CONTROL of SMOOTH CORDGRASS *(SPARTINA ALTERNIFLORA)* on WILLAPA NATIONAL WILDLIFE REFUGE

ENVIRONMENTAL ASSESSMENT

WILLAPA BAY

PACIFIC COUNTY

WASHINGTON

PREPARED BY

DEPARTMENT OF THE INTERIOR

U.S. FISH AND WILDLIFE SERVICE

WILLAPA NATIONAL WILDLIFE REFUGE
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In April 1996, the Service prepared the **Interim Environmental Assessment for Control of Smooth Cordgrass (*Spartina alterniflora*) on Willapa National Wildlife Refuge in 1996.** This document is a more comprehensive EA that addresses *Spartina* control beyond 1996.

1.0 INTRODUCTION: PURPOSE AND NEED FOR ACTION

1.1 PROPOSAL

The Fish and Wildlife Service, Department of the Interior, proposes to implement a long-term integrated pest management (IPM) program to control and reverse the invasion of the non-native grass, *Spartina alterniflora* (*Spartina*) on Willapa National Wildlife Refuge and the surrounding tidelands of Willapa Bay. Off-refuge control would be conducted under cooperative agreements. Lands considered for treatment in this document include those within the Willapa Bay Watershed on which any *Spartina* species is impacting migratory bird habitat (Figure 1). This currently is confined to tidally influenced wetlands on Willapa Bay, but could potentially extend up tributaries of the bay. A sudden increase in the spread of *Spartina* over Willapa Bay in recent years has made it necessary to develop long-term plans to restore and maintain valuable and limited tideland habitat that is being converted by this non-native grass.

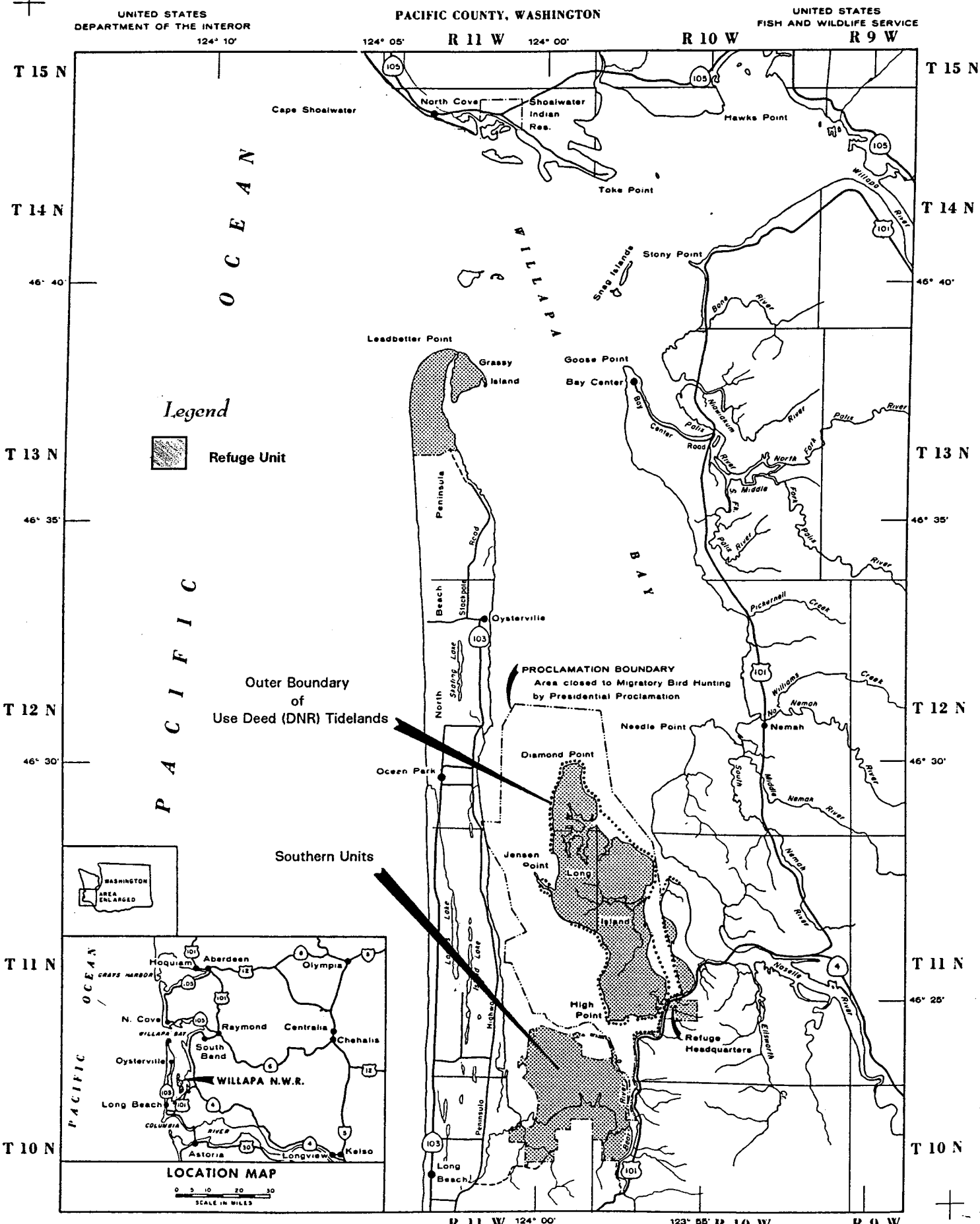
The integrated pest management program proposed for *Spartina* management by the Refuge includes the use of all methods approved by State and Federal regulations. These methods currently are limited to physical and chemical means and/or combinations thereof, but may expand to new methods such as biological control in the future. Methods would be chosen and applied on a site-specific basis. The intent would be to conduct control operations in the safest and most efficient, effective, and environmentally sound manner.

Specific elements of the proposed IPM approach that are currently approved by State and Federal regulation are:

- Hand pulling of individual plants (seedlings) with upland disposal,
- Pushing seedlings deep into the mud,
- Repeated mowing of small to large clones using hand-held brushcutters or larger, self-propelled mowers,
- Hand spraying and wiping with Rodeo® (glyphosate) herbicide and an approved surfactant,
- Aerial application of Rodeo® (glyphosate) herbicide and an approved surfactant, and
- Mowing followed by herbicide application.

Generally, the refuge mudflats are very soft and easily damaged by foot, tracked, and wheeled traffic. Therefore, access for ground operations would rely on airboats, hovercraft, boats, and/or walking with special floatation footwear where necessary. Self-propelled tracked or wheeled equipment may be used on the refuge to treat *Spartina* meadows because the dense root mass can support higher ground pressure equipment. However, such equipment is commonly used on firmer substrates for *Spartina* control and shellfish management activities on other tidelands of the bay and

Figure 1 - PROJECT AREA LOCATION MAP
WILLAPA NATIONAL WILDLIFE REFUGE



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FROM SURVEYS BY B.L.M., U.S.G.S., F.W.S.

PORTLAND, OREGON MARCH, 1976

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may be used in cooperative control efforts.

Integrated pest management is an adaptive process. An important component of the program would be to develop more effective treatment methods while maintaining or improving safety, and reducing costs and time for control. As new control techniques are developed in the future, they would be evaluated for impacts to non-target organisms and efficacy, and then if determined to be safe, incorporated into the IPM program. Such techniques that may become part of the IPM program in the future under this alternative include:

- Use of biological control techniques such as introduction of insects, other invertebrates, or pathogens that affect *Spartina* survival, growth, or reproduction,
- Mowing with waterborne equipment, and
- Use of other herbicides and/or surfactants once approved by the Environmental Protection Agency and Department of Ecology for use in the estuary.
- Use of machinery that removes *Spartina*, including its roots from the substrate.

Generally, *Spartina* control efforts would be prioritized, by tideland ownership, as follows:

1. Independent and cooperative control on fee title Federal lands associated with the Lewis, Porters Point, Riekkola, and Long Island Units (Figures 1 and 2).
2. Cooperative control on State-owned tidelands around Long Island, commonly known as use deed lands, on which the Service has certain management responsibilities (Figure 3).
3. Cooperative control on private and State-owned tidelands immediately adjacent to lands described above.
4. Cooperative control on other tidelands in Willapa Bay.

The strategy for controlling *Spartina* on a particular treatment area would begin by targeting plants furthest out in the tidelands and clones that are expected to be major seed producers. Then, effort would proceed landward toward larger, more-established clones and meadows. The initial objective would be to halt the rapid spread of *Spartina* into new areas. The ultimate goal would be to eradicate *Spartina* from each treatment area.

1.2 PURPOSE AND NEED

Spartina is a perennial, deep-rooted saltmarsh species native to the Atlantic and Gulf coasts of North America. It was introduced to the West Coast during the 1890s as a result of its use as packing material for oyster shipments from the East Coast (Frenkel and Kunze 1984). On the West Coast, *Spartina* ranges from British Columbia to northern California, but the infestation is increasing most rapidly in Washington,

Figure 2
REFUGE TIDELANDS of the SOUTHERN UNITS
(Fee Title Federal Lands of Willapa National Wildlife Refuge)
Pacific County, Washington

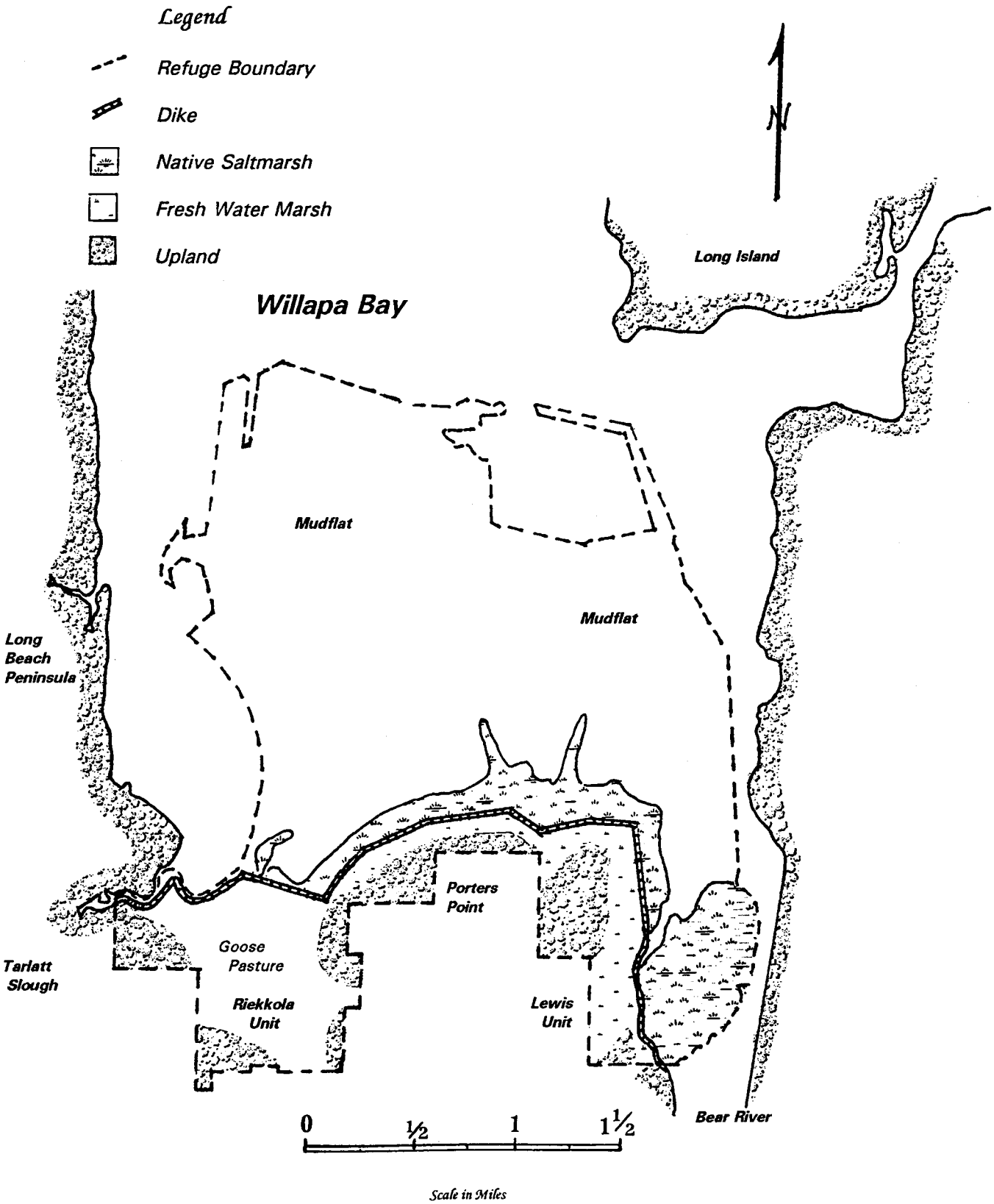
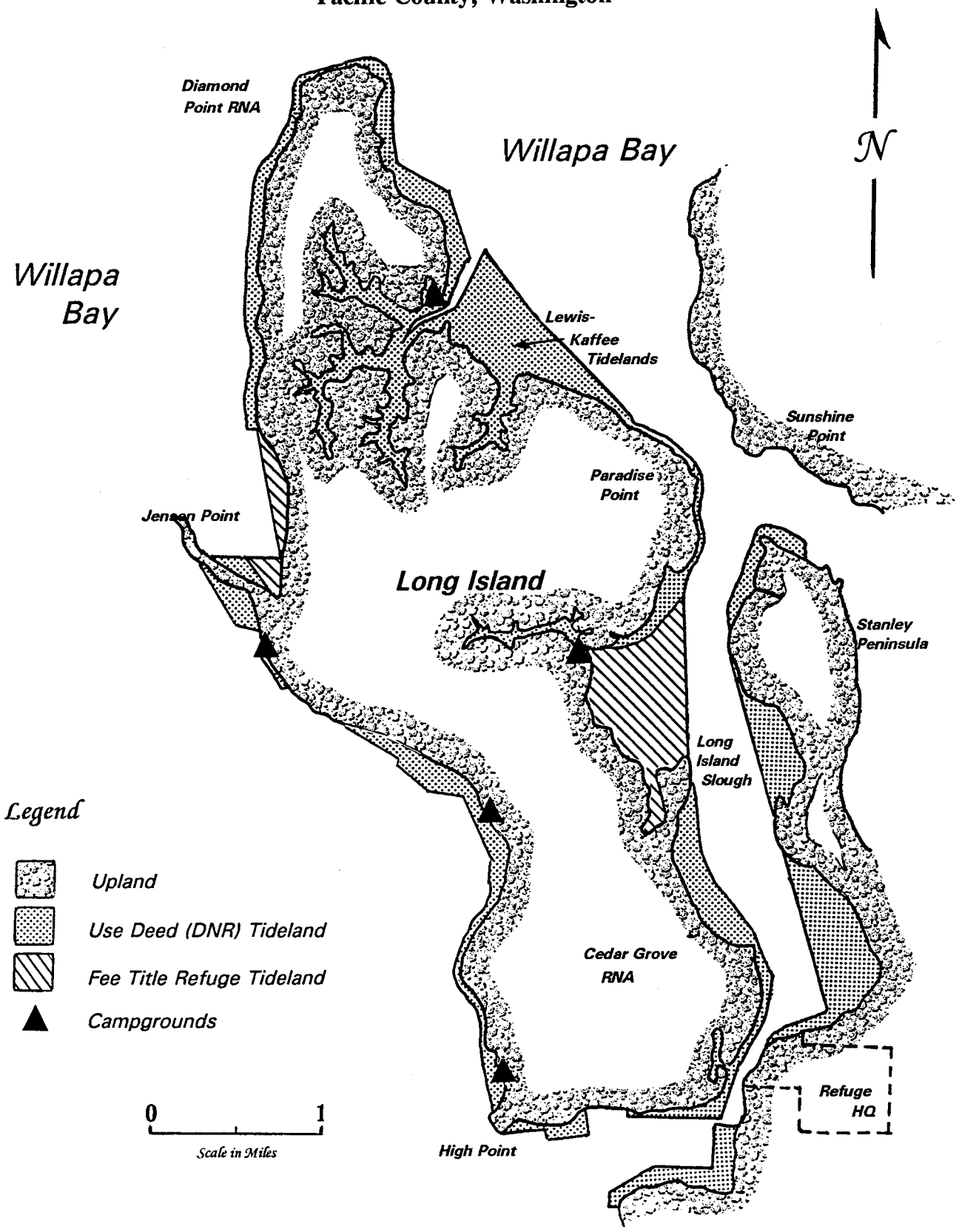


Figure 3
WILLAPA NATIONAL WILDLIFE REFUGE TIDELANDS ASSOCIATED WITH LONG ISLAND
Pacific County, Washington



particularly Willapa Bay (Frenkel and Kunze 1984). In 1991, there were approximately 2,500 acres of *Spartina* in Willapa Bay, and the infestation is expected to occupy over 30,000 acres within 45 years (Sayce 1988, Harrington and Harrington 1993).

Spartina is spreading rapidly over tidelands of the Refuge and Willapa Bay, and it is degrading habitats that support a diverse community of estuarine organisms including aquatic migratory birds and anadromous fish, and the invertebrate and plant communities that support them. Widespread colonization by *Spartina* induces major modifications of physical, hydrological, chemical, and biological estuarine functions. *Spartina* displaces eelgrass (*Zostera spp.*) on mudflats and native vegetation in salt-marshes. Benthic invertebrate species composition in the intertidal zone changes substantially as *Spartina* occupies the tidelands (Atkinson 1992, Norman and Patton 1995, Ratchford 1995, Zipperer 1996b). In New Zealand, *Spartina* has altered the natural flows of rivers and tidal channels by trapping sediment, raising flood plains, and restricting waterways (Asher 1990). As *Spartina* becomes dominant in the tideland, mudflats are raised and channels are deepened. This in turn eliminates the gently sloping bare intertidal zone that lies between the saltmarsh and the tidal channels (Aberle 1993).

The *Spartina* invasion in Willapa Bay is the largest in Washington. The magnitude of this invasion has fostered a considerable amount of study into the ecological implications of associated changes to mudflats, eelgrass beds and saltmarshes, fish and wildlife uses of these habitats, and into effective ways to control it. While research continues, there is evidence at this point in time to indicate that:

1.) No action would allow continued habitat degradation for shorebirds, brant, and other waterbirds;
2.) No action would have greater, irreversible effects on the ecosystem than reasonably applied control measures;
3.) *Spartina* is spreading at an ever-increasing rate; and
4.) Delays in initiating control measures result in geometric increases in impacts and control costs.

The invasion of *Spartina* in tidal mudflats and salt marshes has been recognized as a serious threat to migratory bird use in the bay for over a decade (U.S. Fish and Wildlife Service 1985). The rapid increase in the rate of spread during this period may be related to El Niño events, adaptation of the grass to this climate, or a combination of both factors. Regardless, the geologic youth of Willapa Bay with its characteristically large expanses of tidally-exposed mudflats, provides fertile ground for the expansion of *Spartina*.

Spartina may colonize several substrates (sand, silt, clay, loose cobble, or gravel) where salinity ranges from 1-35 parts per thousand (Kunze and Cornelius 1982, Landin 1991). In Willapa Bay, *Spartina* is found in all but the lowest intertidal zone. *Spartina*

propagates by seeds and rhizomes that spread from a vigorous root system (Landin 1990). As rhizomes intermingle, clonal circular patches ultimately grow together to form dense monotypic meadows that entrap sediments, physically raising the elevation of the tidelands. Sayce (1988) measured up to 0.8 inches of sediment deposition per meter of clone diameter in a single year.

The intertidal mudflats displaced by *Spartina* are particularly valuable habitat for migratory birds, juvenile fishes, eelgrass, and clams (Proctor et al. 1980). Such areas on the Refuge have annually provided important feeding habitat for over 20,000 migrating ducks, tens of thousands of shorebirds, and 3,000 migrating geese at a time. The Refuge tidelands that are vulnerable to *Spartina* invasion are essential to sustaining the estimated 2.2 million duck, 400,000 Canada goose, 200,000 brant, and over 2 million shorebird use-days associated with the southern half of Willapa Bay. At the current rate of invasion, the Refuge mudflats are expected to be eliminated by *Spartina* within ten years.

The Refuge was established by Executive Order No. 7541 in 1937 as a migratory bird refuge. Refuge purposes established though the Executive Order and legislation are:

> "...as a refuge and breeding ground for migratory birds and other wildlife:..." Executive Order 7541, dated January 22, 1937
>
> "...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. 715d (Migratory Bird Conservation Act)
>
> "...suitable for-- (1) incidental fish and wildlife-oriented recreation development, (2) the protection of natural resources, (3) the conservation of endangered species..." 16 U.S.C. 460k-l (Refuge Recreation Act)
>
> "...the conservation of the wetlands of the Nation in order to maintain the public benefits they provide and to help fulfill international obligations contained in various migratory bird treaties and conventions..." 16 U.S.C. 390(b), 100 Stat. 3583 (Emergency Wetlands Resources Act of 1986)

Refuge goals are:

(1) To protect and restore tideland habitat and associated migratory aquatic bird species representative of the native biological diversity of Willapa Bay.
(2) To preserve and protect unique ecosystems associated with Willapa Bay.
(3) To manage for the conservation and recovery of threatened and endangered animal species in their natural ecosystems.
(4) To provide opportunities for wildlife/wildlands-dependent recreation, education, and research.

The continued spread of *Spartina* does not contribute to the purposes or the goals of the refuge. The purpose of the proposed action is to restore and retain valuable tideland habitats for migratory birds, and other fish and wildlife species while stopping the loss of public use values.

The Lewis, Porter Point, and Riekkola units (collectively known as the southern units and shown in Figure 2) support important habitat for meeting Refuge objectives. In these three units the Service has fee-simple title to over 2,900 acres of tidelands supporting saltmarsh and mudflat habitat. Other refuge-associated tidelands include about 1,600 acres of State-owned Use Deed Lands and 200 acres of fee-simple tidelands adjacent to Long Island (Figure 3). Waterbird habitat value is being rapidly lost in both areas by *Spartina* invasions. The proposed action supports Refuge objectives by protecting and restoring aquatic bird habitat on these areas through independent and cooperative action, and by controlling *Spartina* expansion from other tidelands of the bay through cooperative efforts.

1.3 RELATIONSHIPS TO OTHER ENVIRONMENTAL ASSESSMENTS/IMPACT STATEMENTS

Controlling the spread of the introduced *Spartina* has also become an issue with local and State governments, tribal and private land managers, and users. The Washington departments of Agriculture, Ecology, Fisheries, Natural Resources, and Wildlife; and the Washington State Noxious Weed Board prepared the Noxious Emergent Plant Management Environmental Impact Statement (State's EIS), which addressed this issue in coastal bays and estuaries. The proposed action described in this document was IPM which focuses on the coordinated use of multiple biological, mechanical/physical, and chemical treatment methods to control, contain, reduce, and/or eradicate noxious plant species. The final State EIS was released in November 1993. Copies of this EIS are available at local libraries, the Pacific County Noxious Weed Control Board Office, the Washington Department of Fish and Wildlife Shellfish Laboratory at Nahcotta, the Washington State University Cooperative Extension Cranberry Research Station at Long Beach, and Willapa National Wildlife Refuge Headquarters.

The State's EIS also evaluated No Action and exclusive use of mechanical, physical, biological or chemical methods for controlling emergent noxious weeds throughout the State.

In 1994, the Service produced a management plan and EA proposing IPM for control of *Spartina* on Refuge tidelands. The preferred alternative included physical measures as well as hand and helicopter application of Rodeo® (glyphosate) with an approved surfactant. The Service also joined Pacific County and the Washington Department of Natural Resources and Department of Fisheries (now part of the Department of Fish and Wildlife) in applying for Shoreline Management Substantial Development permits

and Short-term Modifications to State Water Quality Standards in order to use IPM procedures to control *Spartina* in Willapa Bay. Permits were granted but were subsequently appealed. The appeals were aimed at preventing the proposed use of herbicides in Willapa Bay. In late 1994, the Service withdrew its permit applications and decided to develop separate NEPA documents addressing interim and long-term *Spartina* management programs.

In early 1996, the Service prepared the Interim Environmental Assessment for Control of Smooth Cordgrass (*Spartina alterniflora*) on Willapa National Wildlife Refuge in 1996 (Interim EA). The interim EA addressed control on refuge-owned tideland, and was limited to a single season. However, much of the information presented in that document applies to this more comprehensive EA. Consequently, this EA builds upon text taken from the Interim EA.

This EA differs from the Interim EA in the following ways:

- **Geographic area**
  This EA discusses measures proposed to be used by the Service for direct control of *Spartina* on the Refuge and for cooperative efforts with others on control projects on public and private lands throughout Willapa Bay and its tributaries. The Interim EA was limited to *Spartina* control on the southern units and State lands adjacent to the Refuge. Cooperative efforts will involve sharing personnel, equipment, and materials to facilitate control work on areas of mutual interest on the bay. Partners may include private, tribal, State, and County interests. The Service has reviewed the State's EIS, and has found that it adequately addresses alternatives, environmental effects, and other National Environmental Policy Act (NEPA)-relevant issues. For Service assistance with proposed cooperative efforts in implementing State plans on lands off-refuge, the Service adopts and incorporates the State's EIS by reference.

- **Time period**
  This EA addresses *Spartina* control beginning in 1997 and continuing into the future as needed. The Interim EA addressed a rapid expansion of *Spartina* on the Refuge that required immediate action in 1996.

- **Control techniques**
  This EA addresses a broader range of techniques, including aerial herbicide application, use of larger machinery, and biological control. The Interim EA focused primarily of the control of newly established clones using hand-held brush cutters and ground-based herbicide application.

1.4 SCOPING AND SIGNIFICANT ISSUES

Control of *Spartina* is a baywide concern. The spread of this grass and control

measures are of interest to everyone concerned about the present and future ecology and productivity of Willapa Bay. It is of special concern to those managing tidal flats of Willapa Bay as waterbird habitat or for shellfish production.

In 1995, The Washington State Legislature passed legislation to address the lack of progress being made by agencies responsible for controlling *Spartina* in the State. The legislation recognized the threat of *Spartina*, and simplified the permit process for agencies and private individuals attempting to implement control.

The Willapa Bay Water Resources Coordinating Council has maintained that the threat posed by *Spartina* is of "devastating proportion". It has further stated in a letter to the Washington State Department of Agriculture (March 12, 1996), "In passing emergency legislation the Washington Legislature unambiguously recognized the enormous threat *Spartina* poses to the State's marine resources, its communities and its economy. In no small part the legislature was responding very forcefully to widespread frustration with the unsatisfactory slow response to this threat by the responsible agencies".

The Willapa Alliance is an independent, nonprofit organization dedicated to developing and implementing strategies for sustainable, conservation-based economic development in the Willapa ecosystem. It is composed of local residents, landowners, and a representative for the Shoalwater Bay Indian Tribe. Willapa Alliance Resolution number 95-1 is entitled, "A resolution declaring the uncontrolled spread of *Spartina* in Willapa Bay, Washington State, and British Columbia an ecological and economic disaster and supporting the immediate implementation of *Spartina* management control and eradication programs as described by the IPM strategy based upon the findings of the EIS plan to control and eradicate *Spartina*". The resolution requests that the State, Federal, and local agencies do everything in their means to support the intent of this resolution.

Pacific County, through a task force committee, prepared the *Spartina* Management Program: Integrated Weed Management for Private and Public Lands in Willapa Bay, Pacific County, Washington in February 1994 (Updated February 1996). The committee consisted of interested public, conservation groups, tribal, and county, State, and Federal agency representatives. This document serves as a plan for management of *Spartina* for all tideland owners in Willapa Bay. The objectives of the program in the short term is contain and control *Spartina* by stopping both seed set and vegetative spread. In the long term, eradication is considered. The plan built on information and proposed actions covered in the State EIS.

The scope of this EA is based on that of the State EIS, and issues that have been raised by the Pacific County Spartina Task Force, public involvement associated with the Interim EA, and various public meetings dealing with permit applications, water quality, and the need to initiate aggressive control of *Spartina*.

Formal scoping meetings for this EA were conducted on January 6, 1997 at the Raymond Community Center in Raymond, Washington and on January 7, 1997 at the Peninsula Church Center in Seaview, Washington. A record of comments recorded at these meetings is available at the Willapa NWR office.

