland restoration as a critical action towards conserving wildlife and recovering listed species. The Southern Pacific Shorebird Conservation Plan (2003) and the North American Waterfowl Management Plan (1998 Update) identify the importance of maintaining, enhancing, and creating wetland habitat for shorebirds and waterfowl. Refuge

management strategies will support these objectives. Restoring or acquiring additional tidal habitat will also serve as a buffer for climate change effects. The San Francisco Bay Conservation and Development Commission identifies much of the tidal marsh of the Refuge as under threat from sea-level rise.

The Refuge and its surroundings support large expanses of undeveloped uplands where wetlands could migrate in response to sea-level rise. The Tidal Marsh Recovery Plan identifies acquisition and restoration of habitat, including tidal environments, as actions needed to recover endangered species populations that occur in San Pablo Bay.

Strategies

- Conduct restoration at Cullinan Ranch through breaching and excavation to create a mosaic of tidal marsh, sloughs, marsh channels, subtidal, and persistent deep water habitats for endangered and other estuarine-dependent species.
- Acquire in fee title or some form of authority, rights to manage Skaggs Island, Guadalcanal, Sears Point, and Sonoma Baylands.
- Identify other properties for acquisition that may support CCP goals and objectives, and expand the approved Refuge boundary to include those properties.
- Initiate NEPA and planning process for Skaggs Island to investigate restoration to additional tidal marsh-upland ecotone (including uplands, seasonal wetlands, tidal marshes, muted tidal marsh, sloughs, and channels) to accommodate movement of terrestrial wildlife species in the face of climate change effects.

Objective 3.3 Within the life of the Plan, identify, prioritize, and begin to implement tidal marsh enhancement projects (e.g., at Sonoma Creek, Tolay Creek, Lower Tubbs Island, and the Strip Marsh) that would reduce human-induced water impoundments and restore tidal hydrology.

Rationale: Several units of the Refuge have poor tidal circulation as a result of levee and berm construction, the rapid expansion of tidal marsh, and the associated lack of tidal channel development during the last century. Decades of water impoundment have led to marsh subsidence and mortality of vegetation. These conditions provide poor quality habitat for wildlife and fish, including listed and other sensitive estuarine-dependent species. Refuge monitoring shows endangered species are less abundant or absent from sites where water impoundments are present (Block 2009). Areas where natural hydrology is compromised also contribute to above average mosquito production and trigger mosquito management by county mosquito abatement districts. A full analysis of where these problem areas occur on the Refuge, and development and implementation of enhancement plans, will improve habitat for estuarine-dependent species.

Strategies

- Delineate and describe tidal impoundments or hydrological issues using satellite imagery, GIS, and modeling.
- Design and implement methods for increasing hydrological connectivity, including levee breaches, lowering levees and berms, and removing culverts.
- Develop alternatives and cost analyses for restoring tidal connectivity.
- Promote conservation or creation of Refuge islands or other high-tide refugia without constructing levees.
- Coordinate mosquito management with local mosquito abatement districts (i.e., Napa-Sonoma, Solano).
- When resources allow, analyze effects of alternative restoration and/or enhancement methods on tidal environments through modeling.

Objective 3.4 Reduce the cover of invasive perennial pepperweed by 90 percent of baseline inventories within upland and tidal areas over the life of the Plan.

Rationale: Non-native and invasive species have become the primary threat of the Refuge System and the Service's wildlife conservation mission. In particular, perennial pepperweed occurs throughout the Refuge, degrading the quality of habitat needed for wildlife. As noted in an earlier objective, the Refuge's proximity to urban environments makes it vulnerable to introduced species, highlighting the importance of vigilant monitoring of Refuge units. The National Strategy for Management of Invasive Species (April 2003) has been developed within the context of the National Invasive Species Management Plan [EO 13112], which functions as the internal guidance document for invasive species management throughout the Refuge System. Also, the 2008-2012 National Invasive Species Management Plan (a revision to the 2003 National Strategy for Management of Invasive Species) (NISC 2008) identifies five strategic goals to prevent, control and minimize invasive species and their impacts. Refuge management strategies will support these goals.

Pepperweed is currently the dominant invasive plant on the Refuge. It has the ability to displace native tidal marsh plants and, at some threshold of density and spatial extent, is assumed to reduce habitat quality and quantity of native estuarine-dependent wildlife and plant species.

Strategies

- Use RLGIS or other database to inventory and monitor pepperweed and treatments.
- Refine and adapt the Refuge pepperweed control plan as needed (e.g., control and monitoring methods).
- Fund and conduct chemical or mechanical treatments, and research new methods of control.
- Evaluate impacts of control efforts on target invasive species and non-target native species.
- Work with neighbors to reduce pepperweed on adjacent lands of San Pablo Bay.

- Participate in Marin-Sonoma Weed Management Area and other forums (e.g., CA Invasive Plant Council) to gather and share information on presence and control of pepperweed and other invasive species.
- Share inventory, monitoring and control data.

Objective 3.5 Search for and eradicate invasive *Spartina* species within all areas of the Refuge that have the potential to harbor this species throughout the life of the Plan.

Rationale: As in Objective 1.4, invasive species are a primary threat and priority for the Refuge System. Non-native *Spartina* species are considered highly invasive tidal and subtidal (mudflat) species that have spread rapidly throughout central and south San Francisco Bay. In 2007, *S. alterniflora* and *S. densiflora* were detected on the Refuge. The Invasive Spartina Project coordinates control of invasive *Spartina* species throughout the Estuary. Active participation and coordination with the ISP is critical to eventual eradication of these species.

Strategies

- Coordinate with the Invasive Spartina Project to monitor pre- and post-*Spartina* cover and treatments, incorporate RLGIS if possible.
- Working with the Invasive Spartina Project and other partners, develop a *Spartina* control plan for the Refuge that incorporates treatment methods, monitoring, and data collection and storage.
- Fund and conduct chemical or mechanical treatments, and research new methods of control.
- Evaluate impacts of control efforts on invasive and native species.

Objective 3.6 Within ten years of Plan completion implement an invasive plant early detection and rapid response program.

Rationale: The National Strategy for Management of Invasive Species (April 2003) identifies invasive and non-native species as one of the greatest threats to native plant communities. The 2008-2012 National Invasive Species Management Plan (NISC 2008) also identifies early detection and rapid response as one of the strategic goals for prevention, control, and minimization of invasive species and their impacts. Early detection and rapid response prevention are one of the most effective means of avoiding costly long-term control measures. Identifying threats at an early stage and at an ecosystem level improves effectiveness and reduces costs. As invasive species are not limited by ownership boundaries, it will be important to work with neighboring landowners and the regional invasive plant organizations to develop and communicate a unified response to invasive threats to reduce costs and effort.

Strategies

- Develop an early detection and rapid response plan for priority invasive species.
- Develop a new or adopt (adapt as needed) an existing early detection protocol (e.g., USGS, National Park Service), and conduct sampling as outlined in the EDRR Plans.

- Develop prioritization scheme for invasive plant monitoring that includes area, environment, and species foci.
- Coordinate with the Bay Area Early Detection Network.
- Participate in Marin-Sonoma Weed Management Area and other forums to share information and resources.
- Share monitoring and control data.
- Conduct or support research on high priority invasive species.
- Develop a volunteer program focused on early detection of high priority species through mapping, imagery, and other data collection techniques.

Objective 3.7 Within the life of the Plan, identify and adopt standards for the collection and maintenance of spatially referenced biological and physical data collected on the Refuge.

Rationale: Collection, storage, and documentation (metadata) of spatially referenced data will permit timely and accurate analysis of trends, analysis of relationships among resources, assist with restoration planning, and foster an adaptive approach to land management on the Refuge. The RLGIS was developed to assist USFWS managers and biologists in the collection, organization, and use of spatial data for their day-to-day management activities, as well as in the development and implementation of biological programs.

Strategies

- Review and integrate current GPS and GIS technologies.
- Develop monitoring database (non-spatial and spatial) for wildlife and plants, and use the RLGIS where appropriate.
- Integrate data sharing (metadata) standards.
- Spatially document existing Refuge resources (e.g., boundaries, ownership, public use opportunities, access, signage, restoration areas, hydrology, and structures) within the Refuge Lands Geodatabases.
- Convert existing data using developed standards to spatially-referenced data.
- Create Federal Geographic Data Committee metadata for all GIS data layers.

Objective 3.8 Within five years after the acquisition of Sears Point, evaluate and develop a habitat management plan for the grazed portions of the site.

Rationale: A century of grazing and land use on the Sears Point site has resulted in a vegetative conversion from perennial native grasses and forbs to cool season annual (non-native) grasses. Photographs indicate that the erosion currently found in the hills surrounding Sears Point were not present prior to the 1940s (J. Brosnan, Sonoma Land Trust, pers. comm.). The lack of perennials and their root structure and the compaction created by sustained continuous grazing practices has created unstable soil situations, resulting in eroded waterways and gullies.

Strategies

- Conduct soil sampling throughout the upland grazed area.

- Work with soil scientists to develop a habitat management plan that will address the stability of the soils.
- Use grazing, seeding, prescribed burn, mowing, or other methods to arrest erosion.
- Enhance historic or develop new perennial waterways through the site using native plantings of willow and other riparian vegetation, as well as mechanical means, to direct or redirect water flows.

Objective 3.9 Within five years after the acquisition of Sears Point, develop a habitat management plan to enhance or restore high quality seasonal wetlands and native perennial grassland communities.

Rationale: Sears Point and the surrounding area have a history of haying and grazing, primarily of non-native grasses. Over time, portions of this area will revert back to seasonal wetland and perennial grasslands, as these were the predominant historical habitats.

Strategies

- Conduct plant inventory of grazed and hayed sites.
- Conduct a herpetological pre- and post-inventory of grazed and hayed sites.
- Establish an expert panel of soils, grassland, and range scientists to develop a restoration plan for the grazed portion of the land.
- Establish a seasonal wetland expert panel of scientists for the hayed wetland portion of the land.
- Initiate grazing and haying strategies to implement plans if needed.
- Contract a local farmer to assist the Refuge with seeding native perennial grasses and forbs within the grazed site.
- Investigate the use of fire, mowing, or other mechanical means to prepare sites within the grazed area for seeding.

Objective 3.10 Within the life of this Plan, conduct an assessment of contaminant sources that may affect the environmental health of Refuge resources, and use results to reduce contaminant inputs or impacts where possible.

Rationale: The Refuge is bound by the Bay, agricultural lands, and urban lands. Studies of the Bay, such as the Pulse of the Estuary (SFEI 2009), indicate that contaminants, particularly mercury and PCBs, in the Bay are sources of concern because of their long-term impact on the health of the environment. The impacts of pesticides and fertilizers from agricultural lands on Refuge resources are not well understood. Contaminant assessments will allow the Service to understand the distribution and level of contaminants present in soils from past or current activities. These results will be used by Refuge management to reduce or eliminate contaminant inputs and impacts to Refuge resources where possible. This will be especially important in areas where tidal restoration is occurring and will provide information on how to remove contaminants from sites or preclude contaminants from migrating (e.g., mercury).