Issues and alternatives discussed in this document are those that have been brought forward by both local and regional interests through several years of interagency and public involvement, and the formal scoping meetings conducted in January of 1997. They are briefly discussed below in terms of the potential effects of activities associated with both action and no action alternatives on the physical, biological, social, and economic resources of the bay.

1.4.1 Physical Resources

Impacts on Sediment Erosion and Deposition

Natural processes of substrate erosion and deposition within the bay would be affected by action and no action alternatives. If *Spartina* is left to expand unchecked, it will entrap sediment rapidly and raise the tidelands, eventually eliminating much of the topographic relief that is so essential to maintaining the existing diversity of the bay. Offsite, land use practices that increase erosion also contribute to sediment accumulation in the bay. Action alternatives that result in effective control of *Spartina* would release, through erosion, some of the sediment that has been trapped over the years.

Changes in Bay Hydrology

Water movement through the estuary is affected by the topography of the tidelands. As stated previously, *Spartina* changes the topographic relief of these tidelands. The tall dense growth habit of *Spartina* also impedes water movement. These influences altogether are expected to slow runoff and water exchange with the ocean over time if *Spartina* is not controlled.

Impact on Water Quality

Water quality has been identified as a critical issue in addressing the *Spartina* problem in Willapa Bay. The Ad Hoc Coalition for Willapa Bay and Friends of the Earth have vigorously opposed the application of any herbicide in Willapa Bay. These groups and the Shoalwater Indian Tribe appealed the Shoreline and Short-term Water Quality permits in 1994, in part, based on their concerns regarding potential water quality impacts of herbicide use. Concerns have been expressed that treatment of *Spartina* with herbicide will disrupt healthy biological processes within the bay and possibly affect human health.

Due to *Spartina's* capacity to trap sediments that would otherwise move out of the bay, concern has been expressed that contaminants from roadways, communities, and other upland sources may be contained within these sediments and would therefore be

released if *Spartina* were effectively controlled.

Impact on Air Quality

Concern about aerial drift of chemicals used to control *Spartina* has been expressed. These concerns are primarily focussed on potential impacts to human health, but potential effects on gardens and ornamental vegetation have also been mentioned.

1.4.2 Biological Resources

Impacts to Vegetation

The native vegetation of the bay is being displaced by *Spartina* at a very rapid rate. Without control, it is expected that all of the mudflat vegetation (mainly eelgrass), and much of the saltmarsh vegetation will be displaced and converted to monotypic *Spartina* meadows. Control measures for *Spartina* would unintentionally impact some nontarget vegetation.

Impacts to Wildlife

Wildlife, particularly migratory aquatic birds, depend on the mix of habitats within the intertidal area of the bay to provide feeding and resting areas. This is of particular importance during migration. The Refuge was established specifically to protect the resources that support migratory birds. It is expected that if *Spartina* is not controlled, most of the high-quality migratory bird feeding habitat will be lost. The potential for various alternatives to affect wildlife resources, including threatened and endangered species, will also be addressed in this document.

Impacts to Fish

As with wildlife species, *Spartina* is changing habitat for fish species. Ultimately, *Spartina* will convert usable intertidal habitat to high meadow, available to fish only during the highest tides. Furthermore, Willapa's fish resources have adapted to the diverse intertidal zones, and the flora and fauna associated with them. There is concern that the more biologically simple *Spartina* meadows would negatively impact fish. There are also concerns that action alternatives could negatively impact fish. The primary concern here is that chemicals used to kill *Spartina* might impact or compromise fish health.

Impacts to Invertebrates

Related to all other biological issues are the concerns about potential impacts of uncontrolled *Spartina* growth, as well as the action alternatives, on invertebrates on the tidelands. The vast array of worms, arthropods and mollusks found on the tidelands is a key component of the estuary's food web which supports the fish and wildlife resources that are directly valued by people. Concerns include, again, the reduction in biodiversity (numbers of invertebrate species) associated with *Spartina* domination and the potential for impacts to invertebrates from the action alternatives.

1.4.3 Social Resources

Impacts to Public Use

An issue that has arisen concerning *Spartina* is centered around its effect on public access and recreation on the bay. *Spartina's* rapid take-over of the upper mudflat in many areas has made boat access to and from the shore difficult except during the highest tides. Some have expressed concern that bird watching opportunities have been limited in areas where broad meadows have developed along shorelines. Recreational boating, shellfish gathering, and hunting have also been affected by the expansion of *Spartina* on the Refuge and on the bay in general. To be addressed also, is the anticipated impacts of control alternatives on these human activities.

Impacts to Human Health

There are concerns that the use of chemicals to control *Spartina* could affect human health. Specifically, the concern is that these chemicals or their byproducts would persist or bioaccumulate in the food web and find their way into finfish, shellfish, or wildlife used for human food. A concern has also been raised about the potential for offsite effects on chemically sensitive people due to airborne drift of sprayed chemicals. The fate, persistence, and potential for impacts on human health will be addressed.

1.4.4 Economic Resources

Economic Impacts Associated with Reduced Tourism

Although the refuge purpose is not intentionally linked to regional or local economics, the refuge is none-the-less connected to economic issues though its influence on tourism. Uncontrolled *Spartina* growth is expected eventually to impact tourism locally by limiting or eliminating some of the recreational opportunities mentioned previously. This, in turn, could reduce tourist dollars spent at local businesses.

Threats to Shellfish and Other Resource Industries

Land management practices on the Refuge can have direct or indirect off-refuge economic consequences. Such is the case with management of *Spartina* on refuge lands. If the refuge supports large acreages of *Spartina*, the seeds produced would increase the cost of controlling *Spartina* on adjacent private and State tidelands. On many of these private and State lands, development and/or harvest of natural resources for economic gain is the primary objective. The commercial shellfish industry has identified *Spartina* as a threat due to its ability to interfere with water flows and capture sediments.

Impacts to Tideland Property Values

Tideland real estate values in Willapa Bay are primarily a function of the land's capacity to grow shellfish, usually oysters. *Spartina* reduces the economic value of the land as it diminishes or eliminates that capacity. On marginal oyster grounds where *Spartina* is established, the cost of controlling the grass can easily exceed the value of the land. In addition, there is the concern that as control of *Spartina* is made

mandatory by noxious weed control laws on more lands, some tideland owners may be forced to choose between expensive control efforts or relinquishing their title to the county.

Control Costs

Effective action alternatives are expensive. Effective control efforts will initially require large commitments of funds by the Service. It is expected that costs will decline as techniques become more efficient and seed sources are reduced. Labor represents a substantial part of *Spartina* control costs. In 1996, at least 12 seasonal workers were hired on Willapa Bay specifically for control activities. Such jobs contribute to local economies.

1.5 PERMITS AND CONSULTATION

Coverage under the Washington State Department of Agriculture (WSDA) water quality permit is required before any chemical control on *Spartina* can take place in Washington State. Due to the legislation passed in 1995, WSDA now negotiates and acquires a water quality permit for Willapa Bay annually from the Washington State Department of Ecology (WDOE). The permit specifies which months chemical treatment is allowed and which chemicals are permitted, along with restrictions on wind speed, drying time, and re-treatment intervals.

Staff members of Willapa NWR responsible for herbicide application to *Spartina* hold valid pesticide licenses, have taken and passed the WSDA aquatic pest control exam, apply to WSDA and agree to permit terms in order to obtain coverage under the WSDA water quality permit.

The refuge will initiate an internal Section 7 Consultation under the Federal Endangered Species Act (16 U.S.C. 1531-1544) to address potential effects of control efforts, both positive and negative (if any) on threatened and endangered species.

The proposal described in this EA no longer requires a Shoreline Management Substantial Development Permit due to amendments of RCW 90.58.030 and 1987 c 474 s 1 in 1995 Washington State Legislation.

1.6 SUBSEQUENT CHAPTERS OF THIS EA

Chapter 2 of this EA identifies a number of alternatives for addressing the *Spartina* problem, including no action, alternatives not considered further, and the proposed action. Chapter 3 describes the affected environment, and Chapter 4 assesses the environmental consequences of the alternatives.

2.0 ALTERNATIVES

2.1 INTRODUCTION

Since 1985, many approaches to *Spartina* control have been discussed among agencies and interest groups. The individual ideas range from simple to complex, and from inexpensive to extremely costly. They also run from potentially effective to likely ineffective and from extremely disrupting to the existing environment to low probability for negative impact.

Although many techniques for *Spartina* management have been suggested, expanding knowledge of *Spartina* and the existing environment has helped to focus management efforts. For this reason, a number of alternatives have been considered but eliminated from detailed analysis in this document. These will be discussed briefly along with the rationale for elimination. This chapter will describe in detail and compare the following four alternatives: No Action, Long-term Integrated Pest Management (the proposed action), Physical/Mechanical Control, and Chemical Control. Further analysis of consequences is found in Chapter 4.

2.2 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED STUDY

2.2.1 Physical/Mechanical

All actions that depend on the movement of heavy equipment on tidelands are complicated by the deep, very soft, silt substrate of the south end of Willapa Bay. In addition to this, complicated machinery with many moving parts requires extraordinary amounts of maintenance and cleaning to keep it operating for a reasonable amount of time in the corrosive environment of the estuary. These factors and the disruption of physical and biological resources tend to limit the number of physical/mechanical control options that can be practically implemented on a sustained basis for effective *Spartina* management.

Commercial Harvesting

Repeated harvesting of stem material for commercial use could have effects analogous to repeated mowing, but repetitions would have to be frequent and prolonged enough to cause death of the plants. We are not aware of adequate demand for cordgrass fiber to sustain a commercial harvesting operation in Willapa Bay sufficient to control the spread of the grass. However, if sufficient demand did exist, it is reasonable to assume that commercial harvest would require a stable or expanding source of *Spartina* and the establishment of pulp processing facilities on Willapa Bay. This would be counter to efforts to reduce infested acreage and would effectively constitute a conversion of tideland use from conservation/aquaculture to industrial agriculture. Small, hand operations would have some capability to reduce the rate of vegetative spread of clones

or prevent seed production, but only on small areas.

Tramping/crushing
This method destroys the above-ground portion, but does not directly affect the roots. Thus, like mowing, repeated actions in a growing season would be required to kill *Spartina* clones. We are aware of no machine that is currently available for large-scale crushing operations. The difficulty of transporting and operating such a machine in the tideland environment must be overcome before such a technique can be realistically evaluated. Potential exists for serious environmental impacts which may include temporary increases in sedimentation and erosion, local decreases in water quality, and disruption of infauna and epifauna, important prey items of aquatic migratory birds, anadromous fish, and other native fish and wildlife.

Excavation/dredging
Conventional dredging equipment would be used to remove sediment and *Spartina* to at least the depth to which the root mass extends. All plant parts must be removed and disposed of at an upland site to avoid resprouting. This alternative is not considered further at this time primarily due to its extreme cost. However, there is also a high likelihood of cutting or breaking plant parts, especially roots, with subsequent dispersal of propagules to other parts of the bay or even outside the bay via currents. Impacts to soils, water quality, hydrology, animals, and other plants are expected to be substantial. Disposal of dredge spoils would be a problem of at least the same proportions as the excavation alone.

Scraping
Scraping would require the development of heavy equipment that could scrape *Spartina*, including roots, into masses that could subsequently be removed from the tidelands. Scraping has the same problems as excavation and dredging.

Plowing/rotovating
Plowing and rotovating involves the mechanical disruption of *Spartina,* its root system, and the supporting substrate. This is effective on some upland weeds because it results in the desiccation of roots. It is not expected to be effective in killing *Spartina* because no drying would occur in the tidal environment. It is expected that such efforts would actually spread the species through propagules created by cutting up the plants. Equipment is not currently available that would efficiently operate on the very soft substrates.

Dewatering/draining
This would require large earthen dikes and other water-control structures such as tidegates and pumps to prevent the inundations required by *Spartina*. Such a large-scale construction effort would result in immense environmental damage including impacts to soils, water quality, hydrology, animals, and other plants.

Flooding/inundating

This entails covering plants with water deep enough to prevent photosynthesis and cause plant mortality. It would require structures even larger than those needed to dewater areas, but with the opposite intent. Again, immense environmental damage is anticipated including impacts to soils, water quality, hydrology, animals, and other plants.

Burning

Spartina in Willapa Bay will not carry flame without the application of additional fuel. Burning with broadcast application of fuel such as gasoline and or diesel oil would generate water-, soil-, and/or air-quality degradation. Impacts of pollutants on invertebrates, fish, and other organisms could be high. Multiple treatments would be required.

Steam

Steam has been used with some success to control *Spartina anglica* in New Zealand (Shaw 1997). This is apparently more effective than mowing on that species since it kills the stem and upper root tissues of the plant. However, it is expected to have limited application on *Spartina alterniflora* because of the much greater above-ground biomass involved. It is anticipated that costs, delivery problems, and impacts to invertebrates would be high. Although it appears that this method would have little use in controlling *Spartina* on Willapa Bay, future testing at least on a small scale seems warranted.

Covering

Long-term covering of clones with sheets of shade or geotextile cloth causes death by preventing photosynthesis. Material must be securely held in place to withstand tidal and wind actions. Refuge studies have shown that this method is labor intensive and requires covering well-beyond the edges of clones to prevent *Spartina* from growing up from roots extending beyond the edge of the visible shoots (U.S. Fish and Wildlife Service 1990). Covering may be torn or lifted off by wind and wave action. Covers also become covered with sediment, which is then released when covers are removed. Generally, it was found to be impractical where treatment of more than a few small clones was required, and it generates substantial site disturbance during cover placement and removal.

Laser beams

Carbon dioxide lasers have been used to kill seed heads on certain plant species. This method has not been tried on *Spartina* for effectiveness. Laser operations are hazardous. Safe, portable laser units have not been developed. Such technology has potential for limited control of seed production if development continues and succeeds.

Freezing roots
This requires an elaborate system to circulate extremely cold liquid through the root mass. No such system has been developed on a large enough scale. If a large but portable system is developed, it might assist in small-scale, local control.

2.2.2 Chemical

Highly selective herbicides
We are not aware that a species-, genus-, or even family-specific herbicide for *Spartina spp.* is currently available.

Smothering with diesel, other oil, or fluid
Application of diesel or other toxic substances in the aquatic and marine environments to control *Spartina* has significant environmental impacts and is illegal.

2.2.3 Biological

Grazing
Grazing by wild or domestic herbivores would have varying effects depending on the season, duration, intensity, and types of animals used. Use of cattle or other large herbivores is not practical because of the extremely soft substrate in the many parts of the bay. If it was feasible, the environmental impacts of such large-scale grazing in the intertidal zone would be significant. Grazing animals could contribute to the spread of *Spartina* through dispersal of seeds and propagules.

Bioengineering
Bioengineering would involve artificial genetic manipulation of organisms to specifically retard *Spartina* growth or reproduction. This method is hypothetically possible and may become feasible in the future.

Succession/competition
Natural succession may cause limited displacement of *Spartina* by other marsh vegetation as the invading grass modifies its environment. This is a result of the physical and hydrological alterations created by *Spartina* clones and meadows. Unfortunately, succession occurs only after the mudflats have converted to higher elevation vegetated marshes. *Spartina* remains dominant with small patches of desirable plants intermixed. Thus, the habitat values of affected open mudflats and high vegetated marshes are still lost. *Spartina* would continue to thrive in the lower intertidal zone and along channels.

2.3 ALTERNATIVES INCLUDING NO ACTION AND THE PROPOSED ACTION

Costs of action alternatives
Approximately $75,000 was spent on *Spartina* control on the Refuge in 1996. It is

impossible to predict with any precision the future costs to the Service of *Spartina* control under any of the action alternatives. The rate of *Spartina* spread and efficacy of evolving control techniques are not static or predictable and will greatly influence future costs. Generally speaking, the more funding applied to *Spartina* control now, the lower that control and/or maintenance costs are likely to be in the future.

We estimate, that for the foreseeable future, the Refuge will spend from $50,000 to $200,000 annually to address *Spartina* management on fee title and use deed lands. However, efforts to expand funding beyond this would be aggressively pursued. Because of the large acreage of *Spartina* dominated land in the bay, any of the three action alternatives could effectively utilize even larger amounts of funding, particularly in the first few years of eliminating existing clones and meadows. Since expenditures for control are primarily dependent on available funding, the annual costs for each action alternative would be identical. In the descriptions that follow, relative control efficacy of each action alternative is described, thus providing some comparison of cost effectiveness. Of course, the No Action Alternative would have no control costs and would result in no *Spartina* control.

Activities common to action alternatives

All action alternatives would include certain basic management requirements, monitoring, and mitigation as is the case with many activities on a national wildlife refuge. Operations on the tidelands would involve standard precautions and methods associated with deployment of equipment, people, and supplies to areas with extremely poor access. The following are specific protocols that would be a part of all action alternatives:

- Transport vessels and vehicles would not be serviced or fueled in the field except under emergency circumstances.

- Hand-operated, gasoline-powered equipment would be fueled in the field using precautions that would contain or avoid spills. This would involve fueling on board a vessel and use of petroleum absorbent cloth.

- Fuel or chemical mixing would be accomplished prior to entering tidelands.

- Safety equipment appropriate to the risks involved would be available on vessels, vehicles, and on individuals. This would include such items as personal protective equipment, spill-response materials, radios, first aid kits, tools, fire extinguishers, location devices, and personal floatation devices.

- Personnel would be trained in the operation of vessels, vehicles, and equipment to ensure that such equipment would be used safely, effectively, and with minimal disturbance to soils, nontarget vegetation, wildlife, control personnel,

and the public. Only employees with Washington State Aquatic Applicator's Licences or workers under their direct supervision would prepare or apply chemicals. Control programs involving chemical application would be in compliance with the USFWS Manual (242 FW 7).

- Operations on the particularly soft mud of Refuge tidelands have evolved toward dependence on hovercraft and airboat technology for moving people and equipment at low tide. This technology has been found to be not only efficient, but also the lowest impact means to move about in this most difficult environment. To minimize impacts to nontarget vegetation, epibenthic invertebrates, and soils, priority would be given to the use of these vehicles to transport personnel, equipment, and supplies when tidelands are exposed. When practical, small power boats would be used to access work sites prior to low tide or via flooded channels. In general, the use of wheeled or crawler-type equipment and walking on the tidelands would be avoided to the extent possible.

- A *Spartina* management and monitoring plan would be developed, then reviewed and updated as needed. The plan would identify proposed treatment areas, methods, cooperative efforts, and monitoring activities.

- Information gained from operations would be shared with others engaged in *Spartina* management on Willapa Bay and elsewhere, such as Puget Sound.

Priorities common to all action alternatives

- Areas selected for treatment would be prioritized as follows.
  1. Fee title federal lands associated with the Lewis, Porters Point, Riekkola, and Long Island units (Figures 2 and 3).
  2. State-owned tidelands around Long Island, commonly known as use deed lands, on which the Service holds certain management responsibilities (Figure 3).
  3. State-owned tidelands immediately adjacent to lands described above.
  4. Cooperative control on other tidelands or wetlands within the Willapa Bay watershed.

- Treatment of *Spartina* on the Refuge would be prioritized as follows.
  1. Early flowering clones which are most likely to produce viable seed.
  2. Scattered outlier clones and seedlings.
  3. Coalescing clones
  4. Meadows

2.3.1 No Action

Under this alternative, *Spartina* would not be controlled on Refuge-owned tideland and

the Service would not provide assistance with *Spartina* control on other tidelands within Willapa Bay.

Table 1 shows the estimated acreage of *Spartina* invasion on refuge lands. If no action is taken to control *Spartina* on the Refuge, it is projected (based on the expansion of *Spartina* in recent years) that all remaining mudflat area on the Southern Units will be dominated by the invading grass within the next 10 years. On Refuge tidelands associated with Long Island, *Spartina* has already dominated about 1,200 acres or 67% of the area. Nearly all of the remaining mudflat habitat on these tidelands will likely be dominated by *Spartina* within the next five years if no action is taken.

Table 1
Estimated Acreage of *Spartina* on Refuge Tidelands
(October, 1996)

Degree of Spartina Invasion	**Three Southern Refuge Units (2900 acres)**	**Tidelands Associated with Long Island (1800 acres)**
Spartina Meadows	300 (10%)	1,000 (56%)
Coalescing Clones	140 (5%)	200 (11%)
Scattered Clones and Seedlings	1,550* (53%)	260 (14%)
Unaffected (1996)	910 (32%)	340 (19%)

* Approximately 90% of the spartina on this area was controlled in 1996.

At the end of the 1996 growing season it was estimated that there were approximately 5,000 acres of *Spartina* on about 15,000 acres of tidelands throughout Willapa Bay (Moore 1997). The no action alternative would not only fail to contribute to *Spartina* control off refuge, it would also interfere with the off-refuge efforts by allowing a major seed source to thrive on the Refuge.

2.3.2 Integrated Pest Management (Proposed Action)

Integrated Pest Management (IPM) is a dynamic approach to pest management which utilizes a full knowledge of a pest problem through an understanding of the ecology of the pest and related organisms. Programs are carefully designed under IPM using a combination of compatible techniques to limit damage caused by the pest to a tolerable level (U.S. Fish and Wildlife Service 1982). In many cases, IPM will utilize combinations of physical/mechanical, cultural, biological, and chemical control techniques to meet objectives. At this time, biological and cultural techniques are not available for *Spartina* control. However, biological control agents are being studied

and will likely become available for use in the future.

Integrated pest management incorporates a broad range of techniques and therefore expands opportunities to do effective control work beyond those of individual control methods. Clone elevation, stage of plant development, tidal conditions, and weather all can influence the efficacy of any individual control technique. Chemical methods, while more effective under ideal circumstances, are most limited by adverse situations. Consequently, crews using IPM can quickly adapt to conditions found in the field to obtain safe, economical results.

Although IPM would retain some of the impacts of chemical, biological, and physical/mechanical methods, it is expected that overall impacts would be reduced by improved efficacy and less reliance on a single control method. To illustrate this, consider a 30- to 50-foot diameter clone that has grown to full height on a low mudflat. It is likely that it would take at least four mowings, with the associated physical impacts (trampling of nontarget species and sediment disturbance) to kill such a clone. Likewise, total reliance on chemical control techniques would likely require the application of large amounts of spray mix perhaps in multiple treatments to kill such a mature clone. Using knowledge gained from 1996 control work and 1995/1996 monitoring (Major and Grue 1997) it was revealed that such a clone can be killed with one mowing followed in 30 to 60 days with an application of glyphosate on the short, soft regrowth. In such a case, the clone would be killed more economically with less spray than when chemicals alone are used and with fewer visits and on site disturbance than when mowing only is used.

The adaptive nature of IPM would permit the program to evolve as more is learned about efficacy and nontarget effects. Consequently, a precise description of actual control work that would be conducted several years in the future is not possible. However, the state of existing programs being conducted on Willapa Bay and in Puget Sound have provided a general picture of the long-term *Spartina* control program being proposed by the Service on Willapa Bay.

Under IPM, control methods would vary throughout the year to take best advantage of *Spartina* growth, weather conditions, and other factors. The following are descriptions IPM proposed by season.

Early Growing Season

Current water quality permit standards allow application of glyphosate and approved surfactants starting June 1.

- If *Spartina* is actively photosynthesizing and is approximately two feet tall or less after this date, herbicide application alone has been found to be effective. Aerial application by helicopter or fixed-wing aircraft would be used on meadows and areas of coalescing clones.

- Spot herbicide application using spray equipment mounted on airboats, hovercraft, and pack frames would be used to treat isolated, scattered clones. Clones that were not completely killed in the previous season would likely be re-treated in the early part of the growing season. Approved marker dye might be used to avoid missing or overlapping parts of clones being treated with herbicide.
- Mowing of clones and meadows as described under the Physical/Mechanical Alternative (see section 2.3.3) would begin where shoots generally exceed two feet in height.
- Seedlings would be treated by crews on mud walking equipment who would pull or push them into the mud as described under the Physical/Mechanical Alternative.

Mid Growing Season

- In late June, a search for flowering clones would be conducted and such clones would be either sprayed or mowed immediately, or marked for later treatment. The intent would be to identify clones that are inclined to produce viable seed and apply special emphasis on stopping their development.
- Initial and repeated mowing of clones and meadows would continue to either directly kill the clones or prepare them for subsequent spray.
- Herbicide application would generally be on clones and meadows that were mowed 30 to 60 days earlier in the season.
- Some spraying of unmowed *Spartina* would occur where prolonged adsorption opportunities existed or if more effective approved chemical became available.
- Pushing and pulling seedlings would continue through this period.
- Flaming of flowers or seed heads using propane torches or similar tools would be used to stop seed production during this time of the year.

Late Growing Season

- Spray operation would generally stop during the month of September, although new developments in chemical methods might extend herbicide application to later dates.
- Mechanical/physical methods would continue through late season when funding permitted since there is some evidence that this weakens the next season's early growth.

Winter

- On-going studies are indicating that winter mowing of *Spartina* stubble and winter shoots to the mudline may kill clones or substantially retard the next season's growth. It is thought that winter mowing may work to smother the roots under some circumstances. Even though the season of maximum dormancy in which this may be used is short and weather conditions further limit safe work on the bay during this time of year, this technique might be used

to complement efforts conducted during the growing season.

All Seasons

- Mechanical methods that would remove *Spartina* along with its root mass could theoretically be used year around. A vibrating fork devise has been tested with some success that is capable of removing *Spartina* along with its root mass.

At such time that new physical/mechanical, cultural, biological, chemical, or other control techniques are tested and approved for use on the bay, they would be incorporated into the IPM program. As has been the case with chemicals currently approved for use in Willapa Bay, the Service would incorporate new herbicides and adjuvants into its IPM program if they proved effective and were approved under the State Water Quality Permit and a U.S. Fish and Wildlife Service Pesticide Use Proposal. Procedures and timing for applying biological control agents would depend on the organisms used. Details about such future developments under IPM, of course, cannot be addressed until specific chemicals or agents are identified or tested.

Further discussions of specific mechanical and chemical application techniques are found in 2.3.3 and 2.3.4.

On the Southern Units of the Refuge, implementation of the IPM Alternative at expected funding levels over the next 5 years would be expected to stop most of the seed production and maintain approximately 2,300 acres of mudflat free of scattered small clones and seedlings. Within about 10 years, IPM would likely permit the conversion of about half of the existing *Spartina* meadow and coalescing clone acreage to native saltmarsh vegetation, while the other half would likely revert to mudflat. Once meadows were controlled, it is reasonable to expect that *Spartina* control work on this area could be reduced to spot treatment of reinvading clones, requiring only a few staff weeks per year.

Due to the greater degree of *Spartina* dominance on Use Deed tidelands around Long Island, elimination of the meadows could take about 10 years to complete using IPM. However, due to the amount of sediment accreted and the tendency of native saltmarsh to stabilize such elevated sediments, little of the former *Spartina* meadow would likely revert to mudflat. Seed production could likely be stopped within 5 years. Variables that could reduce the number of years needed to achieve control on these lands include increased funding allocations, increased assistance from DNR, and advances in IPM techniques.

Cooperative work off refuge using IPM and its success at controlling *Spartina* cannot be precisely quantified, because specific agreements with public and private landowners have yet to be developed. However, IPM would be expected to provide the greatest amount of flexibility for accommodating landowners' management objectives, control

capability, and personal preferences.

2.3.3 Physical/Mechanical Control

Physical and mechanical methods of controlling *Spartina* are those that physically manipulate the grass itself, or some aspect of the habitat on which the grass depends. Such manipulation may or may not involve the use of power tools or machinery. The physical/mechanical alternative addressed in this EA includes the use of hand pulling or pushing of seedlings, mowing, removal of whole clones/meadows from the substrate using machinery, and torching of flower and seed heads. These various techniques would be applied individually or in combination, on a site-specific basis, as appropriate.

Hand pulling

This entails removal of seedlings that have sprouted from the previous year's seed set. This method has proven to be effective at retarding the first stage of *Spartina* invasion on mudflats (Wilson and Lebovitz 1996).