Strategies

- The assessment will include researching (i.e., field surveys, literature search) contaminant sources from:
    - Agricultural runoff and pumping from lands surrounding San Pablo Bay
    - Past land use
    - Pesticide transport from upstream sources (e.g., fungicides from Napa and Petaluma Rivers)
    - Bay water and sediments (e.g., mercury)
    - Past oil spills
    - Past sewage spills
    - Atmospheric deposition
    - Highway runoff (Hwy 37)
    - Mosquito control on non-target species
    - Herbicide use for non-native plant control
- Prioritize actions for removal and prevention.

GOAL 4: Protect and enhance subtidal systems for the benefit of marine and subtidal dependent species.

Objective 4.1 During the life of this Plan, develop a summary of present and historical subtidal wildlife and plant resources of the Refuge, identify subtidal conservation priorities, and work with existing agencies and groups to conduct subtidal restoration or enhancement on the Refuge.

Rationale: Subtidal areas make up a significant portion of the Refuge but are not well understood. The subtidal environment includes eelgrass beds, oyster beds, rocky intertidal, mudflats, channels, sloughs, and many other unique micro environments. Understanding the history and current state of subtidal environments and the habitats they provide will foster restoration and conservation and will assist the Refuge in prioritizing and allocating resources. Presence of sensitive anadromous and listed fish species in this area makes it an important conservation area. The development of subtidal goals for the Estuary, also known as the Subtidal Goals Project, in underway and will provide the Refuge with recommendations on conservation of subtidal environments.

Strategies

- Contract or partner with other agencies or organizations to inventory resources (e.g., fish, invertebrates) of subtidal areas.
- Consider recommendations from the San Francisco Estuary Subtidal Goals Project (in prep).
- Identify and work with USFWS offices and other agencies and groups that monitor native and non-native invasive subtidal species within the San Francisco Estuary to identify actions the Refuge should take to conserve subtidal resources (e.g., eelgrass restoration).
- Where feasible, implement actions that conserve, enhance, or restore subtidal resources.

GOAL 5: Identify, assess, and adapt to current and future climate change impacts to Refuge resources.

Objective 5.1 Within three years of the Plan, assess potential impacts of climate change to Refuge resources, develop adaptive strategies, and prioritize management to address near-term and long-term climate change impacts (e.g., erosion, flooding).

Rationale: Climate change is already affecting wildlife throughout the State (Parmesan and Galbraith 2004), and its effects will continue to increase. Wetlands are especially sensitive to climate change. Nicholls et al. (1999) estimated that 22 percent of wetland loss will be due to inundation, primarily through sea-level rise and other human factors. Historical records show that sea level in San Francisco Estuary has risen 18-20 centimeters (7 inches) during the past 150 years. The 2006 California Climate Action Team Report project that mean sea level will rise 4–33 inches by the year 2100 (CEPA 2006). Pacific Institute's 2009 report estimates a rise of 1.0-1.4 meters by 2100 (Heberger et al. 2009). Much of the Refuge is located below sea level, placing it at greater risk of inundations. This objective also helps to achieve Statewide Conservation Action I in the California Wildlife Action Plan (CDFG 2005).

Strategies

- Obtain climate change modeling results applicable to the Refuge.
- Work with Service experts and others to conduct additional climate change analyses or other appropriate modeling tools (develop minimum, mean, and maximum estimates; estimate accretion rates; estimate erosion rates; estimate and track tide ranges), and develop mitigation.
- Promote and support research that evaluates climate change related effects to endangered species populations.
- Conduct flood risk and erosion analysis of lands on and adjacent to the Refuge
- Develop and prioritize projects to reduce erosion or flooding impacts to Refuge resources.
- Incorporate research on current and expected sediment dynamics in San Pablo Bay (availability, sources, and movement).
- Identify areas that contain high quality habitats or features that will require a high level of protection relative to other refuge resources.
- Evaluate existing and future public access amenities (e.g., siting, maintenance) relative to expected climate change impacts.

Objective 5.2 Within the life of the Plan prioritize wetland restoration, enhancement projects, and acquisition based on climate change data (Objective 5.1).

Rationale: Several tidal restoration projects are occurring or slated to occur in the near future. Climate change data obtained in Objective 5.1 may help us identify critical restorations that warrant higher priority. Such prioritization may also preclude unnecessary costs and effort for certain planned restoration or

enhancement projects in the event that climate change data makes such actions obsolete.

Strategies

- Develop and implement a plan that identifies lands that will be important to acquire in order to allow for tidal marsh migration as sea level rises and inundates existing wetlands on the Refuge.
- Assess ongoing and planned wetland restoration and enhancement projects in light of current data findings.
- Work with adjacent landowners and experts in the San Pablo Bay region to plan and prioritize wetland and upland enhancements, conservation projects, and acquisitions with respect to predicted environmental changes.

Objective 5.3 Develop and implement a climate change inventory and monitoring plan. (refer to Objective 1.1)

Rationale: Collecting data on physical and biological data will help determine how such natural resources on the Refuge are shifting in light of climate change.

Strategies

- Identify and conduct long-term (e.g., 100 year) monitoring of physical (e.g., sediment) and biological resources that will be evaluated relative to climate data (e.g., temperature, salinity, sea-level rise, tide ranges, demographic, and phenological changes in plant and wildlife populations).

Objective 5.4 Within five years of the Plan, develop and implement mitigation measures to reduce the carbon footprint of the Refuge.

Rationale: This objective meets with the Service's Climate Change policy, which recommends reducing Refuge staff carbon footprint to offset climate change impacts. The Refuge could also serve as a leader in the community to encourage neighbors to reduce their own carbon footprints.