The technique typically involves approaching each seedling by hovercraft, airboat, or on foot, using a mud-walking device attached to boots. The seedling is pulled up by hand with its roots attached if a rhizome has not developed. If a rhizome has developed, some digging by hand or with a hand tool such as a trowel or garden fork may be necessary. Plants must be removed from the intertidal zone and disposed in a way that will prevent them from getting back to tidelands. Drying, burning, or burying at an upland site would be sufficient to avoid reintroducing the seedling to the bay.

Care must be taken to minimize propagules that are broken or cut off below ground as they may resprout. Propagules must be properly disposed of to prevent dispersal by tides. Repeated treatments throughout the growing season are required because of resprouting and late germination of seeds. This technique is limited to seedlings, and is most effective early in the growing season before rhizomes become well-developed. It is not practical for established clones due to the amount of hard labor involved in digging up and removing the large root masses.

Pushing Seedlings into the Mud

This newly-developed technique shows promise as a substitute for pulling seedlings (Milne 1995). It is based on the idea that a seedling will die if it is pushed at least 18 inches below the surface of the mud. The procedure is accomplished by using a rod of approximately 1.5 to 2 inches in diameter to shove a seedling down into the soft mud beyond the plant's ability to send a shoot back to the surface. The main advantage of this technique is that removal of the seedlings from the tidelands is not necessary. Less time and movement at the seedling site is needed, and no side trips to unload seedlings would be required. These advantages would reduce physical effort and further reduce impacts associated with trampling. It is expected that the technique can be modified to

be performed from a hovercraft or airboat, thereby reducing or even eliminating impacts associated with walking on the mudflats.

As with hand pulling, the pushing technique is reasonably applied only to seedlings. Once the clone is well-established in its second season, too much effort and disturbance would be required to push so much plant material down to the necessary depth. Furthermore, there would be a high probability of leaving viable rhizome fragments near the surface to permit resprouting.

Mechanical cutting or mowing

Studies have demonstrated that *Spartina* is stressed by repeated mowing (U.S. Fish and Wildlife Service 1991, Atkinson 1992) and that clones can be killed in some situations where the mowings are consistently repeated. A number of variables are suspected to influence the vulnerability of *Spartina* to mowing. How these variables appear to work is demonstrated qualitatively as follows.

Less Effective	More Effective
Few treatments	Many treatments
Inconsistent	Regular repetitions
Mud substrate	Sand or gravel
Large clones	Small clones
Genetic resistance	Genetically vulnerable

To date, several types of mowing devices have been used to cut *Spartina* in Willapa Bay. The device that has been most commonly employed on the soft, irregular surfaces found on the Southern Units of the Refuge has been a gasoline-powered, hand-held, brush cutter. The need for larger, self-propelled mowers/harvesters has been identified, and such machines are expected to be tested on Willapa Bay in 1997. Such devices would be used at locations where they would not get bogged down and excessively disturb sediment. Generally, large mowers would be used to mow meadows and large clones. The dense root mass of established meadows is expected to support larger tracked and wheeled equipment.

The most commonly employed technique would involve mowing all stems within a selected clone as close to the ground as possible without cutting into and lifting the roots. As regrowth occurs, this is repeated until the root system dies and resprouting ceases. Care must be taken not to cut and lift roots and rhizomes that may resprout on site or be dispersed by tidal currents. Mowed material is allowed to float away on subsequent high tides.

A modification of this technique would be used on larger clones located in relatively high areas that are sheltered from wind and wave action. In such areas, the outer margin of the clone would be left standing to prevent the mowed material from floating

away. This technique has been shown to have the added effect of shading some of the regrowth with the trapped cuttings.

Mowing alone has limited application as a means of controlling *Spartina*. It is not practical on large clones and meadows or as the sole method in large-scale operations due to its high cost. In earlier studies on the Refuge (Atkinson 1992), large clones (averaging 150' diameter) in mud had to be mowed 10 times over two growing seasons to be killed. It was estimated from this study that the cost of mowing such large clones to death might exceed $1,000 per acre.

Another limitation of mowing alone is the problem of diminishing returns from repeated mowing effort (Atkinson 1992). Resprouting vigor was reduced substantially when large clones were mowed the first two or three times. Subsequent mowings retard regrowth to a lesser degree. In the end, it was necessary to hand pull remaining shoots sprouting from particularly tenacious roots.

A value of mowing is that it can be employed effectively to stop a season's seed production. To do this, it is essential that mowing be done late enough in the growing season that the clones are unable to recover and flower, but early enough that viable seed has not already been produced. This limits such a strategy to the months of July and August.

Torching

Like mowing, clean burning of *Spartina* stems with a flaming weed torch would leave root systems intact. Thus repeated treatments are necessary to kill the plants. This method may be practical for preventing seed production by flaming flower or seed heads.

Implementation of the Physical/Mechanical Control Alternative would be expected to substantially increase the number of years it would take to gain control of *Spartina* on the Refuge. This is due to the higher cost of killing meadows and large clones, and the delays in retarding seed production from some areas. It is possible that at current funding levels, control would never be accomplished on the Refuge using this alternative. With existing mowing equipment, the refuge would have very little capacity to cooperate in off-refuge *Spartina* control projects.

2.3.4 Chemical Means Only

This alternative would rely exclusively on ground or aerial application of chemicals to control *Spartina*. Only herbicides and adjuvants (e.g., surfactants and dyes) approved by the U.S. Environmental Protection Agency (USEPA), Washington State Department of Ecology (DOE) through its Water Quality Modifications Permit, and U.S. Fish and Wildlife Service (USFWS) through a pesticide use proposal would be applied to *Spartina*. Currently, only Rodeo® and one of three nonionic surfactants (R-11® Spreader

Activator, X-77® Spreader, or LI-700®) may be applied to *Spartina* in Washington state. For general information on Rodeo® and these nonionic surfactants see the Appendix. Herbicides and adjuvants would be applied to *Spartina* consistent with the pesticide label, and restrictions imposed by USEPA, DOE, and USFWS.

For ground applications, a herbicide tank mix would be applied to *Spartina* using a back-pack sprayer or portable spray device that would be mounted in a conventional boat, airboat, hovercraft, or where substrates permit, an all-terrain vehicle. Ground applications would involve spraying foliage on a spray-to-wet basis. Rodeo® and a nonionic surfactant (adjuvant) would be applied by ground equipment at rates equal to or less than the maximum rates permitted for *Spartina* control by USEPA and DOE, which currently are 5% and 2% solutions (volume of chemical to volume of spray solution), respectively. Off-site movement (drift) of chemicals by air currents and tidal washing would be minimized by timing treatments to coincide with favorable environmental conditions. Such conditions would include the following: wind velocity less than 8 km/hour (5 mph), no rain events 6 hours before or during spraying, no visible moisture on plants during application, and at least 5 to 6 hours exposure time between application and subsequent high tide to allow for cuticle penetration of the herbicide. With hand-held equipment used for ground applications, spraying would be directed inward and downward onto *Spartina* to avoid over spray on non-target areas.

Herbicides and adjuvants would be wiped onto *Spartina* using hand-held or self-propelled applicators. Wiping would involve covering foliage until it has a wet appearance. Rodeo® and a nonionic surfactant (adjuvant) would be applied by wipers at rates equal to or less than the maximum rates permitted for *Spartina* control by USEPA and DOE, which currently are 33% and 5% solutions, respectively. Wiping with hand-held applicators is normally impractical for clones larger than a few feet in diameter. Wiping devices mounted on all-terrain vehicles have been developed and used with some success on meadows (Sheldon 1996). Although such machinery has not been tested on the refuge yet, it could become a component of this alternative as technology develops.

For aerial applications, the primary means of applying a herbicide tank mix to *Spartina* would involve a helicopter equipped with a boom. Rodeo® and a nonionic surfactant (adjuvant) would be applied at rates equal to or less than the maximum rates permitted for *Spartina* control by USEPA and DOE, which currently are 8.8 liters/ha (3.75 quarts/acre) and a 2% solution, respectively. The same environmental conditions described for ground applications would be needed to minimize drift. Aerial application would be used on meadows or very large clones and would be conducted so that the herbicide tank mix would not be directed outward beyond the edge of the *Spartina* stand and, would consequently, minimize over spraying of non-target areas.

Because efficacy associated with ground and aerial applications is dependent upon,

among other factors, exposure time (period between treatment and tidal inundation), efforts would be made to maximize time available for uptake of applied herbicide tank mixes by *Spartina*. For example, the exposure time could be maximized by applying herbicide tank mixes when a low high tide is rising, where *Spartina* in the upper regions of the intertidal zone is not completely inundated. During the late summer with mid-morning low high tides, treated *Spartina* could be exposed for about 12 hours before the tide washed treated portions of the plant.

Although limiting *Spartina* control to chemical means only would likely be reasonably effective with little risk of harming non-target species, it has limitations in treating clones in the lower intertidal areas where tidal inundation would usually wash the chemical off of the plants in less than 5 to 6 hours. Another limitation to this alternative is that requisite tidal and weather conditions restrict the amount of time available for control work. Finally, compared to use of multiple techniques, this alternative would require the use of more chemical to achieve equivalent *Spartina* control because it does not benefit from the assistance of mechanical methods and would have to be used in situations that are not particularly suited to high chemical efficacy.

Implementation of the Chemical Means Only Alternative would be expected to somewhat increase the number of years it would take to gain control of *Spartina* on the Refuge. This is expected primarily due to limited opportunities to apply chemicals effectively and safely, and due to the difficulties in killing mature *Spartina* with the chemicals that are currently available for use in the bay. However, it is possible that at current funding levels, control could be accomplished on the Refuge using this alternative, but it would likely take over 10 years.

2.4 SUMMARY COMPARISON OF ENVIRONMENTAL CONSEQUENCES

Tables 2A through 2D provide a summary comparison of the consequences under each of the evaluated alternatives.

TABLE 2A. Alternative Consequences Matrix - Physical Resources.

Physical Issues	No Action Alternative	IPM Alternative	Physical/Mechanical Only Alternative	Chemical Only Alternative
Soils and Topography	*Spartina*-facilitated sediment buildup would continue to raise mudflats in most areas of the bay.	*Spartina*-facilitated sediment buildup in scattered clones and meadows would be slowed or halted in the shortest amount of time. Low concentrations of chemicals would bind to soil and then break down.	*Spartina*-facilitated sediment buildup in scattered clones would be slowed or halted, but some meadows would continue to capture sediment for many years in most areas of the bay.	*Spartina*-facilitated sediment buildup in scattered clones and meadows would be slowed or halted in most areas of the bay, but over a longer period of time than with IPM. Chemicals would bind to soil and then break down.
Hydrology	Alteration of natural flow patterns would continue unchecked.	Alteration of natural flow patterns would be slowed over the next few years and reversed in the long-run.	Alteration of natural flow patterns would likely be slowed over the next few years. Changes in water movement due to *Spartina* would continue in areas where control could not be accomplished.	Alteration of natural flow patterns would be slowed over the next decade, and possibly reversed eventually.
Water Quality	Potential for temperatures to increase and changes in salinity and oxygen levels.	Potential for short-term herbicide contamination. Greatest potential for reducing temperature increases and changes in salinity and oxygen levels caused by *Spartina*.	Greatest localized increases in suspended sediments. Reduces potential for temperature increases and changes in salinity and oxygen levels, but to a lesser degree than other action alternatives.	Potential for herbicide contamination. Reduces potential for temperature increases and changes in salinity and oxygen levels.
Ambient Sound	No changes.	Short term increased ambient noise levels associated with use of aircraft, airboats, weed cutters, etc.	A higher reliance on large machinery that could work night and day would likely result in more noise than other alternatives.	Even with use of aircraft, this alternative would generate less total noise than other action alternatives mainly because of reduced work opportunity. Ground-based chemical application machinery tends to generate less noise than mechanical methods.
Air Quality	No changes	Of action alternatives, least potential for air pollution from combustion of fossil fuels due to higher efficiency. Less potential for herbicide drift than Chemical Only Alternative.	Of action alternatives, highest potential for pollution from combustion of fossil fuels.	Of action alternatives, there would be a higher potential for herbicide spray drift due to total reliance on chemical control. Pollution from burning fossil fuels may be comparable to that of the Physical/Mechanical Alternative.

TABLE 2B. Alternative Consequences Matrix - Biological Resources.

Biological Issues	No Action Alternative	IPM Alternative	Physical/Mechanical Only Alternative	Chemical Only Alternative
Vegetation	The displacement of eelgrass and macroalgae beds would continue. Within 10 years, nearly all of this habitat on the Refuge may be lost, and one-half of the Refuge's native saltmarsh habitat may be lost. *Spartina* seed dispersal from the Refuge would promote loss of similar habitats off-refuge.	The greatest acreage of native plant habitat would be preserved and eventually restored. All existing mudflat habitat supporting macroalgae and eelgrass on the Refuge would be maintained. Some *Spartina* dominated areas would be converted to mudflat and some would convert to native saltmarsh. Existing native saltmarsh would be preserved. Impacts to off-refuge vegetation due to *Spartina* spread would be minimized.	Of the action alternatives, this would preserve the smallest acreage of native plant habitat. About 1,800 acres of mudflat supporting eelgrass and macroalgae on the southern units would be maintained. Some *Spartina* meadow would likely remain and expand on Long Island tidelands. Less efficiency at controlling *Spartina* on Refuge tidelands would have more impacts to off-refuge vegetation.	About 2,000 acres of mudflat supporting eelgrass and macroalgae on the southern units would be maintained. Most of the existing mudflat habitat would be maintained on Long Island tidelands. Most of the existing *Spartina* meadow on the Refuge would convert to native saltmarsh. Seed production would likely be stopped over time, reducing off-refuge impacts.
Spartina	*Spartina* would continue to spread. *Spartina* dominated acreage on the Refuge is likely to increase to over 4,000 acres within 10 years. *Spartina* seed dispersal from the Refuge would interfere with control efforts off-refuge.	*Spartina* would not increase. Seed production from Refuge lands could be stopped within 5 years. *Spartina* meadows and clones would be mostly eliminated from Refuge lands within 10 years.	*Spartina* expansion would be slowed. Seed production could be stopped on the southern units but not on Long Island without assistance from DNR. Some *Spartina* meadows would likely remain after 10 years of control effort.	Seed production from the refuge would likely be stopped in about 10 years. Meadows would be eliminated from the southern units and greatly reduced around Long Island.
Wildlife	Feeding and resting habitat for waterfowl, other waterbirds, and eagles would be degraded. Most habitat for shorebirds on the Refuge would be eliminated within 10 years. *Spartina* dispersal from the Refuge would contribute to habitat loss off-refuge.	Existing mudflat and native saltmarsh habitat on the refuge would be maintained. Former areas of this habitat, now occupied by *Spartina* would revert mostly to native saltmarsh. Wildlife use of the Refuge would be sustained.	Some existing mudflat habitat would continue to be lost to *Spartina*. Nearly all *Spartina* meadow killed by this alternative would convert to native saltmarsh. Of the action alternatives, this would preserve the least mudflat habitat for migratory bird use.	Most of the existing mudflat and native saltmarsh habitat on the Refuge would be maintained. Former areas of this habitat, now occupied by *Spartina* would revert mostly to native saltmarsh. Wildlife use of the Refuge would be sustained.
Fish	Feeding habitat would continue to be degraded and lost. Prey populations would be altered.	More habitat would be protected for existing fish populations than in other alternatives.	Some habitat would become unusable for fish due to this alternative's likely inability to fully control *Spartina*.	Most of the habitat would be protected for existing fish populations.
Invertebrates	Species composition would change in areas occupied by *Spartina*.	Potential for trampling of invertebrates at work sites. More habitat for the existing invertebrate community would be protected than with other alternatives.	Potential for trampling of invertebrates at work sites. Where *Spartina* is not controlled, species composition would change.	This would have the least potential of the action alternatives for trampling of invertebrates at work sites. Most of the habitat for the existing invertebrate community would be protected.

TABLE 2C. Alternative Consequences Matrix - Social Environment.

Social Issues	No Action Alternative	IPM Alternative	Physical/Mechanical Only Alternative	Chemical Only Alternative
Human Health	Possible increases in mosquito problems, mosquito control programs, and pollen allergies.	Health problems associated with *Spartina* pollen production and mosquitos that breed in *Spartina* meadows would be reduced by *Spartina* control on the refuge within 10 years. This alternative provides the greatest opportunity for the Refuge to reduce such impacts off-refuge.	There could be some reduction in pollen production and in mosquito habitat However, this alternative's inability to fully control *Spartina* would allow these problems to persist to a degree. Greater risk of injury to control workers.	Health problems associated with *Spartina* pollen production and mosquitos that breed in *Spartina* meadows would be reduced by this alternative on the refuge within 10 years, but to a slightly lesser extent than IPM.
Concerns	Concerns with chemical use associated with *Spartina* control on the Refuge would be eliminated. Concern over loss of bay resources would not be addressed. Chemical concerns associated with mosquito control might increase.	Concerns about chemical use would be reduced to the degree that control would not depend exclusively on chemical methods. *Spartina* spread would be stopped on the Refuge, reducing concerns over the loss of Bay resources.	The absence of chemical use would remove concerns about chemical risk. *Spartina* spread would be slowed, but not as much as with IPM or chemical only.	Concerns about chemical risk would be greatest under this alternative. Concerns about *Spartina* spread would be reduced.
Recreation	In the short term, no noise or disturbance to recreational users. In the long term, loss of resources and access would reduce recreational opportunities.	Noise from airboats, hovercraft, and aircraft. Disturbance of waterbirds would reduce bird observations. In the long term, would be beneficial to recreational uses.	Due to reduced control, some recreational opportunities would decline. Noise disturbance to recreational users would likely be greater than with other alternatives.	Noise would be generated by airboats, hovercraft, and aircraft, but over shorter periods of time. Disturbance of waterbirds would reduce bird observations. In the long term, would be beneficial to recreational uses.

TABLE 2D. Alternative Consequences Matrix - Economic Environment.

Issues	No Action Alternative	IPM Alternative	Physical/Mechanical Only Alternative	Chemical Only Alternative
Tourism	No effect in short term. In long term, reduced visitation and tourist dollars.	No effect in short term. In long term, would be beneficial to tourism by maintaining attractive features of the bay.	No effect in short term. In long term, recreational opportunities and tourism would decrease somewhat due to declines in wildlife and fish, native plants, and open water.	No effect in short term. In long term, would be beneficial to tourism by maintaining attractive features of the bay.
Mariculture & Fisheries	Growing seed source on the Refuge would increase *Spartina* control costs on adjacent private and State tidelands. Owners forced to choose between expensive control or relinquishing their title. In long-term, changes in habitat and likely reduced production of fish and shellfish.	Reducing and eventually eliminating seed production from the Refuge would substantially slow *Spartina* invasion of commercial beds and important fish-rearing habitat.	Seed production would not likely be fully controlled on the Refuge. Some spread of seeds to off-refuge habitats would continue. Opportunity for cooperative control efforts on adjacent lands would be unlikely.	The major reduction in seed production from refuge lands would substantially slow the invasion of *Spartina* into commercial shellfish beds and important fish rearing habitat.

3.0 AFFECTED ENVIRONMENT

3.1 INTRODUCTION

This chapter describes the existing environment, that is, the baseline condition in Willapa Bay. It emphasizes the environmental resources and components that would be affected by the alternatives or that would affect the alternatives, if implemented. The chapter is divided into four additional subheadings concerning the physical, biological, cultural/social, and economic environments. It does not address effects. They are covered in Chapter 4, Environmental Consequences.

3.2 PHYSICAL ENVIRONMENT

3.2.1 Location

The proposed project area is the 85,000 acre Willapa Bay (formerly Shoalwater Bay) in extreme southwestern Washington. The bay is separated from the Pacific Ocean by the Long Beach Peninsula. The bay forms an estuary between the ocean to the west of the barrier peninsula and the watersheds of several rivers to the east. The bay's generally shallow water depth, twice daily low tides, and often deep muddy substrate have allowed very limited heavy shipping and industry, resulting in a relative clean and productive environment. Recent concerns have risen about the effects of rapidly expanding residential development as well as past land management practices in the watershed.

Willapa Refuge includes four separate areas in Willapa Bay: the Southern (consisting of Lewis, Porter Point, and Riekkola units); Long Island; Leadbetter Point; and Cape Shoalwater units (Fig. 1). Most of the Cape Shoalwater uplands have been lost to shore erosion. The Leadbetter Point Unit is contiguous with Leadbetter State Park. An area sometimes considered with Refuge lands is the Presidential Proclamation Boundary. This area, which surrounds Long Island, was closed to waterfowl hunting by President Roosevelt in 1940. Some topographic maps mistakenly label this area as the Willapa National Wildlife Refuge.

Spartina grows on tidal flats and stream channels in the Willapa Bay estuary. *Spartina* invasions identified for potential control actions addressed in this EA are located at various locations within the bay. Considered for control are the following categories of lands:

1. Refuge-owned tidelands;
2. State-owned, Refuge-managed tidelands (use-deed lands); and
3. Other State or private tidelands that may affect Refuge lands.

First priority for control will be given to Refuge lands. Of particular concern for Refuge management are *Spartina* plants growing within the Porter Point, Riekkola, and

Lewis units, and adjacent to Long Island. Cooperative activities on other public and private tidelands may occur throughout the estuary.

3.2.2 Soils and Topography

Willapa Bay is a bar-built estuary influenced by geological changes in sea and land levels. It is geologically young, isostatically rebounding, and rapidly accreting sediments (Day, et al 1989). Near-shore subsidence events (underwater earthquakes) are thought to periodically change the relative level of land to water along the Pacific Northwest coast.

Like other Northwest estuaries, Willapa Bay is dominated by mudflats rather than saltmarshes. The physical structure is shaped by dynamic natural forces including large tidal ranges, strong currents, and heavy runoff (Day et al., 1989).

The bay has extensive, gradually-sloping, intertidal flats with small, shallow channels connecting to larger, deeper ones which expedite the cyclic flows of tides. The flats in the southern end of the bay have a fine silty substrate accumulated from upland sediments of rivers and streams flowing into the bay. The upper layer of fine sediments may be regularly resuspended by strong currents, wave action, rainfall on exposed mudflats, biological activity on or below the surface (such as that associated with burrowing shrimp), or human activities (such as boating, aquaculture, or dredging). The nutrient-rich, silty substrates may favor *Spartina* colonization, which then enhances sedimentation as currents are slowed by the vegetation. Further north in the bay where currents are stronger, bare tidal flats collect less silty material and tend to have coarser, sandier bottoms.

While it is clear that logging, road construction, and other forms of development have been introducing sediment into the bay for many decades, we are aware of no studies supporting the hypothesis that the spread of *Spartina* in the bay is a biological response to sediment influx. *Spartina*'s ability to invade all substrates (except solid rock) on the bay in the absence of control strongly indicates that the rapid expansion of this grass would continue with or without changes in sediment loading.

Spartina stems and rhizomes trap and accumulate fine sediments from tidal and river flow and upland runoff (Washington State 1993). Zipperer (1996) found that, relative to mudflats, *Spartina* patches in Willapa Bay were characterized by finer grain sizes, more total sediment deposition, and were at higher elevations. Fraser-Quick (1992) noted that *Spartina* can capture sediment at the rate of between 1.2 and 2.0 inches annually. This results in raised elevations of several inches in 15 to 20 feet diameter clumps of *Spartina* (Williamson 1995). Drainage channels cut deeper as flows become more concentrated. This combined with the raised elevation of *Spartina* vegetation causes steeper channel walls.

3.2.3 Hydrology

The rivers and tributaries that enter Willapa Bay drain an area of more than 900 square miles (Shotwell 1977). The main drainages in the watershed are the Bear, Naselle, Nemah, Palix, Willapa, and North rivers. The mouth of Willapa Bay lies between Leadbetter Point and North Cove at the bay's northwest corner (Fig. 1).

Historically, tidal currents have flowed in and out of the bay through various channels in the bay's mouth. Much of the flow has been directed through the north channel toward North Cove resulting in extensive erosion over the last 100 years (WDOE 1996). In response to the threat of further erosion, Pacific County and the State of Washington are proposing emergency dredging of a middle channel to redirect tidal currents away from Cape Shoalwater/North Cove. Concurrently the Washington Department of Ecology and U.S. Geological Survey initiated a five-year study to identify the causes of coastal erosion in Southwest Washington, including the Cape Shoalwater/North Cove area (WDOE 1995). The dynamic circulation forces also enhance the colonization and spread of characteristically invasive species like *Spartina* by distributing propagules throughout the area (Zipperer 1996b).

Runoff patterns of Pacific Northwest coastal rivers exhibit peak flows in the winter associated with increased precipitation (Proctor 1980). Heavy winter runoff combined with storm surges and seasonally high tides produce flooding in adjacent low-lying areas. Restricted flows resulting from raised elevations or intertidal vegetation can cause water to back up, thus, exacerbating flooding.

3.2.4 Water Quality

Willapa Bay is commonly perceived as one of the least spoiled and most productive estuaries remaining in the contiguous 48 states. Adjectives such as 'pristine' and 'unspoiled' are often used as descriptors of the bay and its waters. Water is the principle erosion agent along the Pacific Northwest coast (Proctor 1980). Runoff from upland sites in the watershed combine with the inflow of marine waters, including that from the Columbia River, to produce a rich soup of soil particles, salts, nutrients, pollutants, and organisms. Without mixing agents, the freshwater runoff would tend to remain primarily on the surface above the denser saltwater. But winds and tides combine to mix the waters. In brackish, tidally influenced estuaries of western Washington, salinities range from 20 to 30 ppth at the mouth to 0 ppth at the limit of saltwater intrusion (average salinity is 32 ppth in the Pacific Ocean) (State of Washington 1993).

Where *Spartina* dominates, the water column may be affected in several ways. With restricted flows, surface water temperatures may increase. Salinity may increase or decrease depending on the effects on evaporation and mixing rates. Levels of dissolved oxygen may decrease due to decomposition of *Spartina* litter after seasonal die back.

Water quality may be improved because the *Spartina* traps suspended sediments or filters pollutants.

Beginning in the spring of 1997, the Washington Department of Ecology is conducting an EPA-funded project to study water quality parameters in Willapa Bay. Water temperature, dissolved oxygen, nutrients, chlorophyll, pH, light transmission, and turbidity as measured by Secchi disk depth will be determined at six locations (Newton 1997).

3.2.5 Tides

On the West Coast of North America, there are two high tides and two low tides in each daily cycle. The two sets of tides are of differing heights, producing a higher and lower high tide as well as a higher and lower low tide each cycle (mixed diurnal) (Shotwell 1977). The mean diurnal tide [between mean higher high water (MHHW) and mean lower low water (MLLW)] for Willapa Bay ranges from about 8.1 feet at the entrance to about 10.2 feet near Nahcotta (NOAA 1977).

At high tide, Willapa Bay is a wide expanse of open, albeit shallow, water; whereas, more than 50% of the bay's mud flats may be exposed at low tide (Hedgepeth and Obrebski 1981). All of the proposed project area is tidally influenced to some degree. The highest elevations may be covered only during the higher annual tides whereas the lowest portions are exposed only during the lower annual tides.

The tidal cycles greatly affect mobility and uses in the bay, including *Spartina* control efforts. Although most of the proposed control actions would occur on mudflats exposed between MHHW and MLLW, some actions would be conducted for *Spartina* occurring more than a foot above or below these elevations. The large range of and strong currents associated with the tides increase the potential colonization and spread of *Spartina* within and outside the bay.

3.2.6 Estuarine Functions

As an estuary, Willapa Bay is a semi-enclosed coastal body of water with free connection to the open sea and within which sea water is measurably diluted with freshwater derived from upland drainage (Pritchard 1967). Estuaries provide an interface between riverine freshwater and marine saltwater ecosystems. The intermix of fresh and salt water, a complex drainage structure, ever-changing tidal currents, and varying runoff levels combine to create a dynamic system with shifting circulation, stratification, mixing, and flushing patterns (Day et al. 1989). Sediments, nutrients, and biota flow among the terrestrial, riverine, and marine environments via the estuary (Simenstad 1983). Within the Willapa Bay estuary, a dynamic system of biological, chemical, and physical forces interact to produce an environment which is biologically productive and economically valuable to humans (Shotwell 1977). Since estuarine functions would be affected differentially by the separate alternatives discussed in this

document, functions are tracked through the individual resources that contribute to or are a product of the functions.