Strategies

- Evaluate carbon footprint of Refuge activities, and improve efficiency where feasible (e.g., transportation, energy efficiency, recycling).
- Increase carbon sequestration through tidal restoration projects and grassland restoration on newly acquired properties such as Sears Point; use solar and wind energy to power Refuge operations at Sears Point, replacing carbon producing energy sources.
- Seek additional partnerships and funding sources to promote the use of solar and wind energy outside the Refuge and to fund projects within Refuge.
- Educate and empower visitors to the Refuge about green activities that can reduce their carbon footprint such as vegetation plantings, green technologies, and new construction or renovations of existing structures.
- Convert vehicles and equipment to bio-fuels and hybrid engines.

GOAL 6: Develop a supportive relationship with the surrounding community to foster understanding and stewardship of the Refuge and the National Wildlife Refuge System mission.

Objective 6.1 Within the life of the Plan establish a permanent headquarter site for the Refuge that is accessible to the public.

Rationale: The Refuge was established in 1974 and was managed until 1994 from the Don Edwards Refuge in Fremont. Since 1974, the Refuge staffing has since grown to a permanent staff of four. This staff also manages the Marin Islands and Antioch Dunes National Wildlife Refuges, as well as San Pablo Bay. The Refuge headquarters has been located in four separate locations since 1994. Frequent moves have taken focus away from Refuge missions, redirected valuable resources, and caused the Refuge to lose potential partners and essential relationships. Maintenance efforts can be better facilitated with permanent and adequate infrastructure.

Strategies

- Continue to pursue acquisition of the Sears Point property and other remaining lands within the approved acquisition boundary.
- Sign the boundaries of the Refuge headquarters site, and install Refuge entry signs at entrance.
- Conduct a media event welcoming the public to the Refuge.
- Update the existing site plan to include new construction (e.g., a new entry drive and parking areas) and renovation of existing structures (e.g., maintenance shop, greenhouse storage, and barn renovations).
- Provide adequate facilities for maintenance and management of all refuges administered from this location.

Objective 6.2 Preserve the cultural aesthetic of the Sears Point Refuge headquarter site, thereby maintaining non-invasive plants until restoration plans are complete.

Rationale: Connecting people to nature often requires a connection to cultural relationships to the land. In the event that the current Refuge site is acquired permanently, the ranch aesthetic, which is historic and still prevalent in the area, should be maintained to interpret the agrarian past shared within the North Bay region.

The National Strategy for Management of Invasive Species (April 2003), which was developed for the Refuge System, recommends that farm lands first acquired by the Service should not be left fallow, as these lands are particularly predisposed to invasion. The National Strategy prescribes maintaining non-native, non-invasive cover crop until restoration can be conducted. Grazing and haying controls non-native and invasive vegetation and can aid in promotion of native habitats by mimicking native ungulate behaviors and indigenous human actions.

Strategies

- Conduct a cultural assessment of the Sears Point headquarters property to identify desired cultural characteristics for the headquarter site.
- Renovate and preserve, if possible, existing structures on the site (barns and corral systems).
- Maintain and repair existing structures in the style of the haying and ranching region of the area.
- When maintaining or repairing existing barn structures, reuse materials from site whenever possible.
- Use grazing and haying to continue the historical practices of the region, as well as to manage adjacent grasslands and seasonal wetland.
- Develop interpretive materials describing the use of grazing, haying, and other farm activities that can be used to restore or enhance wildlife habitats.
- Develop interpretive materials describing the historic connection to the natural landscape through past farming practices at Sears Point.

Objective 6.3 Construct new facilities that mimic the farming and ranching culture of the region but also promote and encourage sustainability or energy efficiency.

Rationale: The Refuge is located in a prominent location in the North Bay and has a unique opportunity to demonstrate the ability to convert farm sites to energy efficient structures using renewable energy resources (solar and wind power) while still maintaining the rural aesthetic.

Strategies

- Expand nursery and construct maintenance shop with same ranch outbuilding and barn style.
- Expand office in the same farmhouse style.
- Incorporate energy efficiency or green technologies into new construction or renovations of existing structures.
- Demonstrate sustainable and energy efficient practices through outreach to the public.

Compatible Wildlife-Oriented Recreation

GOAL 7: Provide visitors and the local community with compatible wildlife-oriented outdoor recreation opportunities to enjoy, understand, and appreciate the resources of the Refuge.

Objective 7.1 Within five years of Plan completion, develop a visitor services plan that will expand compatible public use opportunities, including wildlife observation and photography.

Rationale: Wildlife observation and photography are identified in the 1997 Improvement Act as two of six priority public use on refuges. These uses are provided when deemed compatible with wildlife and habitat. Public access opportunities will be expanded from the current single access point to several, once restoration activities are complete. The Refuge units are located on a busy

highway and acceleration and deceleration lanes will need to be constructed to provide safe access. Because the staff and office facilities are small, the public will be encouraged to participate in self-guided opportunities, such as trails (for hiking and bicycling) and kayak (non-motorized) access points. The Refuge is also located near other public access opportunities (e.g. the San Francisco Bay Trail, Bay Water Trail, and CDFG lands) that will require coordination with these and other partners to create a consistent network of recreational options. Trails will also support the San Francisco Bay Trail and Bay Water Trail Plan goals of providing access around the entire bay.