Spartina dynamically alters West Coast estuarine functions. Calloway and Josselyn (1992) noted *Spartina* "may affect sedimentation rates and patterns, available detritus, benthic algae production, wrack deposition and distribution, habitat structure for native wetland animals, benthic invertebrate populations, and shorebird and wading bird foraging areas." In its native East Coast environment, *S. alterniflora* is used in salt marsh creation because of its ability to rapidly convert disturbed or newly created tidal flats to vegetated marsh and its importance as a native primary producer and detritus source. In its endemic distribution, *Spartina* is naturally the dominant vegetation of the lower intertidal area and the foundation of estuarine food webs. On the West Coast, *Spartina* is viewed as an aggressive exotic that alters estuarine structure and function, excludes native salt marsh and mudflat vegetation and eliminates native habitat for shorebirds, waterfowl, and certain shellfish and finfish (Sayce 1988, Mumford et al. 1990, Simenstad and Thom 1995).

Alterations in sediment grain size, marsh elevation, and tidal configuration may occur as *Spartina* patches grow larger or expand into new areas (Thompson 1991, Simenstad and Thom 1995). Zipperer (1996b) found that, relative to mudflats, *Spartina* patches in Willapa Bay were characterized by finer grain sizes, more total sediment deposition, and greater amounts of below- and above-ground structure. She also found that *Spartina* patches were at higher elevations and exhibited dampened temperature fluctuations throughout the year.

3.2.7 Wetlands

The entire project area is tidal wetlands with either mudflats (with or without eelgrass), native saltmarsh, or *Spartina* marsh.

3.2.8 Research Natural Areas

Three Research Natural Areas (RNAs) occur on Refuge uplands. The Diamond Point RNA on Long Island is forested upland habitat immediately adjacent to large expanses of *Spartina* targeted for control. The Cedar Grove RNA on Long Island is also forested upland but is not adjacent to any shoreline or *Spartina*. The Leadbetter Point RNA, a dune complex encompassing the entire Leadbetter Point Unit, has *Spartina* concentrations on the tidal flats to its eastern (bay) side.

3.2.9 Climate

The climate of the Pacific Northwest coastal region is marine influenced (Proctor et al. 1980). It is characterized as a mid-latitude, West-Coast, marine type with very wet winters and dry summers. It has high rainfall and a moderate temperature range (Phillips 1984). Snow is unusual. Rainfall is highest in December and January, and lowest in July. Annual precipitation ranges from about 60 to 80 inches near the coast

on the west side of the bay to 100 to 120 inches in the Willapa Hills to the east (Proctor et al 1980). Predominate winds are on-shore from the open ocean. Strong southerly winds usually accompany winter storms. Some meteorologists think that the region has entered into a 20-year wet cycle with above-average precipitation rates over the past two years.

3.2.10 Air Quality

There are no major industrial sources of air pollution around the Willapa Bay estuary. The predominant onshore winds and winter storms assure an almost constant replenishment of clean, fresh air from the Pacific Ocean. Temperature inversions that might trap smoke or other pollutants are rare. Airborne pollen from *Spartina* is increasing during the plants' flowering season, especially downwind of large clones and meadows.

3.2.11 Visual Resources

From land, the proposed project area is visible from vantage points along Highway 101, all Refuge units, Leadbetter State Park, and bay-front property. The area may also be seen from water or air.

The proposed control sites range from mostly open mudflats, which grow a summer cover of eelgrass and algae, to extensive *Spartina* marshes. Small clones and individual plants may grow far out onto these mudflats while a fringe of saltmarsh vegetation may grow along the higher flats above *Spartina* clones and meadows. On the Refuge, massive *Spartina* meadows visually dominate the intertidal flats along the northeastern shoreline of Long Island, on the east side of Long Island Slough immediately north of Refuge headquarters, and north of the native saltmarsh to the west of Porter's Point. Of these major *Spartina* meadows, those along the northeastern shore of Long Island dominate the intertidal flats from subtidal channel to upland vegetation.

The mud appears grayish brown but turns greenish from algae and eelgrass in summer. The saltmarsh and *Spartina* plants are green in the summer, turning reddish and then brown in the fall. Native saltmarsh plants are usually beaten down in-place during winter, whereas *Spartina* breaks off and washes away leaving a stubble appearance on the mud. The dead *Spartina* stems are seen after they wash up on bay shores and ocean beaches, especially along Long Beach Peninsula. Sometimes large floating mats of dead *Spartina* are carried onto high intertidal saltmarsh vegetation by the highest tides. The brown mats remain until the tidal cycles return to tides high enough to refloat them.

3.2.12 Ambient Sound

Most proposed project sites on- and off-Refuge are relatively isolated and inaccessible with few unnatural sound sources nearby. A few are closer to development and human-generated noises. Engines in oyster dredges, boats, vehicles, and planes are primary

noise sources. Surf crashing onto the ocean beach is the source of a constant background noise that varies in intensity with wind and surf conditions.

3.2.13 Infrastructure

There are no roads, trails, or other access structures to proposed project sites. Most of the intertidal lands in the south end of the bay are soft, silty mud. Primary access to project sites on the Refuge will be via airboat or hovercraft from the boat ramp at Refuge headquarters on U.S. Route 101 or the dike road in the Refuge's southern units. Additional potential access points include Leadbetter Point State Park, Palix River, North River, and Bay Center. Other sites may be identified in the north end of the bay as control efforts expand.

Upland routes associated with the Refuge include a single-lane dirt road atop the dike in the southern units, abandoned logging roads (becoming trails) in the Long Island Unit, and a hiking trail system at the Leadbetter Point Unit. Sandridge Road, including a portion of State Route 103, and Stackpole Road traverse the bay side of the Long Beach Peninsula and provide access to the Leadbetter Point Unit. U.S. Route 101 stretches along portions of the east side and south end of the bay, while State Route 105 runs along the north end.

3.3 BIOLOGICAL ENVIRONMENT

3.3.1 Vegetation

3.3.1.1 Seagrass *(Zostra* spp.) Community

One of the largest seagrass (eelgrass) meadows in the Pacific Northwest occurs in the protected estuarine waters of Willapa Bay (Phillips 1984). Hedgpeth and Obrebski (1981) described an eelgrass community as "a whole system of growth, catchment of detritus, support of microbial associations, source of oxygen by day and deprivation by night, the mainstay of small crustacea, and modifier of current and sedimentation patterns and nutrient regimes." Wyllie-Echeverria and Hershman (1994) listed six major functions of seagrasses from Wood et al. (1969): (1) stabilize bottom sediments; (2) slow and retard current, prompt sedimentation, and inhibit resuspension of organic and inorganic matter; (3) provide shelter and substrate (for other organisms); (4) provide grazing and detrital food pathways; (5) support high productivity; and (6) cycle nutrients internally.

Refuge mudflats, totaling more than 2,700 acres, support beds of native eelgrass *(Zostra marina),* and introduced Japanese seagrass *(Z. japonica),* (referred to collectively as seagrasses in this document). In Willapa Bay, *Z. marina* occurs in the lower intertidal and subtidal; whereas, *Z. japonica* is abundant on the middle to lower intertidal mudflats. The presence of seagrasses is critical in the foodweb (Wylie-Escheverria and Hershman 1994). Many waterfowl species depend on the seagrasses

and small invertebrates associated with them for food. Baldwin and Lovvorn (1994) found that in Boundary Bay, British Columbia, eelgrass comprised the largest single portion of the diet for black brant *(Branta bernicula nigricans)* geese; and American wigeon (*Anus americana*), northern pintail (*A. acuta acuta*), and mallard (*A. platyrhynchos platyrhynchos*) ducks. They also found the greatest amount and variety of most invertebrate foods of waterfowl in the eelgrass zones.

3.3.1.2 Native Saltmarsh Vegetation

Native saltmarsh vegetation in the upper tidal flats includes pickleweed (*Salicornia virginica*), jaumea (*Jaumea carnosa*), saltgrass (*Distichulis spicata*), seaside arrowgrass (*Triglochin maritimum*), tufted hairgrass (*Deschampsia caespitosa*), and saltmarsh bulrush (*Scirpus maritimus*) (Sayce 1993, Zipperer 1996b). There are about 500 acres of native saltmarsh on the Refuge.

Investigations by the Wetland Ecosystem Team, University of Washington were initiated on the Refuge under Special Use Permit in 1994. These studies are investigating the effects of *Spartina* upon littoral mudflat community function and the ecological effects of native species and *Spartina* on marsh progradation. Some preliminary results of this work are discussed throughout this EA under various citations. Final publications for these studies are expected in 1997 or 1998.

3.3.1.3 Exotic *Spartina* Marsh

Spartina or cordgrass was introduced to the West Coast during the 1890's resulting from its use as packing material for oyster shipments from the East Coast (Frenkle and Kunze 1984). Although *Spartina* clones were seen in Willapa Bay in 1911 (Scheffer 1945) and a Refuge Manager noted it in an Annual Report in 1942 (USFWS 1942), recent climatic events have apparently spurred its spread. In the mid-1970's, the growth and expansion of *Spartina* gained the attention of many public and private land owners and natural resource managers. In 1987, the Refuge funded research to inventory and investigate the reproductive ecology of *Spartina* (Mumford et al., 1990).

Several theories have been generated about the rapid growth and expansion of *Spartina* in Willapa Bay in recent decades. A popular one is that warmer ocean temperatures associated with a series of El Niño events in recent years have favored the growth and spread of the plant in the Pacific Northwest. Typical of Pacific Northwest estuaries, the geologically young Willapa Bay with its relatively high tidal range has characteristically large expanses of mudflats which are susceptible to *Spartina* invasion.

In favorable alien environments, plant species tend to be more vigorous and taller, producing more seeds than in their native distribution (Crawley 1987 in Blossey and Notzold 1995). *S. alterniflora* in Willapa Bay represents the largest *Spartina* infestation in the state of Washington (Washington State 1993). The rate of spread of *Spartina* is geometric, that is, the quantity of growth each year increases based on the

increased amount of *Spartina* from the previous year. In 1945, 4.5 acres of *Spartina* were present, 432 acres in 1982, 2,400 acres in 1990 (Marks 1995), and 4,700 acres in 1996. Stiller and Denton (1995) noted that at current expansion rates *Spartina* threatens to occupy most of the intertidal habitat in Willapa Bay within 40 years. Some of the largest acreages of *Spartina* meadows in the bay occur on Refuge fee-simple title lands (300 acres) or Refuge-associated use deed lands around Long Island (1,000 acres). Small *Spartina* clones and individual plants may invade native saltmarsh vegetation and small patches of native vegetation may survive in nearly monotypic *Spartina* meadows.

Each fall the above-ground *Spartina* stems die back and break off to float as wrack. Sometimes large floating mats of dead *Spartina* form that may be carried onto high intertidal saltmarsh vegetation by the highest tides. They remain there, smothering underlying vegetation until the tidal cycle returns to high enough tides to refloat them. The *Spartina* rhizomes sprout new stems which grow in the spring.

Spartina acts as a pioneer species in sheltered tidal coastal and estuarine environments. Calloway and Josselyn (1992) found that *Spartina* in San Francisco Bay had a much better chance of becoming established in new areas than native plants, and once established, it spread more rapidly than native plants. *Spartina* sexually reproduces via yearly seeding and native patches can spread vegetatively an average of 1.5 feet/year via rhizome or tiller expansion (Sayce 1986, Mumford et al 1990, Zipperer 1996b). Seeds are the primary source of new plants and colonies; but plants also grow from pieces of root or rhizomes. Plants spread laterally from underground roots (rhizomes) or by above-ground shoots (tillers) to form clonal colonies. Lateral growth of individual clones has been measured at up to 1.6 feet per year in Willapa Bay and 3.6 to 5.6 feet per year in Padilla Bay (WDOA 1992). As individual colonies spread, the circular clones ultimately grow together to form dense monotypic meadows (Mumford et al 1990).

Spartina can occupy a broad range of intertidal substrates from soft silty muds to coarse sand and cobbles, and it tolerates a wide range of salinity from ocean concentrations to almost pure freshwater (Aberle 1993). Mumford (1990) found that *Spartina* grows within 3 feet of MLLW, is tolerant of a wide range of pH and salinity, and withstands prolonged tidal inundations. Bertness and Ellison (1987) found that, unlike other native high-marsh perennials in saltmarshes of New England, *S. alterniflora* is capable of vigorous growth across the entire marsh zonation. In Willapa Bay, *Spartina* occurs on intertidal and subtidal mudflats - from the sides of tidal drainage channels up into the high vegetated marshes of the upper intertidal, sometimes to upland vegetation. Early establishment usually occurs just below the saltmarsh with further spread occurring both far out onto the mudflats and up into the saltmarsh (Hidy 1995).

In New England saltmarshes, Bertness and Ellison (1987) reported that *S. alterniflora*

and saltgrass occupy recently disturbed areas because of differential mortality and re-occupancy strategies. In short-term disturbance events, such as covering by dead plant material (wrack), these species are more tolerant of burial than other saltmarsh plants. Longer lasting disturbances kill all underlying vegetation, leaving discrete bare spots. S. *alterniflora* recruits into these patches by seed, while saltgrass recolonizes with vegetative runners. The relative abundance of these species in recently created bare patches greatly exceeds their relative abundance in surrounding vegetation.

Possible benefits that have been advanced for *Spartina* include its ability to filter pollutants, control erosion, and as a link in the food-chain. The specific capabilities of a *Spartina* marsh to filter pollutants from the water column compared to native West Coast saltmarsh vegetation are not documented. Perhaps, where *Spartina* accretes sediments, it slows the water column sufficiently so that denser particles and pollutants settle out of the water. Once established on high-energy, shallow flats, thick growths of *Spartina* may help dissipate waves enough to reduce deterioration of adjacent shorelines prone to wave erosion. It will neither retard shoreline erosion associated with a deep undermining current such as that causing erosion at Cape Shoalwater, nor will it affect shoreline erosion caused by the collapse of steep banks due to saturated soils. When available to dabbling ducks, *Spartina* seed may contribute to waterfowl diets in Willapa Bay. But seed concentrations are mostly available only during tides high enough to allow access of the birds over the tall *Spartina* meadows. No grazers, whether macro- or microscopic, are known for *Spartina* in Pacific Northwest estuaries.

Simenstad and Thom (1995) considered *Spartina* as an exotic of questionable benefit to West Coast estuaries. They noted that, while mud and sandflat community food webs (based on benthic microalgae) will decline with continued *Spartina* expansion, they will be replaced by webs driven by the extensive supply of *Spartina* detritus. Food webs based on seagrass communities (*Z. japonica*) are lost by *Spartina* displacement. Ongoing and future research in Willapa Bay may eventually enable us to evaluate and predict more accurately the larger ecosystem consequences and effects on micro and macro communities (whether beneficial or not).

In addition to extensive colonization within Willapa Bay, *S. alterniflora* also appears in Gray's Harbor, Copalis River estuary, Puget Sound, Sequim Bay, and the Strait of Juan de Fuca. Its cogener, *S. patens,* and the English species complex, *S. angelica/townsendii*, are also reported in Puget Sound (Mumford et al. 1990, Rigs and Bulthuis 1994, Simenstad and Thom 1995, Zipperer 1996b). It is not known how all populations of *Spartina* in Washington originated, but it is speculated that the Grays Harbor one derived from Willapa Bay. None are as old or extensive as that in Willapa Bay. Besides Washington, *Spartina* occurs as an exotic species in Oregon, California, Great Britain, France, The Netherlands, New Zealand, and China (Aberle 1993).

3.3.2 Wildlife

Willapa Bay has diverse wildlife resources. About 233 species of birds, 51 species of mammals, and 17 species of amphibians and reptiles (resident or migratory) are known to use Refuge lands and associated waters (US Fish and Wildlife Service 1991).

3.3.2.1 Aquatic Migratory Birds

The Refuge was established for the protection of habitat for wintering and migrating aquatic birds including ducks, geese, brant, swans, shorebirds, and wading birds. The use of the Willapa Bay estuary by waterbirds (here referring to loons, grebes, cormorants, herons, bitterns, ducks, geese, brant, plovers, sandpipers, dunlin, and other shorebirds) is of special significance. Willapa Bay is one of ten major wintering and resting areas for waterfowl and shorebirds of the Pacific Flyway. It is one of three sites in Washington that gets more than 100,000 shorebirds at a time (Page et al., 1992). As a major flyway stopover point and staging area, Willapa Bay is of critical importance for fuel replenishment for migrating aquatic birds, some of which may travel 10,000 miles one way in their annual flights.

The numbers of waterfowl and shorebirds are lowest in summer, and highest in spring and fall, but remain relatively high throughout winter. As many as 135,000 shorebirds may be present at one time during spring migration (Page et al., 1992).

These birds depend on the abundance of mudflat invertebrates, seagrasses, native saltmarsh plants, and associated invertebrates for food. The birds tend to feed mostly in the high intertidal mudflats, which are the first areas available as the tides recede and the last ones covered by incoming tides. Since *Spartina* usually establishes first in the high intertidal and then spreads into lower and higher zones, this important zone is the first lost to most waterbird species by dense *Spartina* vegetation.

Spartina is beneficial to wildlife in its native East Coast environment, but is considered detrimental in Willapa Bay and other estuaries of the Pacific Northwest, where it is not native. This concern draws from the fact that wildlife on either coast has evolved to best use the natural conditions of the native environment. Major changes in an environment can produce profound effects on the wildlife. *Spartina* can impose particularly dramatic, large-scale changes because it colonizes the broad, open mud and sandflats characteristic of the region's geologically young estuaries. The estuary's food-webs are based on the eelgrass and algal communities of those flats. Besides the structural changes, which impede the movement of much of the currently abundant wildlife, *Spartina* also changes the very basis of the food webs that the native wildlife depends on.

Waterbirds speed up nutrient turnover in estuaries through digestion of plant matter and defecation. Baldwin and Lovvorn (1994) found that waterfowl, especially brant, accelerated nutrient regeneration through the excretion of large quantities of feces

derived from eelgrass that would otherwise decompose very slowly. Erwin (1996) also recognized the importance of waterbirds and associated raptors as top-level consumers, and critical links in nutrient flux in shallow-water estuaries.

Ducks using Willapa Bay are mostly widgeon; northern pintail; teals (*Anus crecca carolinensis, A. discors, A. cyanoptera*); and mallards. Average annual duck use on the Refuge is estimated to be 2.2 million use-days. Canada geese (*Branta canadensis*) around the bay are mainly lesser (*B. c. parvipes*), tavenor (*B. c. taverneri*), cackler (*B. c. minima*), and dusky (*B. c. occidentalis*) subspecies with fewer numbers of western (*B. c. moffitti*), Vancouver (*B. c. fulva*), and Aleutian (*B. c. leucoparia*) subspecies. There are an estimated 400,000 goose use-days per year on the Refuge. Black brant use is estimated at about 200,000 use-days within the Presidential Proclamation Boundary and 800,000 use-days baywide annually.

Table 3 shows average waterfowl use at Willapa Bay from 1988-1992. Entries reflect use on or immediately adjacent to Refuge lands and within the Proclamation Boundary (U.S. Fish & Wildlife Service 1992).

TABLE 3. Average Annual Number of Waterfowl Use Days 1988-1992.

	Swans	Geese	Brant	Ducks	TOTAL
Average	916	376,700	213,100	2,106,220	2,697,220

Source: U.S. Fish and Wildlife Service, Annual Narrative Report 1992.

3.3.2.2 Mammals

Few mammals use the proposed project sites. River otter (*Lutra canadensis*) may venture into channels on the mudflats in search of fish. Small mammals such as shrews, mice, or voles live in native saltmarsh vegetation and may be present in *Spartina* clones or meadows in the high intertidal area above regular tidal inundation. Harbor seals use channels for swimming and feeding, and haul out on sandy bars or islands throughout the bay to rest. Other marine mammals generally use the deeper, more saline waters of the northern end of the bay.

3.3.2.3 Threatened and Endangered Species

The following federally listed threatened (T) or endangered (E) Species may occur in Willapa Bay and adjacent uplands: bald eagle (*Haliaeetus leucocephalus*), T; western snowy plover (*Charadrius alexandrinus nivosus*), T; marbled murrelet (*Brachyramphus marmoratus marmoratus*), T; Aleutian Canada goose, T; peregrine falcon (*Falco peregrinus*), E; brown pelican (*Pelecanus occidentalis*), E; and Oregon silverspot butterfly (*Speyeria zerene hippolyta*), T (USFWS 1995 & 1996a & b). The latter species was last seen on the Long beach Peninsula in 1990 (WDW 1993). Stellar sea-lion (*Eumetopias jubatus*), T; green sea turtle (*Chelonia mydas*), E; loggerhead sea turtle (*Caretta caretta*), (T); and leatherback sea turtle (*Demochelys corlacea*), E

(USFWS 1995 & 1996a & b) are considered rare visitors to Willapa Bay. If present, they would use only the deepest, most saline waters at the north end of the bay.

During the spring, 1997, aerial survey, eight active bald eagle nests with incubating adults were observed around Willapa Bay (Anderson, personal communication, 1997). Two nest sites located on Long Island, near the largest *Spartina* meadows, were not active this year. Some of the active nests were up to one mile from water. Some were even further from existing *Spartina*. Leadbetter Point has one of two nesting colonies of snowy plovers in Washington. Small groups of plovers nest on the beach west of the mouth of the bay and on a small island off Leadbetter Point. Federally proposed Critical Habitat for the plovers occurs on the ocean beach at Leadbetter Point.

One Threatened plant, water howellia (*Howellia aquatilis*) may occur in freshwater wetlands, ponds, or lakes in the vicinity of Willapa Bay.

3.3.2.4 Other Species of Special Concern

The Washington, D.C., office of Migratory Bird Management in the U.S. Fish and Wildlife Service prepared a 1995 list of Migratory Nongame Birds of Management Concern in the United States. The Western Washington Office (Olympia) of the U.S. Fish and Wildlife Service identified Species of Concern occurring in the western portion of Washington State in 1996. Species of Concern are those species whose conservation standing is of concern to the Service, but for which status information is still needed. Of those Species of Concern that occur at Willapa Bay, the northern goshawk (*Accipiter gentilis*), olive-sided flycatcher (*Contopus borealis*), long-eared myotis bat (*Myotis evotis*), and long-legged myotis bat (*Myotis volans*) do not commonly use the intertidal habitat.

The State of Washington has its own Threatened and Endangered (T & E) Program and associated lists of species. In addition to State-listed species duplicated in the Federal lists above, the State has named candidate species for consideration for State T & E status. The following candidate species, which occur in Willapa Bay and adjacent lands, merit special consideration: Pacific harbor porpoise (*Phocoena phocoena*), common loon (*Gavia immer*), Brandt's cormorant (*Phalacrocorax penicillatus*), pileated woodpecker (*Dryocopus pileatus*), and western bluebird (*Sialia mexicana*) (WDFW 1994).

The Newcomb's littorine snail (*Algamorda subrotundata*) is on the State candidate species list and is considered a Species of Concern by the Service's Western Washington office. The snail is reported from Neah Bay, Washington to Humboldt Bay, California and occurs in Willapa Bay. Over its range, habitat loss and pollution are thought to be the greatest threats. The greatest known area and most secure habitat for this species appears to be in Washington State. The snail is associated specifically with saltmarshes that have pickleweed or *Salicornia* (WDFW 1995, USFWS 1996). So

the snail is expected to be present in the pickleweed zone of the high intertidal marshes, such as occurs in the south end of Willapa Bay. Its pickleweed habitat is reduced by the invasion of *Spartina* into the high intertidal.

While not listed, the Olympia oyster (*Ostrea lurida*) is native to the Pacific Northwest and occurs in marine waters from Baja California, Mexico to Sitka, Alaska. Once common in Washington, the Olympia oyster now has a restricted and very patchy distribution in Willapa Bay, Gray's Harbor, and southern Puget Sound, where it is locally abundant due to mariculture activities. Olympia oysters are susceptible to significant population declines due to their inclination to settle in discrete aggregations or reefs which are vulnerable to disturbance, over-harvest and pollution (USFWS 1989, Dumbald 1997). Throughout their range, habitat available to the native oyster, besides being naturally limited, has been affected by human activities. Commercially, the Pacific or Japanese oyster (*Crassotrea gigas*) is favored by mariculturalists because of its larger size, better marketability, and ease of production (USFWS 1988). Both species are filter feeders, and rely on zooplankton and phytoplankton. The gill openings are larger in Olympia oysters than Pacific oysters and allow for selection of larger food items but do not allow the Olympia oyster to consume very small plankton. Olympia oysters usually inhabit low intertidal flats or small tidal channels where they avoid freezing or drying, conditions to which they are sensitive if exposed for extended periods (USFWS 1989, Dumbald 1997). Their habitat is threatened by *Spartina* as it spreads into lower intertidal zones.

Not listed, but of concern due to potential disturbance during nesting, great blue herons (*Ardea herodias*), that regularly feed in the bay's intertidal habitat, have historically used a rookery located near Paradise Point on Long Island, adjacent to a large, dense meadow of *Spartina*. This heronry has not been active in recent breeding seasons (1994-97) (Williamson 1997). Willapa Bay is one of two major overwintering and migratory rest areas for black brant in Washington. It is also a major migratory stopover or overwintering area for tens to hundreds of thousands of waterfowl and shorebirds, several of which have special management considerations. While the latter two groups are susceptible to disturbances on the flats, conflicts will be avoided since control activities will take place in summer, while peak numbers occur from fall through spring.

3.3.3 Fish

No comprehensive fish list is available for Willapa Bay. During a research project within the southern units of the Refuge, Allard (1991) reported catches representing 12 different species (Table 4) throughout one year of effort.

TABLE 4. Species and Numbers of Fish Caught in Southern Portion of Willapa Bay, March 1990 through February 1991.

SPECIES	NUMBER
Shiner Surfperch (*Cymatogaster aggregata*)	1,564
Staghorn Sculpin (*Leptocottus armatus*)	434
Surf Smelt (*Hypomesus pretiosus pretiosus*)	394
Threespine Stickleback (*Gasterosteus aculeatus*)	372
Chum Salmon (*Oncorhychus keta*)	56
Northern Anchovy (*Engraulis mordax*)	6
Chinook Salmon (*O. tshawytscha*)	5
Starry Flounder (*Platichthys stellatus*)	5
Walleye Surfperch (*Hyperprosopon argentem*)	2
Pacific Herring (*Clupea harengus*)	1
Bay Pipefish (*Syngnathus californiensis*)	2
Saddleback Gunnel (*Pholis ornata*)	1
TOTAL	2,842

Source: Allard 1991

3.3.4 Micro-Organisms and Other Marine Invertebrates

An important part of the biological environment of the bay is the plankton - the bacteria, and tiny plants and animals living in the water and mud. They combine and convert the many nutrients of the estuarine waters into living matter and more nutrients. Because they are so fundamental an aspect of the overall environment, they are considered an inherent part of the water column itself (Shotwell 1977).

Hedgpeth and Obrebski (1977) consider Willapa Bay as perhaps the most productive bay on the U.S. Pacific Coast. It provides an optimum environment for many estuarine species. Rivers and streams bring minerals and nutrients in terrestrial runoff. Plant matter from saltmarsh plants and eelgrass community is broken up and transported throughout the bay by waves and tidal actions. Invertebrates, waterfowl, fish, and plankton further decompose some of the detritus and deposit recycled nutrients. The resulting rich soup of nutrients is food to various filter-feeding and scavenging invertebrates including plankton, clams, oysters, shrimp, and crab.

Zipperer (1996b) found that invertebrate species composition and total numbers are

different in *Spartina* patches and open mudflats in Willapa Bay. Adjacent mudflats have higher total invertebrate densities and lower taxa richness late in the season (August) but lower total densities and similar taxa richness to *Spartina* early in the season (April). The benthic invertebrate assemblage of the mudflats are characterized by a dominance of crustaceans, polycheates, and mollusks (important shorebird foods), while characteristic assemblages in *Spartina* patches were polychaetes, oliochaetes, and dipteran larvae (not as important an assembly of foods).

3.3.5 Biodiversity

In simplest terms, biodiversity is the variety of life and its processes. Murphy (1988) used Wilcox' description of biodiversity: "the variety of life forms, the ecological roles they perform, and the genetic diversity they contain." It is highest when there are many well-represented species in a place. It is lowest in places with little variety of well-represented species, or where one or a few species dominate. Biodiversity supports the stability, integrity, and resilience of ecological systems. In this document, biodiversity is applied at the species and community level. Willapa Bay tidelands provide crucial habitat for diverse communities of birds, fish, and invertebrates. But the bay's insular nature and relatively low plant diversity also make it vulnerable to exotic species invasions.

3.4 SOCIAL ENVIRONMENT

3.4.1 Cultural

The proposed project area is entirely uninhabited tidal flats of Willapa Bay. Swan (1982) relates several areas that were inhabited, considered sacred places, or were meaningful in the lore of the Native Americans of Shoalwater Bay in the mid-1800s. No known historical or archeological sites occur in Refuge-owned lands proposed for *Spartina* control. Abramowitz (1980) inventoried portions of the southern units, south of the dike that separates intertidal flats from the freshwater wetlands. No evidence of any cultural resources was found during the inventory and he noted none had been found previously. No further inventories have been done in the area.

Abramowitz surmised that better locations for camps or villages of Shoalwater Chinooks existed further up the Bear River or elsewhere in the south end of the bay. Bear River and Tarlatt Slough were identified as the northern termini for portage routes between the Columbia River and points north for trading purposes by Chinook Indians.

Cook and Jordan (1994) noted that 489 residents of Pacific County were identified as "American Indians" in the 1990 census. Approximately 180 members of the Shoalwater Tribe live on approximately 1,000 acres near the base of the Tokeland Peninsula at the north end of the bay.

There are claims by Native Americans that much of the land along the lower Columbia

River and on Willapa Bay was never legally transferred to the United States (Chinook Tribal Council 1996). The Refuge was established by Executive Order in 1937. Refuge purposes have been established by Executive Order and legislation and are summarized in part 1.2 of this EA. In the absence of contrary legal direction, the Service is obligated to abide by such Executive Orders and Federal Statutes.

3.4.2 Social

The proposed project site lies entirely in Pacific County, Washington. The population of this mostly rural county in 1993 was 19,800 (Cook and Jordan 1994). Communities on Willapa Bay include Oysterville, Nahcotta, Bay Center, South Bend, Raymond, and Tokeland. Other nearby communities on the Long Beach Peninsula are Ocean Park, Long Beach, Seaview, and Ilwaco. South Bend is the county seat.

The population of Pacific County is aging. The average age of its citizens is the highest of any county in the State. Between 1990 and 1993 the county had more deaths than births. There was a substantial increase in residents over the age of 59 as a result of retirement and near-retirement migration in addition to aging of younger residents (Cook and Jordan 1994).

3.4.2.1 Human Health

Compared to the State as a whole, Pacific County has statistically higher, age-adjusted lung cancer deaths and heart disease rates. It has lower rates of breast cancer and higher rates of teen pregnancy (Spoor 1997). These and other such statistics will be presented in a document on Pacific County health status which is scheduled to be available in the summer of 1997. The document will consider data from the early 1980s through 1995. There is no indication of local environmental causes for Pacific County's differences in health statistics (Spoor 1997, Harrison 1997).

In the early 1990s, the Shoalwater Bay Tribe experienced an extremely high level of pre-natal complications and infant mortality. In response, the tribe called for improved access to health care and a major effort to evaluate the potential social and environmental causes of their health problems. A health care facility was completed and opened in 1995. Also in 1995, a limited assessment of some potential pollution sources in the vicinity of the reservation was carried out by the EPA's Regional Laboratory in cooperation with its Washington Operations Office. The limited assessment involved a relatively small number of samples collected and analyzed at one point in time. Sampled during the assessment were: 1) an abandoned dump site one mile west of the reservation; 2) drainage from nearby agricultural runoff; 3) adjacent tideflats (tested for carbaryl, glyphosate, septic system effluents, and other organic or inorganic contaminants); and 4) drinking water. While the study found several pesticides exceeding federal and state water quality standards in drainage from cranberry bogs, sediment samples from the tideflats were relatively clean. The study did not reveal a link between infant mortality and environmental conditions (USEPA

1997). Glyphosate was not detected in sediment samples collected for the EPA Limited Environmental Assessment; however, little chemical control of *Spartina* had been attempted in Willapa Bay prior to sample collection for this study.

Public agencies that can be contacted concerning environmental contamination in Pacific County are Pacific County Department of Community Development and Pacific County Department of Public Health. In addition, agencies that can be contacted concerning environmental contamination associated with applications of agricultural chemicals on Willapa Bay are the Washington State Department of Agriculture, Pesticide Management Division and the Washington State Department of Ecology, Office of Water Quality, both in Olympia. Willapa NWR Headquarters office can be contacted by phone for information on scheduled applications of herbicides on the Refuge.

While saltmarsh mosquitos were undoubtably a part of the Willapa Bay's insect community prior to *Spartina's* introduction, older *Spartina* meadows provide habitat that may favor mosquito larval development (pools with poor tidal circulation and an absence of predatory fish). Major programs for the control of saltmarsh mosquitos on *Spartina*-dominated east coast saltmarshes have been in place for decades (Wolfe 1996). Such programs have involved the use of chemicals and environmentally disrupting ditching systems. There is currently no saltmarsh mosquito control program on Willapa Bay.

Spartina is a wind-pollinated grass that is expanding over mudflats on which no wind-pollinated species formerly existed. Therefore, it is expected that *Spartina* is contributing additional pollen to the atmosphere from late July through September. As with many grasses, there would likely be people that are allergic to *Spartina* pollen.

3.4.2.2 Concerns

Some members of the local community, and society as a whole, perceive the use of chemicals, such as herbicides, to be an unreasonable threat to human health and/or the natural environment. They strongly object to the use of any herbicide to control *Spartina* in Willapa Bay. People with chemically sensitivities are concerned about potential effects should airborne sprays drift inland onto the peninsula.

Some landowners are concerned about the effort needed for control and the costs of control on their property.

3.4.2.3 Recreation

Recreational uses of the bay include motor-boating, kayaking, canoeing, sailing, hunting, fishing, clamming, wildlife viewing, and camping. The Refuge allows camping on Long Island, a popular kayaking destination, which has five primitive campgrounds and hiking trails. Because of shallow water depths, large tidal ranges,

swift currents, frequent high winds, and changeable weather patterns in the bay, all forms of boating are limited both spatially and temporally. Most boating occurs at higher tidal stages. Within the bay, recreational clamming is limited to public lands with firm sandy substrates, primarily along the west shore of Long Island.

Waterfowl hunting and wildlife viewing are primarily land-based and occur along the dike and saltmarsh areas in the Refuge's southern units and tidal flats adjacent to the Leadbetter Point Unit. Since 1991, an average of about 250 hunters has used these areas annually. There is also goose hunting at blinds in upland fields of the Reikkola Unit. The Riekkola Unit goose hunt has averaged about 120 participants annually since 1991. Long Island supports an archery hunt for deer, elk, black bear and grouse. The average annual use for Long Island since 1991 is about 185 hunters. No quantitative information is available for other baywide recreational uses associated specifically with tidelands.

3.5 ECONOMIC ENVIRONMENT

Tourism, logging, lumber manufacturing, oyster harvesting, seafood canning, crabbing, commercial and sport fishing, dairy farming, stock raising, and cranberry growing have been the historical bases for the economy of Pacific County (Pacific County n.d.).

Cook and Jordan (1994) stated that the County's economy was more dependent on employment in forestry, fisheries, manufacturing, and personal services than the state as a whole in 1990. Employment in distributive, social, and particularly producer services was under-represented in Pacific County by comparison. The median income per household in Pacific County was $20,029 in 1989. This was a drop of 15.2 % from 1979 as measured in 1989 dollars.

A few residents in Nahcotta have experimented with production of paper from *Spartina*. Initial results indicate that *Spartina* paper may be a quality product as a specialty paper (Washington State 1993). *Spartina* paper has remained in a low-volume niche market and is used primarily in novelty cards or specialty objects. *Spartina* paper products may be suitable for use in crafts and as packing material, flooring, or room dividers.

In Washington, *Spartina* is listed as a "class B" noxious weed with mandatory control in designated areas, including private property. In Pacific County, five management units at the north end of Willapa Bay are mandated for control by the County Weed Board. In all other areas, control of *Spartina* is optional. Control is expensive, while the presence of *Spartina* may lower economic return and property value. The Washington Department of Agriculture has a 50/50 cost-sharing program with private landowners, while the Farm Services Agency offers a 75/25 Federal/private cost-share program for *Spartina* control efforts.

3.5.1 Tourism

The tourism industry is growing both worldwide and within the Pacific Northwest. Tourism is the second largest industry in the world. Since 1988, all tourism has grown at a 4% annual rate while ecotourism has expanded at a 30% annual rate (Peterson 1996). Tourism is also growing rapidly in importance to the local economy, especially on the Long Beach Peninsula. Personal services in tourism-related businesses, and especially eating and drinking places, had the largest percentage of growth in employment between 1980 and 1990 (Cook and Jordan 1994). No information is available on the how much money the tourism industry contributes to the local economy.

A fast growing segment of tourism is travel with nature as a principal objective, sometimes known as nature-based tourism (Peterson 1996). A tour boat company operating from Nahcotta offers tours around Long Island in Willapa Bay. A second tour operation has been proposed for the bay, but its status is uncertain at this time.

The Long Beach Peninsula Visitors Center in Seaview had about 500 (winter) to 5,000 (summer) visitor log entries annually from 1989 to 1995. Visitors are drawn to the Peninsula primarily for recreational activities associated with the ocean beaches and secondarily for those associated with Willapa Bay.

There are two museums, 10 historic sites, and 20 parks or other recreational facilities in Pacific County, including Willapa NWR; Fort Canby, Fort Columbia and Leadbetter State Parks; and Bush Pioneer and Bruceport County parks (State of Washington n.d.).

3.5.2 Mariculture and Fisheries

Many of the private tidal flats in the bay are managed as oyster mariculture sites. Pacific and neighboring Grays Harbor counties are home for two-thirds of the oyster industry in Washington (Conway 1991). Washington Department of Fish and Wildlife (Hoines 1996) reported a five-year average of 462,000 gallons of Pacific oysters harvested in Pacific County. In Pacific County, the oyster growing and processing industry employed 480 workers with a total labor income of $6.3 million, accounting for one out of every twelve jobs in 1990 (Conway 1991). Companies processing fish, shrimp, and crab, but not oysters, employed another 260 to 330 individuals in the County in 1990 (State of Washington n.d.).

The stability of the oyster mariculture industry in Willapa Bay is threatened by two types of burrowing shrimp, the ghost and mud shrimp. The shrimp affect oyster production by smothering of "seed" and adults, competition for food resulting in reduction in growth rates and/or condition, and operational difficulties at harvesting. Since testing by State and Federal agencies in the early 1960s, carbaryl (Sevin ®) has been used to control ghost shrimp in the bay.

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

This chapter forms the scientific and analytical basis for comparisons of the alternatives considered in this document. It is organized by alternative. It discusses the alternatives in the same order as Chapter Two and the resources and issues in the same order as Chapter Three. It addresses direct and indirect effects of each alternative.

4.2 EFFECTS OF NO ACTION ALTERNATIVE

4.2.1 Physical Environment

Continued transformation of open tidal flats to raised *Spartina* marsh would change the physical structure of the environment and alter estuarine functions in ways not yet fully understood. It is predictable that changes in vegetative structure and topographic relief would affect tidal and stream flow velocities and current patterns, sedimentation rates and patterns, fresh and salt water mixing patterns, water quality and chemistry, temperatures, and salinity levels in the proposed project area.

4.2.1.1 Soils and Topography

Sediment buildup and changes in substrate composition and topography would continue over an ever-increasing portion of Refuge lands. Mudflats would continue to be raised and thus converted to high intertidal marshes. Instead of gradually sloping flats, the surface level within *Spartina* marshes would be raised, creating sharp dropoffs along drainage channels sides. Channels would cut deeper with more concentrated currents and increased flows.

Spartina stems and rhizomes would continue to trap and accumulate sediments from tidal flows and terrestrial runoff until an equilibrium is achieved. Sediments in *Spartina* marshes would consist of a higher proportion of softer, finer-grained particles such as silts and clays than open mudflats (State of Washington 1993, Zipperer 1996b). Thus, the proposed project area would continue to have a very soft, silty substrate. With the entrapment of sediments in *Spartina* marshes, there could be a concurrent reduction in sediment input in open areas of the bay.

It has been suggested that *Spartina's* ability to accelerate sediment deposition may help to bury, and thereby isolate, radioactive material transported to Willapa Bay in the 1950s and 1960s from the Hanford Nuclear Site via the Columbia River plume. Normal sediment deposition and radioactive decay processes (some materials have very short half-lives) have already promoted attenuation of the effects of radioactive materials (Young 1997). A recent report on radioactivity in Columbia River sediments done by the Washington State Department of Health concluded that the human-caused radionuclide concentrations found in Columbia River sediments do not pose a significant human health risk (Washington State Department of Ecology 1995). Given this, it appears unlikely that *Spartina*-induced sedimentation would contribute substantially to improving human health in this regard.

4.2.1.2 Hydrology

Tidal and runoff flow velocities and patterns across Refuge tidelands would be affected as currents are reduced or diverted by dense *Spartina* vegetation, increased sedimentation, and stabilized sediments. As more sediments deposit in larger areas of *Spartina*, transformation of the mudflats' configuration would continue. Natural flow patterns would be altered as tidal flats build up and deep, steep-sided, tidal channels form. With the restricted runoff along drainage channels, the frequency of and potential for flooding in low-lying areas landward of *Spartina* meadows might increase, especially at high tides during major storm events. As *Spartina* becomes more widespread and denser over time, flood-control dikes would possibly be exposed to higher, storm-tide levels for longer durations, which could lead to erosion of the dikes.

Emergency dredging at the entrance of Willapa Bay is proposed to stabilize erosion occurring at North Cove. It is not known exactly what effects this alteration of tidal currents and flow patterns in the bay would have on dispersal of *Spartina* propagules. But with ever-increasing seed production in the absence of *Spartina* control and altered flow patterns with the dredging, the potential for establishment of *Spartina* in new areas both within and outside the bay could increase.

4.2.1.3 Water Quality

Few studies have evaluated the effects of *Spartina* vegetation on water quality. The State EIS expressed the following ideas: Surface water temperatures would increase in shallow areas with restricted flow. Salinity could increase or decrease locally depending on the effects on rates of evaporation and mixing of fresh and salt water. Levels of dissolved oxygen might decrease locally due to decomposition of *Spartina* litter after seasonal die back while water quality might improve in some areas because of the cordgrass trapping suspended sediments or filtering pollutants.

Beginning in the spring of 1997, the Washington Department of Ecology is conducting an EPA-funded project to study water quality parameters in Willapa Bay. Water temperature, dissolved oxygen, nutrients, chlorophyll, pH, light transmission, and turbidity, as measured by Secchi disk depth, will be measured at six locations (Newton 1997).

4.2.1.4 Ambient Sound

There would be no changes in ambient sound levels with the No Action Alternative.

4.2.1.5 Air Quality

Since fossil fuels would not be burned and chemicals would not be applied to control *Spartina*, air pollution from these sources would not occur. However, unchecked *Spartina* expansion would result in higher pollen counts in late summer (also see 4.2.3.1.).

4.2.2 Biological Environment

The continued conversion of intertidal mudflat communities and saltmarsh vegetation in the project area to *Spartina* marsh would result in the loss of open mudflats, eelgrass and macroalgae beds, and native saltmarsh vegetation. This, in turn, would affect the numbers and species composition of birds, fish, and invertebrates that live, feed, or otherwise use the mudflats. Increasing amounts of airborne pollen during *Spartina* flowering season would continue.

4.2.2.1 Vegetation

Seagrass and macroalgae beds on mudflats in the project area would be displaced by *Spartina*. At higher elevations in the estuary, native saltmarsh vegetation would sometimes be replaced as *Spartina* meadows invade native marshes. As the level of the bay's bottom rises due to accretion of sediments, some native plant species may be re-established within the *Spartina* meadows at higher elevations.

With no *Spartina* control, all native saltmarsh and mudflat vegetation is at some risk of *Spartina* intrusion and replacement. With the No Action alternative, *Spartina* is expected to dominate all intertidal mudlats and displace about half of the existing native saltmarsh vegetation in the Refuge's southern units within 10 years. Where it is already strongly established around Long Island, *Spartina* would complete its dominance of all intertidal mudflats and convert about half of the existing native saltmarsh in 5 years. Lack of control for *Spartina* seed production on Refuge lands would contribute to its continued spread and interfere with control efforts on other lands throughout the bay.

Although no figures are available on the acreage of seagrass and macroalgae beds in the project area, most of the intertidal flats currently without native saltmarsh or *Spartina* support some level of seagrass and macroalgae growth which are vulnerable to *Spartina* invasion.

4.2.2.2 *Spartina*

No control of *Spartina* would allow its continued vigorous spread and establishment throughout the project area. Larger clones and meadows would grow and dominate areas that currently have only seedlings and small, scattered clones. *Spartina*-dominated acreage on Refuge land would likely increase to 4,000 acres within the next 10 years. Seed production would occur on meadows and larger clones. More seed production would foster *Spartina* spread onto flats on and off the Refuge. *Spartina* would displace native marsh plants and seagrasses and macroalgae beds as described above.

The incidence of viable seeds and propagules transported out of Willapa Bay and establishing new *Spartina* colonies in other coastal tidelands would be expected to increase. In recent years new seedlings have been found in Grays Harbor. It is

presumed that viable seed is transported out of Willapa Bay attached to spikes in floating mats of *Spartina*. The northward, nearshore ocean current, tidal flows within estuaries, and the ability of these *Spartina* mats to float for many weeks potentially exposes much of the coast of Washington and British Columbia to Willapa's *Spartina* (Sayce 1997).

Some particles, including pollutants may settle out of the water column into sediments accreted by *Spartina*. Some shorelines with high-energy, shallow flats supporting large *Spartina* clones or meadows may be less erosion prone due to dissipation of wave energy by the plants. The basis for the food webs in Willapa Bay will be changed from seagrass and benthic microalgae to *Spartina* detritus.

4.2.2.3 Wildlife

No Action would contribute to further decline or loss of habitat value for migratory waterfowl and other waterbirds on tideflats on and off the Refuge. Physical displacement or degradation of habitat for several species of waterfowl, shorebirds, and other waterbirds would occur. Most of the foraging habitat for shorebirds on the Refuge would be eliminated within 10 years. Black brant, Canada geese, and American wigeon, northern pintail, and mallard ducks would be especially impacted by the loss of eelgrass communities. Open-water feeding birds, such as loons, grebes, and diving ducks, would be precluded from using areas of *Spartina* marsh except when extreme high tidal conditions allowed them to swim over the tops of the plants.

Shorebirds that feed on open mudflats, such as the large flocks of sanderlings (*Calidris alba*), western (*C. mauri*) and least (*C. minutilla*) sandpipers, and dunlins (*C. alpina*) would avoid dense *Spartina* marshes. Goss-Custard and Moser (1988) found that during the decline in numbers of dunlin in the British Isles, the greatest declines occurred in estuaries where cordgrass (*S. anglica*) had spread most over the intertidal mudflats on which the birds fed. In estuaries where the extent of *Spartina* had not changed, the numbers of dunlin did not show a statistically significant decline, with the exception of a few small outlying estuaries. At Dyfi estuary, on the coast of Wales, Davis and Moss (1982) noted a "close temporal correlation between the expansion of *Spartina* (*anglica*) and a steep decline in numbers of certain waders.... There seems to be no other obvious reason for the decline in wader numbers, which is much greater than any national or regional trend." Millard and Evans (1982) stated that dunlin and other flocking species at Lindisfarne, Northumberland, England are likely to prefer feeding on the open mud, if food is available there, than among *Spartina* (*anglica*) clumps. Avoidance of the *Spartina* zone may be connected with flocking behavior which acts as an anti-predator device and permits individuals within the flock to feed more efficiently. They also found that the shorebird most commonly found in dense *Spartina* was the redshank (*Tringa totanus*). But no more than 15% of the local population of that species occurred in the *Spartina* habitat at one time. They added that the high density of *Spartina* stems likely prevents birds from landing easily and restricts

their movement on the ground. Most individual birds within *Spartina* were feeding on the few small patches of open mud within the *Spartina*. It is not known what other environmental factors, if any, may have affected these populations.

Populations of invertebrate prey species for shorebirds would also be altered in *Spartina*-infested areas. Zipperer (1996b) found benthic invertebrate assemblages dominated more by prey species favored by shorebirds on mudflats (crustaceans, polycheates, and mollusks) than in *Spartina* patches (dipteran larvae, oliocheates, and polycheates) at Willapa Bay.

No studies have been conducted to determine use of West Coast *Spartina* areas by wading birds such as herons and bitterns. Sayce (1994) observed both groups of birds feeding in *Spartina* stands in Willapa Bay. Great blue herons would feed in shallow water along the edges of *Spartina* marshes when tide levels permitted. However, this habitat would be lost over time as the channel depth increased and channel banks became steeper. They may also use non-vegetated tidal pools within patchy *Spartina* vegetation. More secretive waders such as American bitterns (*Botaurus lentiginosus*) and green herons (*B. striatus)* might utilize the cover of *Spartina* to feed, if the right prey species were available.

Threatened bald eagles would continue to lose feeding habitat.

The Newcomb's littorine snail, a Federally recognized Species of Concern and State Candidate Species, which is thought to live on pickleweed plants in the native saltmarsh in Willapa Bay (WDFW 1995, USFWS 1996), could lose habitat as *Spartina* crowds out native vegetation.

4.2.2.4 Fish

Replacement of intertidal mudflats, eelgrass beds, and native saltmarsh vegetation with *Spartina* marsh would likely have mixed effects on fish use within the project area depending on the species and life stage. Loss of mudflat, eelgrass, and macroalgae habitat would negatively impact those fish species that depend on these areas for feeding, spawning, or rearing habitats. In addition, prey populations and composition, particularly of benthic fauna and their consumers, would likely differ greatly between the native environment and that of the exotic *Spartina* marsh (Zipperer 1996b). The ultimate effect of such changes in food-web dynamics on fish populations is not fully known (Washington State 1993).

Small to medium clones or the edges of large clones and meadows of *Spartina* would provide cover or feeding habitat for some fish species and particular life stages of other species. For example, salmon smolts may use the cover of these areas during their transitional stage in the estuarine environment. However, feeding by juvenile salmon might be limited in *Spartina* because favored prey species (such as bottom-dwelling,

filter-feeding invertebrates) may not survive in the fine, soft sediments trapped by *Spartina* (State of Washington 1993). A study of outmigrating juvenile chum salmon in Hood Canal determined that eelgrass and its associated algae are the basis of the food web for this species in the estuary (Simenstad and Wissmar 1985 in Thom 1987 cited in Washington State 1993). Returning adult salmon would not be able to use tidal flats covered by dense *Spartina* marsh and would be limited to the deeper channels that remain clear of *Spartina*.

As *Spartina* clones grow into large dense meadows, the temporary value of the smaller, isolated clones would be permanently lost. Only small fish would be able to penetrate deep into the marsh and would probably do so only if sufficient amounts of food were available. The University of Washington and the Washington Department of Fish and Wildlife are continuing research into the use of *Spartina* clones of various sizes by fish in Willapa Bay. The studies will allow better specification and quantification of anticipated effects on fish. Early results show that fish use is limited to the edge of smaller clones (Fresh et al 1996).

With the No Action alternative, the incremental growth of *Spartina* in large clones and meadows would cause a corresponding loss of fish habitat for some species due to the expansion. Use by those fish would be expected to decrease accordingly throughout the project area. Ultimately all tidal habitat on the project area except for deeply incised, open channels and their *Spartina* marsh edges would be lost for those species that depend on open water, eelgrass, algae, or mudflat communities to meet one or more of their life requirements.

4.2.2.5 Microbes and Marine Invertebrates

The dense root mat and thick layer of soft, fine sediments associated with *Spartina* marshes would preclude colonization by and the survival of many shellfish and other invertebrates that commonly occur in tidal mudflats, or seagrass and macroalgae beds (Washington State 1993). Thus, populations of some species would decline in areas with extensive *Spartina* infestations. A preliminary investigation to assess the impacts of *S. alterniflora* to benthic invertebrates in Willapa Bay showed, in some cases, decreases in numbers or absence of species in areas colonized by expanding *Spartina* clones compared to adjacent "bare" flats (Atkinson 1992). Zipperer (1996b) found that benthic invertebrate species in *Spartina* patches were characterized by dipteran (fly) larvae, polycheates, and oliocheates, while mudflats had a dominance of crustaceans, polycheates, and mollusks at Willapa Bay.

An increase in the number of salt water mosquitos and flies (diptera) would result from topographic changes associated with sediment accretion (State of Washington 1993, Zipperer 1996b).

4.2.2.6 Biodiversity

It is expected that, with the development of large, monotypic stands of non-native *Spartina*, the diversity of plants, invertebrates, birds, and fish would decrease over much of the bay's affected tidal flats. This loss of diversity in the bay due to *Spartina* spread is not quantified.

4.2.3 Social Environment

Implementation of the No Action alternative in the proposed project area would affect adjacent property owners, wildlife viewers, hunters, and other recreationists on Refuge lands through adverse changes in access or wildlife habitat by the rapid spread of *Spartina.*

4.2.3.1 Human Health

The growth of *Spartina* would be expected to result in increases in saltwater mosquitos (Washington State 1993), flies (Zipperer 1996b), and airborne pollen. Discomfort from mosquito bites would be more common in the vicinity of *Spartina* marshes. People who use the mudflats with *Spartina* marshes would be subject to more mosquito bites with a possible increase in exposure to vector-borne disease. Large-scale mosquito control efforts, like those at many East Coast communities adjacent to *Spartina* marshes, may become necessary. Local mosquito-related nuisance complaints could precipitate the creation of mosquito control districts (as on the East Coast) to conduct control efforts on the bay, possibly including the use of larvicides. Larvicide use would generate concerns about potential impacts on water and air quality, human health, and fish, wildlife and their habitats. Pollen-related allergic reactions in people around the bay and particularly on the predominately downwind east side would be expected to increase.

4.2.3.2 Concerns

Concerns about the use of chemicals to control *Spartina* on the Refuge would be alleviated. Concerns about the spread of *Spartina* would not be addressed. An increasing concern about mosquito control including the use of larvicide might develop.

4.2.3.3 Recreation

Although there have been no studies of changes in recreational uses due to *Spartina*, recreational opportunities in the bay would be reduced by increased *Spartina* growth on the mudflats. It is reasonable to assume that reduced access to open water and mudflats, loss of navigation routes, loss of wildlife habitat, alterations to estuarine functions, and visual barriers would result from continued *Spartina* growth (Washington State 1993). Such changes would eventually result in substantial negative impacts to recreational activities including sport fishing, waterfowl hunting, wildlife viewing, recreational shellfish harvesting, and boating on tidelands and associated

waters. It is not known how many of the approximately 14,000 annual Refuge visitors (US Fish & Wildlife Service unpubl. data) would be affected.

4.2.4 Economic Environment

Even though the Refuge's purpose is not intentionally linked to the regional or local economy, the Refuge is none-the-less connected to economic issues through its influence on tourism and the bay's environment. Economic uses based on an open-water, unrestricted mudflat environment would decline.

If an economy based on use of *Spartina* such as paper making along with an environmentally safe harvest method was developed, it might be used to manage a portion of the *Spartina* in the bay and reduce some of the environmental impacts associated with the plant's spread.

4.2.4.1 Tourism

Uncontrolled *Spartina* growth would eventually impact tourist activities by limiting or eliminating the recreational opportunities mentioned previously. Nature-based tourism in the bay would be impacted as recreational opportunities are reduced. Many out-door activities might be negatively affected by an increase in saltmarsh mosquitos. This, in turn, could reduce visitation and tourist dollars spent at local businesses on the Long Beach Peninsula. It is not known what these costs would ultimately be for the businesses.