Strategies

- Develop primitive access for recreational boaters (non-motorized, kayak, canoe) at Cullinan Ranch.
- Educate boaters on preventing the introduction of nuisance species.
- Develop a safe access point to Cullinan Ranch by constructing deceleration and acceleration lanes and a parking lot.
- Provide interpretive panels, informational signage and kiosks, photography points, and boardwalks at Cullinan.
- Develop self-guided trails (for hiking, bicycling, boating) at Cullinan Ranch, Guadalcanal, Sears Point, Skaggs Island, and Sonoma Baylands once these units are acquired.
- Coordinate trail planning with regional plans such as the San Francisco Bay Trail and Bay Water Trail that implements bay-wide vision of public access around the Bay.
- Develop new entry road access to Sears Point (once acquired).
- Provide additional public access at Figueras. Establish an agreement with the City of Vallejo and/or Mare Island to allow access to the Figueras unit through their property.
- Provide bike access at Sonoma Baylands, Sears Point, Cullinan, Skaggs Island, Tolay Creek, and Lower Tubbs Island units to provide SF Bay Trail linkage.

Objective 7.2 Within five years of Plan completion, expand outreach for the fishing and hunting programs.

Rationale: Hunting and fishing are identified in the 1997 Improvement Act as two of six priority public use on refuges. These two activities are existing uses, occurring prior to the Refuge's establishment, and they are not likely to conflict with the other purposes of the Refuge. Fishing is an existing use of the Refuge and will continue to occur in navigable sloughs and the open bay, while hunting (waterfowl and pheasant) will continue on the open bay and primarily Tolay Creek. To improve contact with hunters and recreational anglers, staff will improve outreach through materials and workshops to understand needs, provide education, and improve services for these user groups.

Strategies

- Create and distribute a public fact sheet on fishing.

- Expand fishing areas to others units of the Refuge, designating specific access points such as Cullinan and including pier fishing at Guadalcanal once this unit is acquired.
- Assess opportunities to conduct a fishing day at Cullinan and at Guadalcanal once this unit is acquired.
- Construct boardwalk at Cullinan for pier-fishing access.
- Develop hunt program and revise existing 1986 hunt plan specifically for Refuge in cooperation with CDFG.
- Organize a hunter clean-up day, and provide an orientation day with Refuge law enforcement to provide hunting regulations and service opportunities.

Objective 7.3 Within five years of Plan completion, expand self-directed individual and family opportunities for people to connect with nature.

Rationale: As part of the Service directive of "Connecting People with Nature," this objective encourages the public to create their own experiences with nature at their own pace through the aid of interpretive materials. This activity also fits with the wildlife observation and photography public uses identified in the 1997 Improvement Act.

Strategies

- Develop and provide maps, brochures, and other materials showing visitor facilities and kiosks. Distribute these materials at key locations to help orient visitors to the Refuge.
- Develop interpretive materials to facilitate appreciation of the Refuge, its resources, and the role it plays in the Pacific Flyway and the San Francisco Estuary.
- Promote and support the Refuge Friends group by encouraging them to conduct Refuge outreach projects and activities.
- Develop computer-based interpretive materials that can be downloaded to electronic devices prior to visiting the Refuge, thus replacing the need for brochures in some areas.
- Create and distribute a public fact sheet on preventing introduction of nuisance species and the "leave no trace" concept.

Environmental Education and Outreach

GOAL 8: To provide a quality environmental education and interpretation program that enriches the local community with the history and purpose of the natural habitats of North San Pablo Bay and the mission of the National Wildlife Refuge System.

Objective 8.1 Within ten years of Plan completion, expand partnering opportunities and volunteerism to offer an environmental education program with local elementary schools in the surrounding cities of Novato, Petaluma, Sonoma, Napa and Vallejo three times per week.

Rationale: Environmental education is identified in the 1997 Improvement Act as a priority public use that can be allowed when compatible with other Refuge purposes. To support this priority public use, staff will work with local elementary schools to bring children to the Refuge. Because the Refuge is surrounded by an urban environment, local schools have few opportunities to access nature settings. Conducting an environmental education curriculum on site is intended to allow children to promote self-discovery and experience the natural environment of the San Francisco Bay tidal marshes. The Refuge will partner with others to conduct in-class programs to prepare students for their field-based experience at the Refuge. The program curriculum will be aligned to current Federal, State, and local standards. The environmental education program will be managed in accordance with Service Manual 605 FW 6 Environmental Education.

Strategies

- Offer an environmental education field trip program three times per week for elementary schools to the Baylands or Guadalcanal units (when acquired), focusing on migratory birds, wetlands, and habitat restoration.
- Construct outdoor education facilities, tables, restrooms, and parking at the Sonoma Baylands and Sears Point sites (when acquired).
- Develop a Refuge headquarters greenhouse program to physically link to the Sonoma Baylands unit (when acquired) field program. Create trails and related aspects to facilitate program.
- Work with non-profit partners to implement in-class programs to support experiences on the Refuge.
- Create an outreach program to recruit, educate, and provide continuing training for teachers.

Objective 8.2 Within five years of the Plan, build a volunteer program to initiate Refuge-to-Backyard connections that reach communities within a 20-mile radius of the Refuge.

Rationale: Due to staff size, the Refuge relies heavily on volunteer staff to conduct biological and maintenance needs. The National Wildlife Refuge System Volunteer and Partnership Enhancement Act of 1998 (P.L. 105-242) identifies the importance of volunteers and strengthens the Refuge System's role in developing relationships with volunteers. Volunteers possess knowledge, skills, and abilities that can enhance the scope of Refuge operations. Volunteers may have a local understanding of community needs and how the Refuge may conduct outreach to the community.

Strategies

- Develop and implement a Refuge-to-Backyard program to educate families about using native plants in their backyards.
- Offer the Garden Education Program for families, with emphasis on native plants and service opportunities, events, or workshops at least twice each year (e.g., Coastal Clean-up, Earth Day, Open House, Refuge Week, Garden Festivals, Backyard Habitat).

- Expand volunteer opportunities for monitoring Refuge resources and threats with the assistance of a volunteer coordinator stationed at the Refuge.