4.2.4.2 Mariculture and Fisheries

Although no commercial operations would be directly affected by a lack of *Spartina* control on Refuge-owned or managed lands, indirect effects are anticipated. If Refuge lands support large areas of *Spartina*, the seeds produced would increase the cost of controlling *Spartina* on other tidelands. On many of these lands, oyster mariculture or other shellfish harvest is the primary use. The growth of *Spartina* can greatly hinder or prevent shellfish production or harvest. On marginal shellfish grounds, the cost of controlling *Spartina* can easily exceed the value of the land (Sheldon 1997). Added to this is the concern that as control of *Spartina* is mandated on more areas by the local noxious weed control board, some tideland owners may be forced to choose between control efforts (with costs in excess of the value of their land) or relinquishing their titles to the county or state. Long-term impacts to maricultural economies would depend on the feasibility of large-scale use of longline, rack, or other suspension methods of oyster culture compatible with *Spartina* presence.

Uncontrolled *Spartina* growth in the bay could affect commercial fisheries through long-term changes in habitat, and production of fish and shellfish, or the harvest thereof. However, the importance of the changes or the effects on commercial species cannot be predicted with existing information.

NOTE: For more discussion of the consequences of the No Action Alternative, see pages 91-100 and the Element C report of the State FEIS on Noxious Emergent Plant Management, 1993.

4.3 EFFECTS OF INTEGRATED PEST MANAGEMENT ALTERNATIVE (IPM) (PROPOSED ACTION)

The Integrated Pest Management (IPM) alternative allows for the selection of one or more methods to meet site-specific requirements to maximize efficacy and minimize impacts to non-target biota. Within a site, variation in environmental sensitivity can be addressed through use of a combination of methods for *Spartina* control. For example, it is important to control *Spartina* clones that have been identified as major producers of viable seed. While such clones are at a growth stage that would be particularly vulnerable to herbicide application, location, tidal conditions, or weather may make this technique ineffective or risky to nontarget organisms. In such cases mechanical methods could be used exclusively or to preserve options for later effective herbicide treatment.

In general, impacts from two or more methods likely would be the sum of impacts associated with individual methods (sections 4.4 and 4.5) as well as potential cumulative impacts, particularly disturbance of surrounding vegetation and mudflats. However, greater efficacy of combined treatments ultimately would result in less long-term disturbance than would be associated with repeated applications of individual methods. For example, mowing followed by herbicide application appears to be more effective in controlling small to medium-sized *Spartina* clones and, therefore, fewer treatments ultimately would be required to achieve the desired control. Fewer treatments means reduced impacts to surrounding vegetation or mudflats and/or less herbicide used than with mechanical or chemical means only.

IPM would provide the greatest baywide control of *Spartina* through control of seed production and the Refuge's ability to work cooperatively with other tideland owners. Furthermore, IPM's potential to incorporate future technological advances in mechanical, chemical, and biological control techniques has by far the greatest potential for accelerated control.

4.3.1 Physical Environment

4.3.1.1 Soils and Topography

The sediment buildup and changes in substrate composition and topography resulting from *Spartina* growth would be slowed or halted in control areas in the shortest amount of time. This would result in more normal movement and distribution of sediments in the water column. The existing mudflat topography would be preserved where *Spartina* seedlings are removed.

At treated sites, some erosion and transport of sediments might occur. Tidal action, wind, waves, and currents might cause erosion and redistribution of fine particles in treated areas. The extent of erosion would depend upon the magnitude of tidal exchanges, frequency and intensity of storms, and size of the area treated. Because roots of treated *Spartina* might take several years to decay and allow erosion, eroded sediment would not contain measurable quantities of glyphosate or adjuvant. Erosion may be minimized through colonization by native species.

Control operations might result in temporary increases in sediment load in the water column due to disturbance of the substrate and erosion of previously accreted sediments where clones were killed. The weight of people and equipment might cause temporary localized compaction of substrates.

Glyphosate is not environmentally persistent and would not accumulate within sediment from ground applications of Rodeo® tank mixes. Kroll (1991) found that glyphosate concentrations in sediment of tidal marshes treated by hand-held sprayer with Rodeo® (0.75% solution) and Arborchem Aquatic surfactant (0.5% solution) declined 88% by 56 days post-treatment. For *Spartina* clones treated by a hand-held sprayer with Rodeo® (5% solution) and LI-700® (2% solution) in Willapa Bay, average concentrations of glyphosate in substrates underneath *Spartina* declined 14% (1.39→1.18 ppm DW [dry weight]; North River) and 29% (2.23→1.58 ppm DW; Lewis Unit on the Refuge) to 43% (3.60→2.05 ppm DW; Nemah Beach) and 73% (5.31→1.44 ppm DW; Leadbetter Point) for muddy and sandy substrates between spray day and 30 days post-treatment, respectively (Major and Grue 1997). After 1 year post-treatment, glyphosate concentrations from treated clones with the highest concentrations at 30 days after application ranged from 0.088 to 0.772 ppm DW and 0.134 to 1.84 ppm DW for sandy (Nemah Beach) and muddy substrates (Lewis Unit on the Refuge), respectively (Major and Grue 1997). Greater declines in glyphosate concentrations occurred for sandy substrates because less glyphosate likely was translocated to *Spartina* rhizomes incorporated into sediment samples. Application rates were 14 (Leadbetter Point) to 47 liters/ha (Nemah Beach) and 54 (North River) to 63 liters/ha (Lewis Unit on the Refuge) for clones on sandy and muddy substrates, respectively.

Glyphosate also would not accumulate within sediment from aerial applications of Rodeo® tank mixes. Paveglio et al. (1996) found that average concentrations of glyphosate in sediment directly exposed to spray significantly declined (51% [1.16→0.563 ppm DW] to 72% [2.82→0.799 ppm DW]) 119 days after aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1 liter/ha) to control *Spartina* in Willapa Bay. Average concentrations of glyphosate in sediment underneath *Spartina* declined (31% [0.420→0.290 ppm DW]) 30 days after aerial application of Rodeo® (8.8 liters/ha) and X-77® Spreader (1.2 liter/ha) to a *Spartina* meadow in Willapa Bay (Major and Grue 1997). For sampling

locations within this treated meadow with the highest concentrations 30 days after application, glyphosate levels ranged from 0.088 to 0.404 ppm DW at 1 year post-treatment (Major and Grue 1997). Feng et al. (1990) reported a 92 to 96% decline in glyphosate concentrations 360 days after aerial application of Roundup® (2.0 kg/ha glyphosate) to a watershed in a Canadian forest.

Alkylphenol polyethoxylates, the principal active ingredient potentially hazardous to fish and wildlife within X-77® Spreader (nonylphenol polyethoxylates) and R-11® Spreader Activator (octylphenol polyethoxylates), also would not accumulate within sediments because they undergo rapid and complete primary degradation (Naylor 1992). Alkylphenol polyethoxylates degradation occurs through shortening of the ethoxylate chain by microbial activity (Swisher 1987), which produces polyethylene glycols that are biodegradable and less toxic than the precursors (Conway et al. 1983). Extensive biodegradation (>90%) occurred within 14 days post-treatment for shake-culture tests where nonylphenol polyethoxylates were placed in flasks with a bacterial-inoculated medium (Huddleston and Allred 1965, Lashen et al. 1966). In contrast, Paveglio et al. (1996) found that average concentrations of nonylphenol polyethoxylates in sediment directly exposed to spray declined 42% (0.181→0.105 ppm DW) within 14 days following aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1 liter/ha) to control *Spartina* (Willapa Bay). Lower temperatures and reduced microbial activity associated with later sampling periods may have contributed to the stabilization of nonylphenol concentrations. Unlike shortening of the ethoxylate chain, ultimate degradation (conversion to carbon dioxide and water) of alkylphenol polyethoxylates may not be complete (Swisher 1987). Laboratory studies (Fuka 1978, 1980; Pitter 1979) found 80-90% ultimate biodegradation for nonylphenol polyethoxylates.

No information is available regarding the degradation of LI-700®; however, it is composed of a natural lipid (phosphatidylcholine [lecithin]) that is likely subject to biodegradation

Drift of Rodeo® tank mixes to non-target areas associated with ground applications to *Spartina* would be minimal under favorable environmental conditions. For sites in Willapa Bay with *Spartina* clones treated by a hand-held sprayer with Rodeo® (5% solution) and LI-700® (2% solution), average concentrations of glyphosate in off-target substrates 0.5 m from the clone edge immediately after treatment ranged from 1.07 to 5.28 ppm DW (Major and Grue 1997). The highest concentration of glyphosate (5.28 ppm DW) for sediments adjacent to hand-treated *Spartina* clones on spray day occurred at the site (Lewis Unit on the Refuge) with the highest rate of Rodeo® application (63 liters/ha). Grue and Major (1997) also found glyphosate in substrate samples 5 m from edges of hand-sprayed clones, but concentrations were less than 0.087 ppm DW. Glyphosate likely was detected 5 m from clones because the height of the *Spartina*

resulted in applications directed up or across clones rather down onto plants.

Drift of Rodeo® tank mixes to non-target areas associated with aerial applications to *Spartina* also would be minimal under favorable environmental conditions. Grue and Major (1996) found that drift associated with aerial application of Rodeo® (8.8 liters/ha) and X-77® Spreader (1.2 liter/ha) to a *Spartina* meadow in Willapa Bay was minimal. Glyphosate concentrations in sediment 3 and 10 m from the plot boundary immediately after spray ranged from below the detection limit (0.020 ppm DW) to 0.114 ppm DW and below the detection limit (4 of 5 samples) to 0.117 ppm DW, respectively. No visible mortality of non-target vegetation on mudflats or salt marsh was found immediately adjacent to a *Spartina* meadow (152 ha) at Kaffee-Lewis Slough as well as a 12-ha meadow at Seal Slough 5 weeks following aerial application with Rodeo® (8.8 liters/ha) and R-11® Spreader Activator (0.5% solution) in 1996 (C. Moore, Washington Dept. Agric., pers. commun.). Feng et al. (1989) found that average off-target distance between the spray boundary and healthy vegetation associated with aerial application of Roundup® (2.0 kg/ha glyphosate) was 2 m.

4.3.1.2 Hydrology

Hydrologic patterns in the project area would be directly affected by the removal of *Spartina*, especially dense clones and meadows. Removal of *Spartina* plants would allow increased flow velocities and unobstructed flow patterns. Over time, redistribution of sediments from treated clone sites and meadows would likely allow tidal and runoff flows to return to pre-*Spartina* velocities and patterns. Because IPM would most effectively control the *Spartina* invasion, flow velocities and patterns across treated tidelands would be expected to return to pre-invasion condition sooner compared with individual control methods.

Natural tidal drainage patterns would be preserved in treated areas where early stages of *Spartina* growth is halted or prevented. Some changes may still occur because of the presence of nearby uncontrolled *Spartina*. The potential for flooding resulting from the restricted runoff associated with *Spartina* growth on Refuge tidelands would be avoided or reduced.

4.3.1.3 Water Quality

Beginning in the spring of 1997, the Washington Department of Ecology is conducting an EPA-funded project to study water quality parameters in Willapa Bay. Water temperature, dissolved oxygen, nutrients, chlorophyll, pH, light transmission, and turbidity, as measured by Secchi disk depth, will be measured at six locations (Newton 1997).

Disturbance to the substrate caused by people and equipment may result in local increases in suspended sediments as work areas are tidally reflooded. These effects

should be minor because only relatively small areas would be involved. Mitigation measures to reduce
trampling effects would include use of an air boat or hovercraft to directly access each clone or meadow, thus avoiding or minimizing trampling of adjacent mudflats and eelgrass beds.

The degree of water-quality degradation by chemicals would be dependent upon the amount of Rodeo® tank mix that reaches the water and its subsequent biodegradation. Because *Spartina* intercepts most of the aerially (Kilbride et al. 1995, Major and Grue 1997) and ground-applied herbicide tank mix (Major and Grue 1997), and overspray or drift are minimal (Feng et al. 1989, Major and Grue 1997), the primary source for glyphosate and adjuvant introduction into seawater results from the initial washing of target vegetation by the first tidal inundation or rainfall that occurs before chemical incorporation into *Spartina* tissue.

Dilution, dissipation, and biodegradation quickly diminish waterborne concentrations of glyphosate and adjuvant. Paveglio et al. (1996) found that concentrations of glyphosate and nonylphenol polyethoxylates in seawater were below detection limits (0.5 and 2.0 ppb, respectively) 1 day post-treatment (2 tidal cycles) after aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) to control *Spartina* in Willapa Bay. Similarly, Kroll (1991) found seawater concentrations of glyphosate dropped below the detection limit (5 ppb) by 7 days post-treatment in tidal marshes with *Phragmites communis* patches treated by a hand-held sprayer with Rodeo® (0.75% solution) and Arborchem Aquatic surfactant (0.5% solution).

Because the sea-substrate microlayer (seawater-sediment interface) provides habitat for a wide variety of marine biota, concern exists regarding toxicity resulting from exposure to Rodeo® tank mixes from drift or overspray particularly during low tides. Paveglio et al (1996) found that average concentrations for glyphosate and nonylphenol polyethoxylates from the leading edge of the first high tide after treatment were ≤ 25.6 and ≤ 16.0 ppb, respectively, and they quickly declined (≤ 9.77 and ≤ 0.5 ppb [detection limit] for glyphosate and nonylphenol polyethoxylates, respectively) as a result of water-column dilution from the subsequent tidal inundation. Similarly, Sundaram et al. (1980) found that after aerial application of 0.47 liters/ha nonylphenol (to determine the environmental fate of nonylphenol associated with applications of the pesticide Metacil) the highest concentration (9.1 ppb) in a stream 1 hour post-treatment declined to undetectable levels (< 1.0 ppb) within 24 hours post-treatment; they attributed the rapid dissipation to dilution by water flow. Consequently, hazards to microlayer biota at low tide are unlikely because glyphosate and alkylphenol polyethoxylates would be present at non-toxic concentrations (see subsection 4.3.2.5) that are relatively short-lived as a result of water-column dilution.

Water-quality degradation through interaction of Rodeo® tank mixes with other

pesticides used in and adjacent to Willapa Bay would be unlikely. In intertidal areas where *Spartina* has been sprayed with Rodeo® tank mixes, dilution, dissipation, and biodegradation quickly diminished waterborne concentrations of glyphosate and adjuvant (Paveglio et al. 1996). Areas with *Spartina* are geographically separated from areas where oyster beds with burrowing shrimp are sprayed with Sevin (carbaryl) and cranberries (grown in inland bogs) are sprayed with a variety of insecticides, herbicides, and fungicides. Moreover, carbaryl concentrations in water on oyster tracts treated for shrimp were only detectable for 20 to 30 minutes following the first tidal inundation after treatment (Tufts 1990). The detectable levels of carbaryl were only found within 68 m (225 feet) of treated tracts (Tufts 1989). For cranberry crops, water applied to bogs along the Long Beach peninsula generally drains into freshwater wetlands rather than directly into Willapa Bay (Patterson 1994).

Fuel spills/leakages could result from the use of power tools and vehicles in control operations. Incomplete fuel combustion during torching could result in pollution. Protocols would be established to minimize the risk (section 2.3).

Although degradation of water quality from Rodeo® tank mixes would likely be minimal, decomposition of treated *Spartina* may temporarily reduce dissolved oxygen levels and release nutrients (nitrogen, phosphorus, and carbon) which may result in algal blooms. Conversely, nutrient releases from decaying *Spartina* may beneficially increase primary production. The potential negative effects of *Spartina* on water quality, including increased surface water temperatures and reduced levels of dissolved oxygen (see subsection 4.2.1.3), would be ameliorated to the degree that control is successful.

4.3.1.4 Ambient Sound

Operation of airboats, hovercraft, skiffs, and/or helicopters to support control efforts would increase noise on and around the proposed project site. Higher noise levels would occur primarily during transport of staff, equipment, and supplies to and from work sites as well as during aerial herbicide application. The increase would be most noticeable to those in non-motorized boats in the vicinity of the activity or along transport routes. Work on refuge-owned and refuge-associated tidelands would temporarily elevate noise levels around Long Island, along highway 101 from Stanley Peninsula south to Greenhead Slough, and near Leadbetter Point. On calm days, the sounds would become more noticeable along the east edge of the Long Beach Peninsula.

4.3.1.5 Air Quality

Of the action alternatives, IPM would likely produce the least amount of air pollution. Higher efficiency in the control effort would reduce the hours of equipment operation over time. The potential for herbicide drift is discussed in 4.3.1.1. *Spartina* pollen production would be reduced to the greatest extent under IPM. Torching of flower

and/or seed heads would generate smoke and some pollution from incomplete combustion of torch fuel; however, this technique has been used only on a very small scale.

4.3.2 Biological Environment

4.3.2.1 Vegetation

With IPM, about 2,300 acres of mudflats supporting seagrass and macroalgae habitat would be maintained on the Refuge's southern units. Nearly all existing mudflat habitat around Long Island would be maintained. Some *Spartina*-dominated areas would be converted to mudflat and some would convert to native saltmarsh. Existing native saltmarsh would be preserved. Impacts to off-refuge vegetation due to *Spartina* spread would be minimized.

The movement of people and vehicles across tidelands during control efforts may result in damage to native vegetation such as saltmarsh plants, eelgrass beds, and macroalgae beds. It is expected that negative impacts would be minor and temporary. Damage would be minimized by using mudwalkers and low-impact vehicles (hovercraft and airboat). Native plants living in *Spartina* colonies would be damaged or destroyed by control methods.

Rodeo® tank mixes have had variable effects upon non-target marine plants. Japanese eelgrass (*Z. japonica*) growth was adversely affected at 1 of 2 plots aerially treated with Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) in Willapa Bay (Fresh et al 1996). The affected plot had shallower water depth and, therefore, greater eelgrass exposure during the herbicide application. Rodeo® (10.3 [4.44 quarts/acre] to 0.7 liter/ha [0.3 quarts/acre]) and X-77® Spreader applied by hand-held sprayer to eelgrass (*Zostera* spp.) in Padilla Bay did not affect biomass during an 8-week study period (Bulthuis and Hartman 1994). Rodeo® (4.7 liters/ha) and X-77® Spreader (1% solution) applied by hand-held sprayer to plots with native salt marsh vegetation had no effect upon density, cover, and biomass of pickleweed or salt grass up to 1 year post-treatment; however, cover and biomass of saltbush (*Atriplex patula*) were reduced at 60 days post-treatment because exposure time (>8 hours) was longer for this species located higher in the intertidal zone (Bulthuis and Scott 1993). No adverse effects were found to microalgae after aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) to control *Spartina* in Willapa Bay (Simenstad et al. 1996). Direct application of Rodeo® to marine macrophytes would likely result in impacts. However, these impacts may be reduced or eliminated if non-target macrophytes are covered with seawater. No impacts to marine microalgae would result from herbicide control of *Spartina*.

The 96-hour LC_{50} value, concentration found to cause mortality in 50% of the individuals during a laboratory toxicity test, for the marine alga (*Skelatonema costatum*) is 27 ppb for nonylphenol (Naylor 1992), which is the nonylphenol polyethoxylate

degradation product with the greatest toxicity to aquatic organisms. This value is 1.7 times higher than the maximum average concentration of nonylphenol polyethoxylates (16 ppb) from the leading edge of the first high tide following aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) from the Paveglio et al. (1996) study.

Although no biological or cultural techniques are currently available for *Spartina* control, possible future techniques include use of microbial pathogens, insect herbivores, and genetic engineering (State of Washington 1993). A realistic goal of biological control methods would be to reduce *Spartina* abundance to a more easily managed level for other techniques, rather than complete eradication.

Potential risks of using biological control agents include unintended damage to or loss of native plants or animals and reduced palatability of affected native plants (forbs and grasses) to animals. Because of these potential risks, biological control methods such as use of new pathogens, introduced insects, or genetic engineering, typically require several years for research and approval to assess efficacy, effects on target and nontarget organisms, and other environmental concerns. Then after introduction, several more years may pass before viability of the target plant is affected (State of Washington 1993).

The beneficial effect of Integrated Pest Management would be to preserve and restore native plant habitat by stopping the spread of *Spartina*. Eelgrass would quickly recolonize areas where *Spartina* was controlled.

4.3.2.2 *Spartina*

Spartina would be directly affected by physical/mechanical and/or chemical control actions of IPM. It would slow or prevent *Spartina* spread via asexual growth. It would also reduce or prevent the establishment of seedlings. *Spartina* seed production would be mostly stopped in about 5 years on the southern units and around Long Island. It is estimated that about half of the existing *Spartina* meadow and coalescing clones would convert to native salt marsh and the other half would revert to mud flat on the southern units. Around Long Island, it is anticipated that most existing *Spartina* meadows would convert to native saltmarsh in about 10 years. Little meadow would return to mud flat there. The lowest potential for viable seed movement out of Willapa Bay to other estuaries would occur under the IPM alternative.

Ground applications with Rodeo® tank mixes would control *Spartina* within the intertidal zone. Kilbride et al. (1996) sprayed *Spartina* clones on the Refuge (Porter Point) by hand-held equipment and achieved 84% control (reduction in stem densities) 1 year post-treatment. R. Crockett (Monsanto Agric. Co., pers. commun.) found ≥90% declines in *Spartina* 1 year after treatment with Rodeo® (0.56 to 2.24 kg glyphosate/ha) and R-11® Spreader Activator (1% solution) by hand-held boom. Major

and Grue (1997) found 80 to 90% and 89 to 93% reductions in stem densities 1 year after treatment of *Spartina* clones in Willapa Bay on sites with muddy substrates (North River and Lewis Unit on the Refuge) associated with spraying Rodeo® (5% solution) and LI-700 (2% solution) by hand-held equipment alone and in combination with mowing 6 weeks prior to herbicide application, respectively. Lesser control (6 and 69% reductions for spray alone and mowing/spraying treatments, respectively) was found for a site (Nemah Beach) identically treated on sandy substrate (Major and Grue 1997). Differences in efficacy may have been related to Rodeo® delivery rates, where muddy sites received 54 to 63 liters/ha compared with 47 liters/ha at the sandy site. Garnett et al. (1992) found a 74 to 89% decrease (1 year after treatment) in stem densities of *Spartina anglica* sprayed by hand-held boom with Roundup® (1.80 kg glyphosate/ha) and Pro-Mix surfactant (2% solution). Pritchard (1995) applied glyphosate (Glyphosate 360 at 40 liters/ha) to plots within a *Spartina* meadow (Victoria, Australia) by held-held sprayer and achieved 84% control after 1 post-treatment year.

Aerial applications of Rodeo® tank mixes to *Spartina* would also result in control. Kilbride et al. (1996) found 32% declines in stem densities of *Spartina* for three 1-ha plots with clones aerially sprayed in August 1992 with Rodeo® (4.7 liters/ha) and X-77® Spreader (1 liter/ha) in Willapa Bay. Short exposure time (≤5.5 hours) and low rate of Rodeo® application (4.7 compared with 8.8 liters/ha [maximum rate by label]) likely prevented cuticular penetration of sufficient amounts of glyphosate to effect better control. In August 1995, a 2-ha plot within a *Spartina* meadow in Willapa Bay (Kaffee-Lewis Slough) was aerially sprayed with Rodeo® (8.8 liters/ha) and X-77® Spreader (1.2 liter/ha). Pre- and post-treatment (1 year) data (stem densities) were collected and indicated no *Spartina* control (Grue and Major 1997). In addition, the *Spartina* meadow (152 ha) in Kaffee-Lewis Slough, which included the 2-ha plot treated in 1995, as well as a 12-ha meadow in Seal Slough were aerially sprayed in early July 1996 with Rodeo® (8.8 liters/ha) and R-11® Spreader Activator (0.5% solution). Visual (aerial) observations of the treated meadows 5 weeks after application indicated approximately 65 to 75% brown down with no seed set (C. Moore, Washington Dept. Agric., pers. commun.). Greater control likely will be achieved with meadow spraying that occurred during 1996 compared with the 1992 and 1995 treatments because exposure time was greater. The 1996 application was conducted during a rising low-high tide with 12 hours of exposure before most of the treated *Spartina* was inundated; whereas, exposure times for the 1992 and 1995 treatments were about 6 hours.

If any new techniques become available, biological control would most likely reduce expansion of *Spartina* by preventing seed set and reducing vegetative spread. Standing biomass of *Spartina* in treated areas might also be reduced.

4.3.2.3 Wildlife

Overall, *Spartina* control would be beneficial to wildlife. Native habitat would be

restored or preserved for aquatic migratory birds that utilize the mudflats and saltmarsh on the Refuge. *Spartina* growth would continue on the remainder of the area. Mudflats would remain for shorebird feeding. Black brant, Canada geese, American wigeon, northern pintail, and mallards would continue to find food in protected eelgrass communities. In order to avoid disturbances, aerial control activities would not take place within ½ mile of any active bald eagle nest. Loons, grebes, scaup, and other diving birds would have open-water areas.

Human activity and noise from the airboats, hovercraft, and skiffs would temporarily disturb aquatic migratory birds from the project area during operations at low tides. Most waterbirds, shorebirds, herons, and raptors, including bald eagles, would be expected to flee from and/or avoid localities where and when work is in progress. Disturbance would be minimized by the relatively small scale of control operations. On a typical day, a crew of two to four people (larger crews may be used at times) would be working on a few acres. Birds that are displaced from a work site would be able to move to nearby areas and continue their activities. Birds that use water for resting and feeding would be expected to return to control sites during high tides. Control activities would occur during the spring and summer when use of Willapa Bay by brant, geese, ducks, shorebirds, loons, and many other waterbirds is low to nonexistent. Because of the probable synergistic effects of IPM and the resultant smaller control effort, any risks of negative impacts associated with control efforts would be lessened.

Little is known concerning the use of *Spartina* on the West Coast by marsh and water birds. It is possible that some species that prefer dense vegetation, such as bitterns, could lose cover and feeding habitat by removal of *Spartina*.

Because toxic dietary thresholds are not likely to be reached after Rodeo® applications to control *Spartina*, no effects upon aquatic migratory birds are expected. Dietary toxicity tests with mallard ducklings found a LC_{50} value of 4,640 ppm for glyphosate, which classifies glyphosate as practically nontoxic (Heydens 1991). This LC_{50} level would require an average daily intake of 1,106 mg/kg (Heydens 1991). Female mallards exposed to dietary concentrations ≤1,000 ppm (equivalent to an average daily intake of 126 mg/kg) showed no reproductive effects. In addition, the highest average concentration of glyphosate in *Spartina,* which might be similar to what could be expected in sprayed eelgrass (a species consumed by aquatic birds), 1 day after aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1 liter/ha) in Willapa Bay was 65.6 ppm (Paveglio et al. 1996). Because this value is 71 times less than the LC_{50} value for mallard ducklings, toxic dietary thresholds for aquatic birds would not likely be reached after Rodeo® applications to control *Spartina*.

Field studies have not demonstrated direct adverse effects of Rodeo® tank mixes on birds. Solberg and Higgins (1993) found nesting success of waterfowl species was not affected in wetlands sprayed with Rodeo® (2.8 liters/ha) and X-77® Spreader (0.33%

solution) to control cattails (*Typha* spp.). Roundup® (2.3 liters/ha) applied to an Oregon coastal forest for conifer release did not affect the bird community although habitat was altered for 2 years post-treatment (Morrison and Meslow 1984). In contrast, Santillo et al. (1989) found that aerial application of Roundup® to clearcuts in north-central Maine reduced total numbers of birds, but this was a result of changes in habitat structure rather than mortality from pesticide exposure.

Several field studies have been conducted to determine the effects of glyphosate on mammals. Sullivan (1979) found that black-tailed deer (*Odocoileus hemionus*) did not alter browsing habits and showed no adverse effects from consuming forage in areas aerially treated with Roundup®. Anthony and Morrison (1985) found that aerial application of Roundup® (2.25 liters/ha) in coastal forests of western Oregon increased the abundance and diversity of small mammal populations. D'Anieri et al. (1987) found that richness of the small mammal community was not affected after clearcuts in northern Maine were aerially treated with Roundup® (2.25 liters/ha).

Acute toxicity based upon a limited number of laboratory studies indicate that X-77® Spreader, R-11® Spreader Activator, and LI-700® are nontoxic to mammals. For nonylphenol polyethoxylates, the oral LD_{50} for rats and mice ranges from 2,000 to 4,000 ppm (Benson and Nimrod 1994). No nonylphenol polyethoxylates were detected in *Spartina* 1 day after aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1 liter/ha) in Willapa Bay (Paveglio et al. 1996), and nonylphenol polyethoxlates were found at an average concentration of 0.181 ppm in sediment on spray day. Because these values are at least 11,000 times less than the LD_{50} value for rats and mice, effects on mammals are not likely after applications of Rodeo® and alkylphenol polyethoxylate-based surfactants to control *Spartina*.

Through laboratory studies (Mueller and Kim 1978, Soto et al. 1991, Jobling and Sumpter 1993), alkylphenol polyethoxylates have recently been recognized as xenoestrogens (environmental estrogens) capable of mimicking estrogen and, therefore, affecting reproductive endocrine function in biota. However, nonylphenol polyethoxylates did not persist in seawater and sediment after herbicide applications to control *Spartina* (Paveglio et al. 1996) and, consequently, estrogenic effects upon wildlife are unlikely.

4.3.2.4 Fish

IPM would be expected to have an overall positive effect on fish. The loss of temporary cover habitat along the edges of *Spartina* clones and meadows for salmon smolts and other small fish would be more than offset by the restoration of eelgrass, algae, and mudflat habitat and the prevention of the development of large monotypic *Spartina* meadows.

The risk of fuel spills and localized temporary increases in suspended (water column)

sediments in work areas would be minimized by protocols which would forbid fueling outside contained areas such as boats and would use hovercraft or airboats to directly access *Spartina* clones. Because of the very low concentrations of glyphosate found in saltwater after application and the low toxicity of glyphosate and surfactant, acute or chronic toxicity to fish are not expected to occur. Because of the probable synergistic effects of IPM and the resulting smaller control effort, any risks of impacts associated with control efforts would be lessened.

Potential benefits are associated with preservation or restoration of native fish habitat (intertidal mudflats). The mudflats support a rich and diverse benthic fauna upon which fish feed and the mudflats are accessible through a substantial part of the tidal cycle. Species that depend on open water, eelgrass, algae, or mudflat communities to meet one or more of their life requirements could utilize areas where *Spartina* is controlled. The composition of the benthic fauna and hence the food web of fish in treated areas would likely revert back to pre-*Spartina* conditions in some areas over time. In the future, trapped sediments would be resuspended, lowering the elevation of treated sites so that they would be inundated (and thus available to fish) during more of the tidal cycle.

A biological opinion written by the Service's Klamath Basin Ecosystem Restoration Office (February 2, 1996) entitled "Reinitiation of Formal Consultation on the Use of Pesticides and Fertilizers on Federal Lease Lands and Acrolein and Herbicide Use on the Klamath Project Right-of-Way Located on the Klamath Project" stated that laboratory studies show glyphosate is soluble in water and very toxic to fish. According to Elaine Snyder-Conn, the contaminant specialist for the Service who co-authored this biological opinion, the statement was based upon laboratory toxicity tests with freshwater fishes such as rainbow trout, fathead minnows, and bluegill exposed to Roundup (Mayer and Ellersieck 1986). However, Rodeo is ten times less toxic than Roundup because of the difference in surfactants present in the two formulations (Mitchell et al. 1987).

A very large margin of safety exists between maximum concentrations of glyphosate found in seawater in the Paveglio et al. (1996) study and concentrations resulting in acute and subacute impacts to anadromous fishes. The maximum average concentration of glyphosate (25.6 ppb) found during the first tidal inundation for the Paveglio et al. (1996) study was 23,000 to 56,000 times less than 96-hour LC_{50}s (Rodeo® and X-77® Spreader) for chinook and coho salmon (*O. kisutch*) fingerlings (Mitchell et al. 1987*a*), and 108 times less than concentrations that did not disrupt seawater adaptation or growth of coho salmon smolts (Roundup® [Mitchell et al. 1987*b*]).

Acute toxicity based upon a limited number of laboratory studies indicate that X-77® Spreader/R-11® Spreader Activator and LI-700® are moderately and nontoxic to fish, respectively. LC_{50}s (96- and 48-hour) values for nonylphenol and nonylphenol polyethoxylates were $\leq$ 3.0 ppm and range from 0.13 ppm for Atlantic salmon (*Salmo*

salar; McLeese et al. 1980) to 3.0 ppm for saltwater cod (*Gadus morhua*; Swedmark 1968) and flounder (*Pleuronectes flesus*; Swedmark et al. 1971). In general, young fish have been found to be more sensitive than adults. For example, developmental abnormalities and increased mortality rates occurred for cod eggs and larvae exposed to >0.2 ppm (Swedmark et al. 1971). Because maximum mean concentrations of nonylphenol polyethoxylates in the leading edge of the first high tide after treatment (worse case) was considerably less (16 ppb [Paveglio et al. 1996]) than these LC_{50} values, toxicological effects upon fish are unlikely.

Estrogenic effects upon fish associated with alkylphenol polyethoxylate-based surfactants are unlikely. Sheahan and Harries (1992) found nonylphenol concentrations between 20 and 50 ppb induced the production of vitellogenin (protein usually found only in sexually mature females) in male rainbow trout. Jobling et al. (1996) found induction of vitellogenin synthesis and reduction in testicular growth for juvenile male rainbow trout continuously exposed to 3 and 10 ppb nonylphenol and octylphenol, respectively, during a 3-week laboratory study. Jobling et al. (1996) also found that the degree of inhibition for testicular growth associated with nonylphenol and octylphenol depended upon the timing of exposure as well as sexual maturity, where inhibition was less pronounced for exposure toward the end the gonad growth phase and no inhibition was found for sexually mature fish. Although Paveglio et al. (1996) found higher average concentrations of nonylphenol polyethoxylates (≤16 ppb) in the leading edge of the first tidal inundation after herbicide application, nonylphenol polyethoxylates were undetectable (≤2.0 ppb) in seawater during the first high tide after treatment.

4.3.2.5 Microbes and Marine Invertebrates

The presence of people and equipment on the tidelands would have some negative impacts on invertebrates. Organisms living in or on the mudflats and salt marsh as well as *Spartina* seedlings, clones, and meadows could be crushed, burned, or dislodged. When seedlings are removed, organisms adhering to the seedlings would perish. Impacts would be minimized by the use of mudwalkers and low-impact vehicles such as hovercraft and airboats.

The results of field and laboratory studies indicate that Rodeo® tank mixes applied to *Spartina* likely would not affect marine invertebrates through seawater exposure. Simenstad et al. (1996) found no short- (28 days post-treatment) or long-term (119 days post-treatment) effects to epibenthic invertebrate communities associated with aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) to control *Spartina* in Willapa Bay. Kubena (1996) conducted 96-hour bioassays with marine amphipods native to the Atlantic Coast (*Leptocheirus plumulosus*) and the Pacific Northwest (*Eohaustrorius estuarius*) that were placed in various dilutions (0.1 to 10%) of the herbicide tank mix representing the maximum application rate for aerial control

of *Spartina* (8.8 liters/ha for Rodeo® [500 ppm glyphosate] and 2% solution for a nonionic surfactant [25 ppm nonylphenol polyethoxylates {X-77® Spreader}, 40 ppm octylphenol polyethoxylates {R-11® Spreader Activator}, or 22 ppm phosphatidylcholine {LI-700®}]). Amphipod survival was not affected for these 96-hour bioassays up to the highest concentrations tested (50 ppm glyphosate and 2.5, 4.0, or 2.2 ppm for nonylphenol polyethoxylates, octylphenol polyethoxylates, and phosphatidylcholine, respectively). In another series of 96-hour bioassays, amphipod survival was reduced by 30% and 25 to 80% at 248 ppm glyphosate and 11 ppm phosphatidylcholine and 124 ppm glyphosate and 6.2 or 9.9 ppm nonylphenol polyethoxylates or octylphenol polyethoxylates, respectively. Bioassays (48-hour) with echinoderm larvae (*Dendraster excentricus*) indicated that glyphosate and nonylphenol polyethoxylates, octylphenol polyethoxylates, or phosphatidylcholine concentrations up to the highest concentrations tested (5 ppm and 0.25, 0.40, or 0.22 ppm, respectively) did not affect survival. Kubena et al. (1996) conducted a 96-hour bioassay with Pacific oysters (*Crassostrea gigas*) in which seawater spiked with Rodeo® and R-11® Spreader Activator was added to 2.8 ml chambers with seawater from Puget Sound. For this 96-hour bioassay, glyphosate and octylphenol polyethoxylate concentrations at 250 and 20 ppm, respectively, reduced survival of larval oysters. The maximum average concentration of glyphosate in seawater (25.6 ppb) found on sprayed plots during the first high tide after application for the Paveglio et al. (1996) study was 4,844- and 9,766-fold less than glyphosate concentrations that reduced survival of amphipods and oysters, respectively, in bioassays.

The results of field and laboratory studies indicate that Rodeo® tank mixes applied to *Spartina* likely would not affect marine invertebrates through sediment exposure. Simenstad et al. (1996) found no short- (28 days post-treatment) or long-term (119 days post-treatment) effects to benthic invertebrate (infauna and meiofauna) communities associated with aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) to control *Spartina* in Willapa Bay. Kubena (1996) conducted 10-day bioassays with *Leptocheirus plumulosus* and *Eohaustrorius estuarius* in which Refuge (Lewis Unit) sediment spiked with Rodeo® and R-11® Spreader Activator were added to the 1-liter test chambers with seawater from Puget Sound. For these 10-day bioassays, glyphosate and octylphenol polyethoxylates up to the maximum concentrations tested (2,066 and 165 ppm, respectively) did not affect amphipod survival. Kubena et al. (1996) conducted 96-hour bioassays with Pacific oysters in which Refuge sediment spiked with Rodeo® and surfactant (X-77® Spreader, R-11® Spreader Activator, or LI-700®) was added to 2.8 ml chambers with seawater from Puget Sound. For these bioassays, glyphosate and nonylphenol polyethoxylates, octylphenol polyethoxylates, or phosphatidylcholine concentrations at 5,122 ppm and 256, 410, or 224 ppm, respectively, reduced survival of larval oysters. The maximum average concentrations of glyphosate and nonlyphenol polyethoxylates in sediment (2.82 and 0.181 ppm DW, respectively) found on treatment plots for the Paveglio et al. (1996) study were 1,816- and 1,414-fold less than glyphosate and nonylphenol polyethoxylate concentrations,

respectively, that reduced survival of oysters in bioassays.

The results of LC_{50} tests with glyphosate or alkylphenol (nonylphenol and octylphenol) polyethoxylates also indicate that Rodeo® tank mixes applied to *Spartina* likely would not affect marine invertebrates. The maximum average concentration of glyphosate in seawater found on sprayed plots during the first high tide after application for the Paveglio et al (1996) study was 25 to 39,000 times less than 96-hour LC_{50}s for fertilized eggs of Atlantic oysters (*Crassostrea virginica)*, fiddler crabs (*Uca pugilator*), grass shrimp (*Palaemonetes vulgaris*), a marine alga (*Skeletonema costatum*), mysid shrimp (*Mysidopsis bahia*), and sea urchins (*Tripneustes esculentus*) tested with glyphosate (Heydens 1991). For alkylphenol polyethoxylates, 96-hour LC_{50}s values of 2.9 to >100 ppm and <5 to >100 ppm were found for marine crustaceans and bivalves, respectively (Talmage 1993:270), but nonylphenol polyethoxylates were not detected (<2.0 ppb) in seawater found on sprayed plots during the first high tide after application for the Paveglio et al. (1996) study. Laboratory studies also indicate that LI-700® is nontoxic to aquatic invertebrates.

Because nonylphenol polyethoxylates did not persist in seawater or sediment after herbicide applications to control *Spartina* (Paveglio et al. 1996), estrogenic effects upon invertebrates associated with alkylphenol polyethoxylate-based surfactants are unlikely.

By preserving and restoring mudflats, eelgrass, and macroalgae beds, *Spartina* control using IPM would have the greatest potential to benefit shellfish and other invertebrates associated with these habitats. By reducing seed production in the bay, fewer Spartina seedlings would be expected to sprout on Refuge and neighboring tidelands, thus maintaining more mudflat habitat for invertebrates. In areas still dominated by *Spartina*, many species of shellfish and other benthic macroinvertebrates would either not survive or be reduced in numbers (Washington State 1993, Atkinson 1992, Simenstad and Thom 1995).

4.3.2.6 Biodiversity

With careful procedures to avoid application to nontargeted organisms and the unlikelihood of toxicological effects at maximum concentrations in the saltwater or sediments, biodiversity should not be adversely affected by use of glyphosate in IPM. Control to prevent monotypic stands of *Spartina* would protect biodiversity of plants, wildlife, and invertebrates.

4.3.3 Social Environment

4.3.3.1 Human Health

Little potential exists for acute toxicity to human health nor long-term health impacts associated with cancer or other maladies from exposure to glyphosate associated with Rodeo® applications to control *Spartina*. Knowledge regarding the acute toxicity of glyphosate to humans comes from a study conducted by Japanese physicians who

investigated 56 poisoning cases, most of which were suicides or attempted suicides, involving Roundup®. For the 9 cases in which the suicide attempts were successful, the mean amount ingested was 200 ml (¾ of a cup) of herbicide; however, the polyethoxylated tallowamines (surfactant in Roundup® but not Rodeo®) likely caused the herbicide toxicity (Sawada et al. 1988). Short- and long-term non-cancer health effects were below levels of regulatory concern for adults and children (1 in 1,000,000). Similarly, all risks calculated for cancer effects were also below the regulatory concern level (1 in 1,000,000). Because no carcinogenic effects were found for chronic studies with rats and mice, glyphosate has been classified by the U.S. Environmental Protection Agency as noncarcinogenic to humans (Washington State 1993).

Because nonylphenol polyethoxylates did not persist in seawater or sediment (see subsections 4.3.1.1 and 4.3.1.3) after herbicide applications to control *Spartina* (Paveglio et al. 1996), estrogenic effects upon humans associated with alkylphenol polyethoxylate base surfactants are unlikely.

There are certain health problems that have occurred with a statistically higher frequency in Pacific County than in the State as a whole. However, there are no indications that any of these health problems are associated with environmental conditions (See 3.4.2.1). The low potential for movement of approved chemical compounds off of treatment sites, the tendency for these compounds not to persist, and the low toxicity of concentrations found on treatment sites make it unlikely that the chemical component of IPM would generate an environmental health hazard or contribute to existing health problems.

Health problems associated with *Spartina* pollen production and mosquitos that breed in *Spartina* meadows on the Refuge would be reduced within 10 years by *Spartina* control. This alternative also provides the greatest opportunity for the Refuge to reduce such impacts off-refuge.

Control workers would be exposed to the risks of cuts, bruises, sprains, etc., associated with manual labor. They would also be exposed to high noise levels generated by airboats, hovercraft, and weedeaters. The use of appropriate safety procedures and equipment, including hearing protection, would minimize these risks.

4.3.3.2 Concerns

IPM would involve the use of a chemical herbicide (glyphosate) and adjuvants to control *Spartina*. Current information about these chemicals is provided in other parts of this document. The intent of the proposal is to maximize efficacy of control efforts and minimize risks of all methods. Efforts to find new methods and chemicals that improve efficacy and safety would continue.

There is a high level of consensus among interest groups within Pacific County on the

use of IPM for the control of *Spartina*. However, resistance to the chemical component of IPM persists from those that have taken the position that no agricultural chemicals should be used in Willapa Bay and that *Spartina* expansion in the bay is not a serious problem. Information regarding the physical, biological, and socio-economics problems posed by *Spartina* in Willapa Bay can be found throughout this document. Since there is a substantial body of evidence that the concentrations of chemicals that would be applied would pose little risk to humans and the environment, and that the chemicals would not persist or bioaccumulate, concerns about chemical use assume that there are hidden risks, people are exposed to those risks involuntarily, and/or the hazards would be irreversible.

While there are risks in any endeavor and complete knowledge of biological systems is impossible, the widespread use and investigation of the chemicals used for *Spartina* control has reduced the likelihood that serious hidden risk remains. The known risks associated with the chemicals proposed for use are accepted by most with a stake in maintaining the diversity and health of Willapa Bay. However, the known risks of failure to control *Spartina* are not acceptable to stakeholders and this, of course, is why aggressive control is on-going through out the bay.

On Willapa Bay, most of the known risk associated with chemical use is borne by the stakeholders in the resource voluntarily. This is particularly true on the one-third of the tidelands that are privately owned. On these lands, 59% of the owners that have been contacted have expressed a willingness to use chemicals to control *Spartina*. Furthermore, resistance to chemical use is based more on efficacy and cost concerns rather than health concerns (Lebovitz 1997). Risk is borne voluntarily by these stakeholders both in terms of cost and exposure to the chemicals. The tendency of chemicals not to persist, bioaccumulate, or move off site minimizes involuntary exposure to risk off site. Chemical dilution, degradation, and incorporation into plant tissue and sediment minimizes involuntary risk of exposure to recreational users visiting tidelands previously treated.

Current understanding of the chemicals approved for use on *Spartina* indicate that effects would not continue long after use of these chemicals ceased. There is no evidence that the use of these chemicals would have irreversible impacts. However, the uncontrolled spread of *Spartina* might not be reversible by any practical means.

4.3.3.3 Recreation

Noise from airboats, hovercraft, helicopters, and/or weedeaters would be heard by non-motorized boaters on the bay and users of the Long Island and Leadbetter Point Units during operations. These sounds would be most noticeable in the immediate vicinity of operations or along transport routes. This could distract from their recreational experiences. Disturbance of waterbirds during the low tide operations would occasionally interfere with bird watching in the vicinity of control activities. Fishermen

would not normally be affected by operations since operations would occur on exposed flats during low tides.

In the long term, recreational boating, shellfish gathering, sportfishing, hunting, and bird watching would benefit by *Spartina* control via the restoration and maintenance of habitats, and access and navigation capabilities.

4.3.4. Economic Environment

Integrated Pest Management would provide the greatest contribution of resources to off-Refuge control efforts.

4.3.4.1 Tourism

The project would contribute to the overall health of local tourist-related businesses in future years by protecting the recreational qualities listed above.

4.3.4.2 Mariculture and Fisheries

The oyster mariculture industry would benefit directly from *Spartina* control. The export of *Spartina* seed from the Refuge to other tidelands accelerates the spread of *Spartina*, threatening valuable shellfish beds in the Bay. Under IPM, *Spartina* seed production from Refuge tidelands would be minimized in the shortest period of time. It also provides the maximum opportunity for the Service to work cooperatively with adjacent tideland owners. For these reasons, IPM would provide the greatest benefits to mariculture and fisheries of the alternatives discussed in this EA.

NOTE: For more discussion of the consequences of the Integrated Pest Management Alternative, see pages 174-175 and the Element D, E_A, E_B, and F reports of the State FEIS on Noxious Emergent Plant Management, 1993.

4.4 EFFECTS OF PHYSICAL/MECHANICAL MEANS ONLY ALTERNATIVE

Practical limitations on the scale of physical/mechanical control would allow the continued growth of *Spartina* in large areas. The large amount of effort required per unit of treated area would limit the total acreage that could be treated in this alternative.

4.4.1 Physical Environment

The transformation of open tidal flats to higher elevation *Spartina* marsh would be slowed. The removal of seedlings would prevent the development of large clones in control areas. In areas where clones were killed, wave and current action might erode some sediments trapped by the plant thus restoring tidal flats to their original elevation. Alternately, native marsh plants might occupy the sites, maintaining the elevation while increasing plant diversity. The extent to which either response would occur is unknown - both may occur to some degree.

4.4.1.1 Soils and Topography

The sediment buildup and changes in substrate composition and topography resulting from *Spartina* growth would be slowed or halted in control areas. The existing mudflat topography would be preserved where *Spartina* seedlings are removed. Where meadows could not be controlled, sediment would continue to be captured at high rates for many years.

The entrapment and accretion of sediments by *Spartina* would be reduced or prevented in control areas. This would result in more normal movement and distribution of sediments in the water column.

Control operations might result in temporary increases in sediment load in the water column due to disturbance of the substrate and erosion of previously accreted sediments where clones were controlled. The weight of people and equipment might cause temporary compaction of bottom sediments.

4.4.1.2 Hydrology

Natural tidal drainage patterns would be preserved in areas where *Spartina* growth was halted or prevented. Some changes might still occur because of the presence of nearby *Spartina* stands. The potential for flooding resulting from the restricted runoff associated with *Spartina* growth would be reduced.

4.4.1.3 Water Quality

Where *Spartina* clones were mowed, decomposition of the resulting plant litter could temporarily reduce dissolved oxygen levels in the immediate area. As work areas were tidally reflooded, disturbance to the substrate caused by people and equipment might result in greater local increases in suspended sediments than with other alternatives.

Fuel spills/leakages could result from the use of power tools and vehicles in control operations. Incomplete fuel combustion during torching could result in pollution. Protocols would be established to minimize risks (Sec. 2.3).

The potential effects of *Spartina* on water quality, including increased surface water temperatures and reduced levels of dissolved oxygen (see subsection 4.2.1.3), would be ameliorated to the degree that control was successful.

Beginning in the spring of 1997, the Washington Department of Ecology is conducting an EPA-funded project to study water quality parameters in Willapa Bay. Water temperature, dissolved oxygen, nutrients, chlorophyll, pH, light transmission, and turbidity, as measured by Secchi disk depth, will be measured at six locations (Newton 1997).

4.4.1.4 Ambient Sound

Considerable noise would be generated by weedeaters, airboats, hovercraft, etc., during work periods. Work would normally occur during the daylight hours. However, self-propelled mowing equipment would be equipped with lighting to extend operations into the night. A higher reliance on large machinery that could work night and day would likely result in more noise than with other alternatives.

4.4.1.5 Air Quality

Of the action alternatives, total reliance on physical and mechanical control of *Spartina* would require the greatest consumption of fossil fuel and, consequently, would generate the highest degree of associated air pollution. There would, however, be no potential for herbicide drift.

4.4.2 Biological Environment

Physical and mechanical control would prevent *Spartina* from occupying all of the Refuge's intertidal lands. Some mudflats and native saltmarsh would be preserved and would continue to be utilized by birds, fish, and invertebrates that flourish in these habitats. However, this type of control is labor intensive and costly, and would be applied only on a limited scale. A large proportion of tidelands would continue to be colonized and occupied by *Spartina* and substantial seed production would still occur.

4.4.2.1 Vegetation

It is anticipated that much of the existing and expanded *Spartina* growth on the Refuge's southern units would be converted to native saltmarsh in 10 years. Around Long Island, *Spartina* would continue to gradually expand into existing native saltmarsh. Little, if any, land currently dominated by *Spartina* would be converted to native saltmarsh.

About 1,800 acres of intertidal mudflats supporting seagrass and macroalgae beds would be maintained on the southern units. Little or no mudflat habitat would be maintained around Long Island to provide seagrass and macroalgae environment.

The lower efficacy of this alternative would permit more seed and propagules to move off refuge and establish *Spartina* colonies that would crowd out desirable vegetation on adjacent tidelands.

The movement of people and vehicles across tidelands during control efforts might result in damage to native vegetation such as saltmarsh plants, eelgrass beds, and macroalgae beds. It is expected that negative impacts would be minor and temporary. Damage would be minimized by using mudwalkers and low-impact vehicles (hovercraft and airboats). Native plants living in *Spartina* clones would be damaged or destroyed by mowing and burning.

The beneficial effect of this alternative would be to prevent *Spartina* from completely taking over shallow mudflats and associated plant habitats. Some existing areas of native plant habitat would be preserved. Where *Spartina* clones were killed, native saltmarsh plants might increase because sediment accrual in the clones has raised the elevation of the mudflats to a suitable level. Depending on the elevation, either saltmarsh plants or eelgrass would quickly recolonize areas where *Spartina* was controlled. However, unless erosion in these accumulated sediment areas occurred, mudflat habitat would continue to be lost.

4.4.2.2 *Spartina*

It is estimated that it would take about 10 years for *Spartina* seed production to be halted in the southern units. Without Washington Department of Natural Resources assistance, seed production around Long Island would not be stopped. Less control over seed production would interfere with *Spartina* control by others on adjacent tidelands and sustain the potential for viable seed movement out of Willapa Bay.

This degree of control would not keep pace with the spread of *Spartina*. On the southern units, *Spartina* meadows would continue to expand for several years before the trend is reversed. Some *Spartina* meadow would remain after 10 years there. Around Long Island the meadows would expand as long as space allows.

4.4.2.3 Wildlife

Human activity and noise associated with control efforts would cause some disturbance to wildlife. Most waterbirds, shorebirds, herons, and raptors, including bald eagles, would be expected to flee from and/or avoid localities where work was in progress. Human movements to and from work areas, along with the noise of airboats and other watercraft used to transport workers, would also disturb birds temporarily.

Little is known concerning marsh and waterbird use of *Spartina* on the West Coast. Some species that prefer dense vegetation, such as bitterns, could be displaced from feeding habitat by removal of *Spartina*.

Disturbance would be minimized by the relatively small scale of control operations. On a typical day, a crew of two to four people (larger crews might be used at times) would be working on a few acres at a time. Birds disturbed at the project site would probably move to nearby areas and continue their activities. Work would occur during the spring and summer when use of the bay by black brant, geese, ducks, shorebirds, loons, and many other waterbirds was low to nonexistent.

As larger, more effective mowing machines are developed and used, disturbance to wildlife would be expected to increase. Total dependence on mechanical control would expand the need to conduct night mowing operations, thus extending the amount of disturbance.

Overall, *Spartina* control would be beneficial to wildlife. Some native habitat would be preserved for aquatic migratory birds that have historically used the mudflats and saltmarsh on the Refuge. Black brant, Canada geese, American wigeon, northern pintail, and mallards would continue to feed on eelgrass. Loons, grebes, scaup, and other diving birds would continue to use open water areas. Although some existing mudflat habitat would be lost, a portion of the mudflats would remain for shorebird feeding. There would be less eelgrass for aquatic migratory birds, and less area of open mudflat for shorebirds and bald eagles. Nearly all *Spartina* meadow killed by this alternative would convert to native saltmarsh. Of the action alternatives, this would preserve the least mudflat habitat for migratory bird use.

4.4.2.4 Fish

Physical/mechanical control would not be expected to have short-term negative impacts on fish, except for the slight risk of a fuel spill and a possible temporary, localized sedimentation increase in work areas.

Potential benefits are associated with preservation of some areas of native fish habitat (i.e., intertidal mudflats). The mudflats support a rich and diverse benthic fauna upon which fish feed (Nichols and Pamatmat 1988) and are accessible through a substantial part of the tide cycle. Species that depend on open water, eelgrass, algae, or mudflat communities to meet one or more of their life requirements could utilize areas where *Spartina* was controlled.

The practical limitations of physical/mechanical control would preclude large-scale control operations. *Spartina* growth would continue on the majority of Refuge tidelands. The composition of the benthic fauna and hence the food web of fish would likely change. Over time, trapped sediments would raise the elevation of *Spartina* clones and they would be inundated (and thus available to fish) during less and less of the tide cycle.

4.4.2.5 Microbes and Marine Invertebrates

The presence of people and equipment on the tidelands would have some negative impact on invertebrates. Organisms living in or on the mudflats, salt marsh, and *Spartina* clumps would be more likely to be crushed, burned, or dislodged with this alternative. The Newcomb's littorine snail, a Federally recognized Species of Concern and State Candidate Species living on pickelweed plants, would be in greater danger of such a fate, than with other alternatives. When seedlings were removed, organisms adhering to the seedlings would perish. Impacts would be minimized by the use of mudwalkers and low-impact vehicles such as hovercraft and airboats. The affected area would be relatively small because of the limited scale of physical/mechanical control. However, as larger, more effective machines are developed for mowing, impacts to invertebrates would increase, particularly on *Spartina* meadows where such machinery would be used.

By preserving mudflats, eelgrass, and macroalgae beds, *Spartina* control would benefit shellfish and other invertebrates associated with these habitats. In areas dominated by *Spartina*, many species of shellfish and other benthic macroinvertebrates would either not survive or be reduced in numbers (Washington State 1993, Atkinson 1992, Simenstad et al. 1996).

4.4.2.6 Biodiversity

A limited amount of native saltmarsh and mudflats, with their diverse flora and fauna, would be preserved. However, *Spartina* clones and seedlings would continue to occupy tidelands and spread into new areas. The development of monotypic *Spartina* clones would decrease biodiversity.