Objective 8.3 Seek new local outreach opportunities beyond the current two off-site events per year.

Rationale: The Refuge is located on a busy two-lane highway and is easily passed over. Furthermore, with access points difficult to reach, outreach is critical to connecting people with nature. In 2007, the Service declared that "connecting people with nature" is among the agency's highest national priorities (USFWS 2008). A connection with nature, whether it's hiking, fishing, camping, hunting, or simply playing outside, helps children develop positive attitudes and behaviors towards the environment. Positive interactions with the environment can lead to a lifelong interest in enjoying and preserving nature. People's interest in nature is crucial to the Service mission of conserving, protecting, and enhancing populations of fish, wildlife, plants, and their habitats.

Strategies

- Develop and update handouts and other materials to reflect current activities and information about the Refuge on an annual basis.
- Inform visitors through outreach materials about protection of sensitive wildlife habitat through waste control and use of designated access points only.
- Develop and update website and downloadable information.
- Participate in at least one new local outreach opportunity.
- Work with the news media to highlight activities and programs at the Refuge.
- Develop outreach materials (paper and electronic) to promote green energy initiatives developed or demonstrated on the Refuge, highlighting those that can be implemented in households.

Objective 8.4 Throughout the life of the Plan, continue to provide and expand opportunities for interpretation of the North Bay habitat, wildlife, and cultural history.

Rationale: Interpretation is identified in the 1997 Improvement Act as a priority public use that can be allowed when compatible with other Refuge purposes. By providing interpretation opportunities, the Refuge will instill stewardship and support for conservation of natural resources. Activities will be provided for all age groups and for families, emphasizing field-based experiences and programs that educate the public about the human history of the area. This objective also helps achieve the Service's 2007 priority of "connecting people with nature" (USFWS 2008), where positive experiences with the environment can lead to lifelong enjoyment and stewardship of natural resources.

Strategies

- Replace guided walks to Tolay Creek with walks at Sonoma Baylands and Skaggs Island (once acquired).

- Conduct docent and/or staff-led kayak tours of units of the Refuge twice a year.
- Expand Docent Guide Program to train and enrich volunteers once a year.
- Develop docent-led tour program at Guadalcanal, Sears Point, Sonoma Baylands, Skaggs Island, and Lower Tubbs units.
- Work with Native American tribes affiliated with the Refuge lands to develop interpretive materials about their history on these lands.
- Research, through partners such as Sonoma Ecology Center, and develop interpretive materials that depict the Native American presence on the Refuge prior to Spanish presence.
- Provide presentations to the public that describe the influence of Native Americans, Spanish, and European settlers on the landscape.

Chapter 6. Plan Implementation

Implementation

Once the CCP has been approved and the Service has notified the public of its decision, the implementation phase of the CCP process will begin. During the next 15 years, the objectives and strategies presented in this CCP will be implemented; the CCP will serve as the primary reference document for all Refuge planning, operations, and management until it is formally revised at the end of the 15-year period. The Service will implement the final CCP with assistance from existing and new partner agencies and organizations and from the public.

CCPs provide long-term guidance for management decisions and set forth goals, objectives, and strategies needed to accomplish refuge purposes and identify the Service's best estimate of future needs. These plans detail program planning levels that may exceed current budget allocations and, as such, are primarily for Service strategic planning and program prioritization purposes. Plans do not guarantee a commitment of resources.

Activities required to accomplish the management strategies discussed in this CCP are referred to as projects. Every effort will be made to implement these projects by the deadlines established here. However, the timing of implementation of the management activities proposed in this document is contingent upon a variety of factors, which are listed in further detail in the following text.

- Funding and Personnel
- Step-Down Management Plans
- Appropriate Uses and Compatibility Determinations
- Compliance Requirement
- Monitoring and Evaluation
- Partnerships and Opportunities
- Adaptive Management
- Plan Amendment and Revision

Funding and Personnel

To implement the proposed action and achieve the objectives and goals of this CCP, the Service will need additional funding. Needs are recorded in the Maintenance Management System (MMS) and Refuge Operating Needs System (RONS) for the Refuge System. Maintenance projects include repair and replacement of existing buildings and facilities and removal of unneeded infrastructure. RONS projects are proposed new Refuge projects that do not represent replacement of existing equipment or facilities. RONS projects for this Refuge include the addition of habitat restoration projects, wildlife monitoring, and visitor services programs. Additional projects proposed in this CCP will be added to the RONS list during the life of this CCP. The estimated startup cost to implement management and projects in the CCP is $10,451,000 (based on 2010 dollars). Staff costs (both existing and additional staff needed to implement the CCP) total $397,000 annually. However, costs must be incrementally increased for inflation and increased activities such as new research studies and non-native control methods.

The Refuge is managed as a satellite refuge within the San Francisco Bay NWR Complex. While the Refuge manager, biologist, maintenance worker, wildlife refuge specialist, and part-time administrative assistant are based in an office in Petaluma, this staff receives law enforcement and administrative support from the complex headquarters in Fremont. Current staffing costs for the San Pablo Bay Refuge are estimated at $169,500 for these positions, which are shared with Marin Islands and Antioch Dunes NWRs (estimate does not include staffing costs for these other refuges). Salaries constitute a significant cost of implementing the CCP. Funding for seven additional permanent staff (positions shared with Marin Islands and Antioch Dunes NWRs) is needed to implement the objectives and strategies of the CCP. No positions at Marin Islands NWR have been filled. An additional $228,000 (based on 2010 salary costs) per year is needed to fund the seven additional staff positions; this figure does not include staffing costs for managing Marin Islands and Antioch Dunes NWRs, nor does it include salary increases over time. Table 22 describes the staffing needs for the Refuge for each project proposed by this CCP; Table 23 describes the budget proposal needed to implement the CCP. The needs and costs shown in Table 22 and Table 23 are best estimates and may not entirely reflect the costs of managing the Refuge. Table 24 provides a sample of maintenance needs and costs for the Refuge.

Table 22. Staffing Plan and Needs

Current Staffing Level	***Unit Costs (includes benefits)***	***Quantity***	***Costs***
Refuge Manager GS-0485-12	$115,000	0.33 (position shared with Marin Island and Antioch Dunes NWRs)	$38,000
Wildlife Biologist GS-0486-11	$98,000	0.5 (position shared with Marin Islands NWR)	$49,000
Maintenance Worker WG-4749	$80,000	0.5 (position shared with Marin Islands NWR)	$40,000
Wildlife Refuge Specialist GS-0485 9/11	$98,000	0.33 (position shared with Marin Islands and Antioch Dunes NWRs)	$33,000
Office Clerk	$43,000	0.2 (position shared with Marin Islands and Antioch Dunes NWRs)	$9,000
Total Existing Staff Cost:			***$169,000***
Staffing Additions	***Unit Costs (includes benefits)***	***Quantity***	***Costs***
Law Enforcement Officer GS-0025-7/9	$75,000	0.33 (position shared with Marin Island and Antioch Dunes NWRs)	$25,000
Outdoor Recreation Planner GS-0023-7/9	$68,000	0.33 (position shared with Marin Island and Antioch Dunes NWRs)	$23,000
Administrative Officer GS-0-5/7	$55,000	0.33 (position shared with Marin Island and Antioch Dunes NWRs)	$18,500
Biological Technician GS-0404-5/7 (assist Wildlife Biologist tidal wetlands)	$55,000	1.0	$55,000
Biological Technician GS-0404-5/7 (assist Range Con/biologist)	$55,000	0.5 (position shared with Antioch Dunes NWRs)	$27,500
Maintenance Worker WG-4749-8	$75,000	0.5 (position shared with Antioch Dunes NWR)	$37,500
Biologist/Range Conservationist GS-0486 -9/11	$83,000	0.5 (position shares Antioch Dunes NWR duties)	$41,500
Total Additional Staff Cost			***$228,000***
TOTAL STAFF COST:			**$397,000**

Table 23. Budget Proposal for San Pablo Bay NWR Comprehensive Conservation Plan

Project Description	***Operational Cost for Startup***	***Average Annual Cost***
Manage and maintain newly acquired Refuge units	$180,000	$80,000
Pepperweed and Spartina control	$150,000	$50,000
Early detection and rapid response plan	$40,000	
Inventory and monitor subtidal wildlife; RLGIS database management	$115,000	$50,000
Predator Management Plan	$25,000	
Strip Marsh tidal restoration	$250,000	
Sonoma Creek tidal enhancement	$250,000	
Improve tidal connectivity with sea-level rise model	$250,000	
Hydrological delineation/modeling of refuge units (i.e., Strip Marsh)	$100,000	
Skaggs Island restoration plan	$100,000	
Conduct contaminants assessment	$90,000	
Climate change modeling, flood risk analyses	$45,000	
Climate change inventory and monitoring plan	$50,000	
Convert vehicles and mechanical equipment to fuel efficient technology		$20,000

Renovate and construct additional headquarters office	$500,000	
Renovate barn	$1,000,000	
Repair/replace corrals, driveway, parking lots, signage	$100,000	
Skaggs Island/Cullinan Ranch management	$78,000	$78,000
Wastewater wetland addition	$300,000	
Cultural resource assessment of Sears Point	$25,000	
Solar and wind energy conversion	$250,000	
Fishing pier at Guadalcanal	$100,000	
Deceleration/acceleration lanes at Cullinan Ranch	$4,500,000	
Shade and interpretive entry site	$100,000	
New entry road and parking area at Sears Point	$1,500,000	
Trails and infrastructure at Guadalcanal, Sears Point, Skaggs Island, Sonoma Baylands	$350,000	
Develop outreach materials	$3,000	$1,500
TOTAL	**$10,451,000**	**$279,500**

Table 24. Sample of Maintenance Costs Associated with San Pablo NWR

Project Description	*Priority*	*Operational Cost for Startup*	*Average Annual Cost*	*RONS/Deferred Maintenance*
Construct maintenance shop	Med	$271,000	$5,000	MMS #02122620
Construct public restroom	Low	$52,000		MMS #02122627
Renovate barn structures for storage needs (retrofit for earthquake)		$250,000 (excluding engineering estimate)		
Daily operation and maintenance of headquarter facilities, including transportation fees		$75,000	$75,000	

Step-Down Management Plan

Some objectives in the Plan require more detailed planning than the CCP process is designed to provide. For these projects, the Service will refer to step-down management plans and other plans to provide additional details necessary to implement objectives and strategies in the CCP. Some of these plans include NEPA documentation. A number of step-down plans will be developed or updated, including:

- Fire Management Plan (last updated 2004)
- Draft Integrated Pest Management Plan
- Integrative Pest Management Plan for Mosquitoes
- Habitat Management Plan
- Marsh-Upland Ecotone Plan
- Early Detection and Rapid Response Plan
- Predator Management Plan
- Climate Change Inventory and Monitoring Plan
- Visitor Services Plan
- Fishing Plan
- Hunting Plan (last updated 1985)

Appropriate Uses and Compatibility Determinations

Federal law and policy provide the direction and planning framework to protect the Refuge System from inappropriate, incompatible, or harmful human activities and to ensure that Americans can enjoy Refuge System lands and waters. The 1997 Improvement Act is the key legislation on managing appropriate public uses and compatibility.

Before activities or uses are allowed on a refuge, uses must be found to be appropriate and then compatible through a written appropriate use and compatibility determination. An *appropriate use* is defined as a proposed or existing use on a refuge that meets at least one of the following four conditions: 1) use is a wildlife-dependent recreational use; 2) use contributes to fulfilling the refuge purposes, Refuge System mission, or goals or objectives of the Refuge; 3) use involves the take of fish and/or wildlife under State regulations; or 4) use has been found appropriate in prior determinations (603 FW 1 of the Service Manual). A *compatible use* is defined as a proposed or existing wildlife-dependent recreational use or any other use of a refuge that, based on sound professional judgment, will not materially interfere with or detract from the fulfillment of the Refuge System mission or the purposes of the refuge. *Sound professional judgment* is defined as a decision that is consistent with the principles of the Service's management and administration, available science and resources, and adherence to the requirements of the 1997 Improvement Act and other applicable laws. Wildlife-dependent recreational uses may be authorized on a refuge when they are compatible and not inconsistent with public safety.

Appropriate use determinations are included in Appendix D for research and monitoring, haying, livestock grazing, boating, bicycling, and mosquito management.

Compatibility determinations are included in Appendix E for research and monitoring, haying, livestock grazing, wildlife observation and photography, environmental education and interpretation, hunting, fishing, recreational boating, and bicycling.

Compliance Requirements

This CCP was developed to comply with all Federal laws, executive orders, and legislative acts. Some activities (particularly those that involve a major revision to an existing step-down management plan or preparing a new plan) would need to comply with additional laws and/or regulations besides NEPA and the Improvement Act.

Seedlings at the native plant greenhouse
USFWS

The Refuge System has established laws that guide the identification and evaluation of accidentally discovered archaeological resources. Any discovered resources will be handled in accordance with regulations that include the Native American Graves Protection and Repatriation Act, National Historic Preservation Act (NHPA), Antiquities Act of 1906, Archaeological Resource Protection Act of 1979, and Historic Sites Act of 1935.

Monitoring and Evaluation

The CCP is designed to be effective for a 15-year period. The Plan will be reviewed and revised as required to ensure that established goals and objectives are still applicable and that the CCP is implemented as scheduled. The monitoring program will focus on issues involving habitat management programs, wildlife and plant inventory, other monitoring and management activities, visitor service activities, and environmental education programs. Monitoring and evaluation will use the adaptive management process. This process includes setting goals and objectives, applying management tools and strategies, and subsequently conducting monitoring and analysis to measure achievement of objectives and refine management techniques.

Collection of baseline data on wildlife populations will continue. This data will be used to update existing species lists, wildlife habitat requirements, and seasonal use patterns. Migratory and resident birds, raptors, and species of management concern will be the focus of monitoring efforts.

Where information gaps exist, a concerted effort will be made to obtain information. With new information, goals and objectives may need modification. Public involvement will be encouraged during the evaluation process.

Monitoring of public use programs will involve the continued collection of visitor use statistics. Monitoring will be done to evaluate the effects of visitor service on Refuge habitat, wildlife populations, and visitor experience.

Partnership Opportunities

Volunteer efforts are critical to the achievement of Refuge objectives and strategies. The Refuge has partnered with governmental agencies, non-governmental organizations, and individuals to conduct wildlife monitoring, habitat restoration, and facility maintenance activities. These partners play an important role in helping the Service achieve its mission and the Refuge's goals. The Service will continue to rely on these and other partners in the future to help implement this CCP and to provide input for future CCP updates. In addition, the Service will continue to explore other potential avenues for partnerships and assistance in the monitoring and restoration of the Refuge.

Adaptive Management

Adaptive management is the process of implementing policy decisions as scientifically driven experiments that test predictions and assumptions about management plans, and using the resulting information to improve the plans. Adaptive management provides the framework within which biological measures and public use can be evaluated by comparing the results of management to results expected from objectives. Management direction is periodically evaluated

within a system that applies several options, monitors the objectives, and adapts original strategies to reach desired objectives. Habitat, wildlife, and visitor service management techniques and specific objectives would be regularly evaluated as results of a monitoring program and other new technology and information become available. These periodic evaluations would be used over time to adapt management objectives and strategies to better achieve management goals. Such a system embraces uncertainty and provides new information for future decision making while allowing resource use. The management scenario proposed in this CCP provides for ongoing adaptive management of the Refuge. The CCP may be amended as necessary at any time in keeping with the adaptive management strategy. However, any major changes to the CCP may require additional NEPA documentation and public involvement processes.

Plan Amendment and Revision

The CCP is intended to evolve as the Refuge changes, and the 1997 Improvement Act specifically requires that CCPs be formally revised and updated at least every 15 years. The formal revision process would follow the same steps as the CCP creation process. In the meantime, the Service would be reviewing and updating this CCP periodically based on the results of the adaptive management program. While preparing annual work plans and updating the Refuge database, the Refuge staff will also review the CCP. It may also be reviewed during routine inspections or programmatic evaluations. Results of any or all of these reviews may indicate a need to modify the Plan. The goals described in this CCP would not change until they are reevaluated as part of the formal CCP revision process. However, the objectives and strategies may be revised to better address changing circumstances or to take advantage of increased knowledge of the resources on the Refuge. It is the intent of the Service to have this CCP apply to any new lands that may be acquired. If changes are needed, the Refuge manager will determine the appropriate public involvement and associated NEPA documentation.

The intent of the CCP is for progress and/or achievement of Refuge objectives during the lifetime of this Plan. Management activities would be phased in over time, and implementation is contingent upon and subject to results of monitoring and evaluation, funding through Congressional appropriations and other sources, and staffing.