4.4.3 Social Environment

4.4.3.1 Human Health

The continued growth of *Spartina* would be expected to result in increases in salt water mosquitos (Washington State 1993), flies (Zipperer 1996), and airborne pollen. The Mechanical Control Only Alternative would reduce these effects but would be less effective than other alternatives at doing so. Use of aerially-sprayed chemical larvicides to control saltwater mosquitoes is prevalent along many East Coast *Spartina* marshes.

Control workers would be exposed to the risks of cuts, bruises, sprains, etc., associated with manual labor. They would also be exposed to high noise levels generated by airboats, hovercraft, and weedeaters. The use of appropriate safety procedures and equipment, including hearing protection, would minimize these risks.

4.4.3.2 Concerns

Concerns about the use of chemicals to control *Spartina* on the Refuge would be alleviated. Because *Spartina* would continue to colonize and grow on a substantial portion of tidelands, concerns about its spread in the Bay would be only partially addressed. Seed from the Refuge would continue to move to other areas of the Bay.

4.4.3.3 Recreation

Protection of native habitats and their associated fish and wildlife values would continue to provide for human recreational uses including sport fishing, waterfowl hunting, wildlife viewing, recreational shellfish harvesting, and boating to the extent that control could be accomplished. Because the efficacy of physical/mechanical control would be limited, *Spartina* meadows would continue to grow on Refuge and other tidelands and, thus, recreational opportunities would continue to decline accordingly.

The noise from weedeaters, boats, and self-propelled mowing machines used in control operations could bother some recreationists. Noise disturbance to recreational users

would likely be greater than that of other alternatives due to greater reliance on large machinery and more night operations.

4.4.4 Economic Environment

The Refuge is linked to regional and local economies through its association with tourism, mariculture, and commercial fisheries. Few, if any, of the Refuge' resources would be applied to off-Refuge control efforts.

4.4.4.1 Tourism

The Refuge received approximately 14,000 public visits in 1994. No studies have been conducted on the origins or motivations of these visitors, but it can be reasonably assumed that many tourists are drawn to Willapa Bay and the Refuge for outdoor experiences, including wildlife and plant viewing, boating, hunting, and fishing.

Physical/mechanical control only would mean that while some native habitats, and associated wildlife and open water were preserved, large areas of tidelands would continue to be colonized by *Spartina*. Recreational opportunities, and thus tourism, would be expected to decrease because of declines in wildlife and fish, native plants, and open water. Fewer tourists translates to fewer dollars spent at local businesses.

4.4.4.2 Mariculture and Fisheries

Spartina on Refuge tidelands produces seed that spread to adjacent private and State tidelands, many of which support oyster mariculture and clam harvesting. *Spartina* inhibits shellfish production by creating unfavorable habitat and thus has a high potential for negatively impacting the shellfish industry.

Spartina seed production, especially on Refuge lands, would be reduced by this alternative. However, seed from the Refuge would continue to be a problem for the shellfish industry in other parts of the Bay.

Under this alternative, there would be little opportunity to engage in cooperative control efforts off-refuge. Refuge resources would likely be exhausted in dealing with control work on high priority sites on the Refuge.

NOTE: For more discussion of the consequences of Physical/Mechanical Means Only Alternative, see the State FEIS on Noxious Emergent Plant Management, 1993.

4.5 EFFECTS OF CHEMICAL MEANS ONLY ALTERNATIVE

4.5.1 Physical Environment

4.5.1.1 Soils and Topography

The sediment buildup and changes in substrate composition and topography resulting from *Spartina* growth would be slowed or halted in control areas. This would result in

more normal movement and distribution of sediments in the water column. The existing mudflat topography would be preserved where *Spartina* seedlings, clones, and meadows were removed.

Glyphosate is not environmentally persistent and would not accumulate within sediment from ground applications of Rodeo® tank mixes. Kroll (1991) found that glyphosate concentrations in sediment of tidal marshes treated by hand-held sprayer with Rodeo® (0.75% solution) and Arborchem Aquatic surfactant (0.5% solution) declined 88% by 56 days post-treatment. For *Spartina* clones treated by a hand-held sprayer with Rodeo® (5% solution) and LI-700 (2% solution) in Willapa Bay, average concentrations of glyphosate in substrates underneath *Spartina* declined 14% (1.39→1.18 ppm DW; North River) and 29% (2.23→1.58 ppm DW; Lewis Unit on the Refuge) to 43% (3.60→2.05 ppm DW; Nemah Beach) and 73% (5.31→1.44 ppm DW; Leadbetter Point) for muddy and sandy substrates between spray day and 30 days post-treatment, respectively (Major and Grue 1997). After 1 year post-treatment, glyphosate concentrations from treated clones with the highest levels at 30 days after application ranged from 0.088 to 0.772 ppm DW and 0.134 to 1.84 ppm DW for sandy (Nemah Beach) and muddy substrates (Lewis Unit on the Refuge), respectively (Major and Grue 1997). Greater declines in glyphosate concentrations occurred for sandy substrates because less glyphosate likely was translocated to *Spartina* rhizomes incorporated into sediment samples. Application rates were 14 (Leadbetter Point) to 47 liters/ha (Nemah Beach) and 54 (North River) to 63 liters/ha (Lewis Unit on the Refuge) for clones on sandy and muddy substrates, respectively.

Glyphosate also would not accumulate within sediment from aerial applications of Rodeo® tank mixes. Paveglio et al. (1996) found that average concentrations of glyphosate in sediment directly exposed to spray significantly declined (51% [1.16→0.563 ppm DW] to 72% [2.82→0.799 ppm DW]) 119 days after aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1 liter/ha) to control *Spartina* in Willapa Bay. Average concentrations of glyphosate in sediment underneath *Spartina* declined (31% [0.420→0.290 ppm DW]) 30 days after aerial application of Rodeo® (8.8 liters/ha) and X-77® Spreader (1.2 liter/ha) to a *Spartina* meadow in Willapa Bay (Major and Grue 1997). For sampling locations within this treated meadow with the highest concentrations 30 days after application, glyphosate levels ranged from 0.088 to 0.404 ppm DW at 1 year post-treatment (Major and Grue 1997). Feng et al. (1990) reported a 92 to 96% decline in glyphosate concentrations 360 days after aerial application of Roundup® (2.0 kg/ha glyphosate) to a watershed in a Canadian forest.

Alkylphenol polyethoxylates, the principal active ingredient potentially hazardous to fish and wildlife within X-77® Spreader (nonylphenol polyethoxylates) and R-11® Spreader Activator (octylphenol polyethoxylates), also would not accumulate within sediments because they undergo rapid and complete primary degradation (Naylor 1992). Alkylphenol polyethoxylates degradation occurs through shortening of the

ethoxylate chain by microbial activity (Swisher 1987), which produces polyethylene glycols that are biodegradable and less toxic than the precursors (Conway et al. 1983). Extensive biodegradation (>90%) occurred within 14 days post-treatment for shake-culture tests where nonylphenol polyethoxylates were placed in flasks with a bacterial-inoculated medium (Huddleston and Allred 1965, Lashen et al. 1966). In contrast, Paveglio et al. (1996) found that average concentrations of nonylphenol polyethoxylates in sediment directly exposed to spray declined 42% (0.181→0.105 ppm DW) within 14 days following aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1 liter/ha) to control *Spartina* (Willapa Bay). Lower temperatures and reduced microbial activity associated with later sampling periods may have contributed to the stabilization of nonylphenol concentrations. Unlike shortening of the ethoxylate chain, ultimate degradation (conversion to carbon dioxide and water) of alkylphenol polyethoxylates may not be complete (Swisher 1987). Laboratory studies (Fuka 1978, 1980; Pitter 1979) found 80-90% ultimate biodegradation for nonylphenol polyethoxylates.

No information is available regarding the degradation of LI-700®; however, it is composed of a natural lipid (phosphatidylcholine [lecithin]) that is likely subject to biodegradation

Drift of Rodeo® tank mixes to non-target areas associated with ground applications to *Spartina* would be minimal under favorable environmental conditions. For sites in Willapa Bay with *Spartina* clones treated by a hand-held sprayer with Rodeo® (5% solution) and LI-700® (2% solution), average concentrations of glyphosate in off-target substrates 0.5 m from the clone edge immediately after treatment ranged from 1.07 to 5.28 ppm DW (Major and Grue 1997). The highest concentration of glyphosate (5.28 ppm DW) for sediments adjacent to hand-treated *Spartina* clones on spray day occurred at the site (Lewis Unit on the Refuge) with the highest rate of Rodeo® application (63 liters/ha). Grue and Major (1997) also found glyphosate in substrate samples 5 m from edges of hand-sprayed clones, but concentrations were less than 0.087 ppm DW. Glyphosate likely was detected 5 m from clones because the height of the *Spartina* resulted in applications directed up or across clones rather down onto plants.

Drift of Rodeo® tank mixes to non-target areas associated with aerial applications to *Spartina* also would be minimal under favorable environmental conditions. Grue and Major (1997) found that drift associated with aerial application of Rodeo® (8.8 liters/ha) and X-77® Spreader (1.2 liter/ha) to a *Spartina* meadow in Willapa Bay was minimal. Glyphosate concentrations in sediment 3 and 10 m from the plot boundary immediately after spray ranged from below the detection limit (0.02 ppm DW) to 0.114 ppm DW and below the detection limit (4 of 5 samples) to 0.117 ppm DW, respectively. No visible mortality of non-target vegetation on mudflats or salt marsh was found immediately adjacent to a *Spartina* meadow (152 ha) at Kaffee-Lewis Slough as well as a 12-ha meadow at Seal Slough 5 weeks following aerial application with Rodeo® (8.8 liters/ha) and R-11® Spreader Activator (0.5% solution) in 1996 (C. Moore,

Washington Dept. Agric., pers. commun.). Feng et al. (1989) found that average off-target distance between the spray boundary and healthy vegetation associated with aerial application of Roundup® (2.0 kg/ha glyphosate) was 2 m.

On intertidal mudflats where *Spartina* was treated with Rodeo® tank mixes, erosion and transport of sediments might occur. Tidal action, wind, waves, and rainstorms might erode, transport, and redistribute fine sediments. The extent of erosion would depend upon the magnitude of tidal exchanges, storm(s) size, and area treated. Because roots of *Spartina* controlled by Rodeo® applications might take several years to decay and permit erosion, eroded sediment would not be expected to contain measurable quantities of glyphosate and surfactant. Erosion could be minimized through natural revegetation by native species.

4.5.1.2 Hydrology

Hydrologic patterns in the project area would be directly affected by the removal of *Spartina*, especially dense clones and meadows, with herbicide application. Removal of *Spartina* plants would allow increased flow velocities and unobstructed flow patterns. Over time, redistribution of sediments from treated clone sites and meadows would likely allow tidal and runoff flows to return to pre-*Spartina* velocities and patterns. Natural tidal drainage patterns would be preserved in treated areas where early stages of *Spartina* growth is halted or prevented. Some changes may still occur because of the presence of nearby uncontrolled *Spartina*. The potential for flooding resulting from the restricted runoff associated with *Spartina* growth on Refuge tidelands would be avoided or reduced.

4.5.1.3 Water Quality

Beginning in the spring of 1997, the Washington Department of Ecology is conducting an EPA-funded project to study water quality parameters in Willapa Bay. Water temperature, dissolved oxygen, nutrients, chlorophyll, pH, light transmission, and turbidity, as measured by Secchi disk depth, will be measured at six locations (Newton 1997).

The degree of water-quality degradation would be dependent upon the amount of Rodeo® tank mix that reached the water and its subsequent biodegradation. Because *Spartina* intercepts most of the aerially (Kilbride et al. 1995, Major and Grue 1997) and ground-applied herbicide tank mix (Major and Grue 1997) and overspray or drift are minimal (Feng et al. 1989, Major and Grue 1997), the primary source for glyphosate and surfactant in seawater results from the initial washing of target vegetation by the first tidal inundation or rainfall that occurs before chemical incorporation into *Spartina* tissue.

Dilution, dissipation, and biodegradation quickly diminish waterborne concentrations of glyphosate and adjuvant. Paveglio et al. (1996) found that concentrations of glyphosate

and nonylphenol polyethoxylates in seawater were below the detection limit (0.5 ppb) 1 day (2 tidal cycles) after aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) to control *Spartina* in Willapa Bay. Similarly, Kroll (1991) found seawater concentrations of glyphosate dropped below the detection limit (5 ppb) by 7 days post-treatment in tidal marshes with *Phragmites communis* patches treated by a hand-held sprayer with Rodeo® (0.75% solution) and Arborchem Aquatic surfactant (0.5% solution).

Because the sea-substrate microlayer (seawater-sediment interface) provides habitat for a wide variety of marine biota, concern exists regarding toxicity resulting from exposure to Rodeo® tank mixes from drift or overspray particularly during low tides. Paveglio et al (1996) found that average concentrations for glyphosate and nonylphenol polyethoxylates from the leading edge of the first high tide after treatment were ≤25.6 and ≤16.0 ppb, respectively; and they quickly declined (≤ 9.77 and ≤ 0.5 ppb [detection limit] for glyphosate and nonylphenol polyethoyxlates, respectively) as a result of water-column dilution from the subsequent tidal inundation. Similarly, Sundaram et al. (1980) found that after aerial application of 0.47 liters/ha nonylphenol (to determine the environmental fate of nonylphenol associated with applications of the pesticide Metacil) the highest concentration (9.1 ppb) in a stream 1 hour post-treatment declined to undetectable levels (< 1.0 ppb) within 24 hours post-treatment; they attributed the rapid dissipation of nonylphenol to dilution by water flow. Consequently, hazards to microlayer biota at low tide are unlikely because glyphosate and alkylphenol polyethoxylates would be present at non-toxic concentrations (see subsection 4.2.2.5) that are relatively short-lived as a result of water-column dilution.

Water-quality degradation through interaction of Rodeo® tank mixes with other pesticides used in and adjacent to Willapa Bay would be unlikely. In intertidal areas where *Spartina* has been sprayed with Rodeo® tank mixes, dilution, dissipation, and biodegradation quickly diminished waterborne concentrations of glyphosate and adjuvant (Paveglio et al. 1996). Areas with *Spartina* are geographically separated from areas where oyster beds with burrowing shrimp are sprayed with Sevin (carbaryl) and cranberries (grown in inland bogs) are sprayed with a variety of insecticides, herbicides, and fungicides. Moreover, carbaryl concentrations in water on oyster tracts treated for shrimp were only detectable for 20 to 30 minutes following the first tidal inundation after treatment (Tufts 1990). The detectable levels of carbaryl were only found within 68 m (225 feet) of treated tracts (Tufts 1989). For cranberry crops, water applied to bogs along the Long Beach peninsula generally drains into freshwater wetlands rather than directly into Willapa Bay (Patterson 1994).

Although degradation of water quality from Rodeo® tank mixes likely would be minimal, decomposition of treated *Spartina* could temporarily reduce dissolved oxygen levels and release nutrients (nitrogen and phosphorus) which could result in algal blooms. Conversely, nutrient releases from decaying *Spartina* could beneficially increase primary production.

4.5.1.4 Ambient Sound

Operation of airboats, hovercraft, skiffs, and/or helicopters to support wand, wick, or aerial application of herbicide would increase the sound level on and around the proposed project site. Higher noise levels would include the transport of staff, equipment and supplies to and from work sites as well as herbicide application. The increase would be most noticeable to those in non-motorized boats in the vicinity of the activity or along transport routes. Work on refuge-owned and refuge-associated tidelands would temporarily elevate noise levels around Long Island, along highway 101 from Stanley Point south to Greenhead slough, and near Leadbetter Point. On calm days the sounds would become more noticeable along the east side of the Long Beach Peninsula. In spite of its use of aircraft, this alternative would generate less total noise than other action alternatives mainly because of reduced work opportunity. Ground-based chemical application machinery tends to generate less noise than mechanical methods.

4.5.1.5 Air Quality

Of action alternatives, this alternative would create a higher potential for herbicide spray drift due to total reliance on chemical control. Drift is discussed further in 4.5.1.1. Pollution from burning fossil fuels would be comparable to that of the Physical/Mechanical Alternative.

4.5.2 Biological Environment

4.5.2.1 Vegetation

Most of the existing and expanding *Spartina* meadow on the Refuge's southern units and around Long Island would be converted to native salt-marsh within 10 years. About 2,000 acres of intertidal mudflats supporting seagrass and macroalgae beds would be maintained on the southern units. Around Long Island most of the existing mudflat habitat would be maintained but little, if any, existing *Spartina* meadow would be restored to mudflat.

Rodeo®tank mixes have had variable effects upon non-target marine plants. Japanese eelgrass growth was adversely affected at 1 of 2 plots aerially treated with Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) in Willapa Bay (C. Fresh et al 1996). The affected plot had shallower water depth and, therefore, greater eelgrass exposure during the herbicide application. Rodeo® (10.3 [4.44 quarts/acre] to 0.7 liter/ha [0.3 quarts/acre]) and X-77® Spreader applied by hand-held sprayer to eelgrass (*Zostera* spp.) in Padilla Bay did not affect biomass during an 8-week study period (Bulthuis and Hartman 1994). Rodeo® (4.7 liters/ha) and X-77® Spreader (1% solution) applied by hand-held sprayer to plots with native salt marsh vegetation had no effect upon density, cover, and biomass of pickleweed or salt grass up to 1 year post-treatment; however, cover and biomass of saltbush were reduced at 60 days post-treatment likely because exposure time (>8 hours) was longer for this species located higher in the intertidal zone (Bulthuis and Scott 1993). No adverse effects were found to marine microalgae

after aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) to control *Spartina* in Willapa Bay (Simenstad et al. 1996). Direct application of Rodeo® to marine macrophytes would likely result in impacts. However, these impacts might be reduced or eliminated if non-target macrophytes are covered with seawater. No impacts to marine microalgae would result from herbicide control of *Spartina*.

The 96-hour LC_{50} for the marine alga is 27 ppb for nonylphenol (Naylor 1992), which is the nonylphenol polyethoxylate degradation product with the greatest toxicity to aquatic organisms. This value is 1.7 times greater than the maximum average concentration of nonylphenol polyethoxylates (16 ppb) from the leading edge of the first high tide following aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) from the Paveglio et al. (1996) study.

Chemical control would prevent *Spartina* from completely taking over shallow mudflats and associated plant habitats. Most existing areas of native plant habitat would be preserved. Where *Spartina* clones were killed, native saltmarsh plants might increase because sediment accrual in the clones has raised the elevation of the mudflats to a suitable height. Depending on the elevation, either saltmarsh plants or eelgrass would quickly recolonize areas where *Spartina* was controlled. Seed production on the Refuge would likely be stopped over time, reducing impacts to plant communities on adjacent tidelands.

4.5.2.2 *Spartina*

Spartina seed production would be stopped within 5 years on the southern units and 10 years around Long Island. Over time, this alternative would control seed production affecting neighboring lands and reduce the potential for viable seed movement out of Willapa Bay. Expansion of *Spartina* meadows on southern units would continue for a few years before the trend was reversed. No meadow would be expected to remain after 10 years there. Some *Spartina* meadow would probably remain in 10 years around Long Island.

Ground applications with Rodeo® tank mixes would control *Spartina* within the intertidal zone. Kilbride et al. (1996) sprayed *Spartina* clones on the Refuge (Porter Point) by hand-held equipment and achieved 84% control (reduction in stem densities) 1 year post-treatment. R. Crockett (Monsanto Agric. Co., pers. commun.) found ≥90% declines in *Spartina* 1 year after treatment with Rodeo® (0.56 to 2.24 kg glyphosate/ha) and R-11® Spreader Activator (1% solution) by hand-held boom. Major and Grue (1997) found 80 to 90% and 89 to 93% reductions in stem densities 1 year after treatment of *Spartina* clones in Willapa Bay on sites with muddy substrates (North River and Lewis Unit on the Refuge) associated with spraying Rodeo® (5% solution) and LI-700 (2% solution) by hand-held equipment alone and in combination with mowing 6 weeks prior to herbicide application, respectively. Lesser control (6 and 69% reductions for spray alone and mowing/spraying treatments, respectively) was

found for a site (Nemah Beach) identically treated on sandy substrate (Major and Grue 1997). Differences in efficacy may have been related to Rodeo® delivery rates, where muddy sites received 54 to 63 liters/ha compared with 47 liters/ha at the sandy site. Garnett et al. (1992) found a 74 to 89% decrease (1 year after treatment) in stem densities of *Spartina anglica* sprayed by hand-held boom with Roundup® (1.80 kg glyphosate/ha) and Pro-Mix surfactant (2% solution). Pritchard (1995) applied glyphosate (Glyphosate 360 at 40 liters/ha) to plots within a *Spartina* meadow (Victoria, Australia) by held-held sprayer and achieved 84% control after 1 post-treatment year.

Aerial applications of Rodeo® tank mixes to *Spartina* would also result in control. Kilbride et al. (1996) found 32% declines in stem densities of *Spartina* for three 1-ha plots with clones aerially sprayed in August 1992 with Rodeo® (4.7 liters/ha) and X-77® Spreader (1 liter/ha) in Willapa Bay. Short exposure time (≤5.5 hours) and low rate of Rodeo® application (4.7 compared with 8.8 liters/ha [maximum rate by label]) likely prevented cuticular penetration of sufficient amounts of glyphosate to affect better control. In August 1995, a 2-ha plot within a *Spartina* meadow in Willapa Bay (Kaffee-Lewis Slough) was aerially sprayed with Rodeo® (8.8 liters/ha) and X-77® Spreader (1.2 liter/ha). Pre- and post-treatment (1 year) data (stem densities) were collected and indicated no *Spartina* control (Grue and Major 1997). In addition, the *Spartina* meadow (152 ha) in Kaffee-Lewis Slough, which included the 2-ha plot treated in 1995, as well as a 12-ha meadow in Seal Slough were aerially sprayed in early July 1996 with Rodeo® (8.8 liters/ha) and R-11® Spreader Activator (0.5% solution). Visual (aerial) observations of the treated meadows 5 weeks after application indicated approximately 65 to 75% brown down with no seed set (C. Moore, Washington Dept. Agric., pers. commun.). Greater control likely will be achieved with meadow spraying during 1996 compared with the 1992 and 1995 treatments because exposure time was greater. The 1996 application was conducted during a rising low-high tide with 12 hours of exposure before most of the treated *Spartina* was inundated; whereas, exposure times for the 1992 and 1995 treatments were about 6 hours.

Spartina would be directly affected by the application of herbicide and surfactant. The action would kill or retard treated *Spartina* seedlings, clones, and meadows, slow the spread via asexual growth, and prevent seed production. It would not effectively prevent the establishment of seedlings from seed sources outside the treated area.

4.5.2.3 Wildlife

Under this alternative, most of the existing mudflat and native saltmarsh habitat on the Refuge would be maintained. Former areas of these habitats, now occupied by *Spartina* would revert mostly to native saltmarsh due to the sediment accretion that has occurred. Wildlife use similar to existing conditions on the Refuge would be sustained.

Because toxic dietary thresholds are not likely to be reached after Rodeo® applications

to control *Spartina*, no effects upon aquatic migratory birds are expected. Dietary toxicity tests with mallard ducklings found a LC_{50} value of 4,640 ppm for glyphosate (Heydens 1991), which classifies glyphosate as practically non-toxic. This LC_{50} level would require an average daily intake of 1,106 mg/kg (Heydens 1991). Female mallards exposed to dietary concentrations ≤1,000 ppm (equivalent to an average daily intake of 126 mg/kg) showed no reproductive effects. In addition, the highest average concentration of glyphosate in *Spartina,* which might be similar to what could be expected in sprayed eelgrass (a species consumed by aquatic birds) 1 day after aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1 liter/ha) in Willapa Bay was 65.6 ppm (Paveglio et al. 1996). Because this value is 71 times less than the LC_{50} value for mallard ducklings, toxic dietary thresholds for aquatic birds would not likely be reached after Rodeo® applications to control *Spartina*.

Field studies have not found direct adverse effects of glyphosate on birds. Solberg and Higgins (1993) found nesting success of waterfowl was not affected in wetlands sprayed with Rodeo® (2.8 liters/ha) and X-77® Spreader (0.33% solution) to control cattails (*Typha* spp.). Roundup® (2.3 liters/ha) applied to an Oregon coastal forest for conifer release (control of competing deciduous shrubs and trees) did not affect the bird community although habitat was altered for 2 years post-treatment (Morrison and Meslow 1984). In contrast, Santillo et al. (1989) found that aerial application of Roundup® to clearcuts in north-central Maine reduced total numbers of birds, but this was a result of changes in habitat structure.

Several field studies have been conducted to determine the effects of glyphosate on mammals. Sullivan (1979) found that black-tailed deer (*Odocoileus hemionus*) did not alter browsing habits and showed no adverse effects following consumption of forage in areas aerially treated with Roundup®. Anthony and Morrison (1985) found that aerial application of Roundup® (2.25 liters/ha) in coastal forests of western Oregon increased the abundance and diversity of small mammal populations. D'Anieri et al. (1987) found that richness of the small mammal community was not affected after clearcuts in northern Maine were aerially treated with Roundup® (2.25 liters/ha).

Short-term (acute) toxicity based upon a limited number of laboratory studies indicate that X-77® Spreader and R-11® Spreader Activator are non-toxic to mammals. For nonylphenol polyethoxylates, the oral LD_{50} for rats and mice ranges from 2,000 to 4,000 ppm (Benson and Nimrod 1994). No nonylphenol polyethoxylates were detected in *Spartina* 1 day after aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1 liter/ha) in Willapa Bay (Paveglio et al. 1996), and nonylphenol polyethoxlates were found at an average concentration of 0.181 ppm in sediment on spray day. Because these values are at least 11,000 times less than the LD_{50} value for rats and mice, effects on mammals are not likely after applications of alkylphenol ethoxylate-based surfactants to control *Spartina*.

Through laboratory studies (Mueller and Kim 1978, Soto et al. 1991, Jobling and Sumpter 1993), alkylphenol polyethoxylates have recently been recognized as xenoestrogens (environmental estrogens) capable of mimicking estrogen and, therefore, affecting reproductive endocrine function in biota. However, nonylphenol polyethoxylates did not persist in sediment and seawater (see subsections 4.5.1.1 and 4.5.1.3) after herbicide applications to control *Spartina* (Paveglio et al. 1996) and, consequently, estrogenic effects upon wildlife are unlikely.

Noise from the airboats, hovercraft, skiffs, and/or helicopters would likely drive waterbirds from project areas during operations at low tides. Swimming-type birds would be expected to return during high tides. The disturbances would be minimal because operations would be outside the peak-use period (fall and winter) for migratory waterfowl and shorebirds which concentrate on the mudflats and shallow water. In order to avoid disturbances, aerial control activities would not take place within ½ mile of any active bald eagle nest.

4.5.2.4 Fish

Most of the existing fish habitat on the refuge would be preserved under this alternative. However, some mudflat habitat would be lost and native saltmarsh would likely increase.

The maximum average concentration of glyphosate (25.6 ppb) found during the first tidal inundation for the Paveglio et al. (1996) study was 23,000 to 56,000 times less than 96-hour LC_{50}s (Rodeo® and X-77® Spreader) for chinook and coho salmon fingerlings, respectively (Mitchell et al. 1987*a*); and 108 times less than concentrations that did not disrupt seawater adaptation or growth of coho salmon smolts (Mitchell et al. 1987*b*).

Acute toxicity based upon a limited number of laboratory studies indicate that X-77® Spreader and R-11® Spreader Activator are moderately and non-toxic to fish, respectively. LC_{50}s (96- and 48-hour) values for nonylphenol and nonylphenol polyethoyxlates were $\leq$ 3.0 ppm, and range from 0.13 ppm for Atlantic salmon (McLeese et al. 1980) to 3.0 ppm for saltwater cod (Swedmark 1968) and flounder (Swedmark et al. 1971). In general, young fish have been found to be more sensitive than adults. For example, developmental abnormalities and increased mortality rates occurred for cod eggs and larvae exposed to $>$0.2 ppm (Swedmark et al. 1971). Because the maximum mean concentrations of nonylphenol polyethoxylates in the leading edge of the first high tide after treatment (worst case) was significantly less (16 ppb [Paveglio et al. 1996]) than these LC_{50} values, toxicological effects upon fish are unlikely.

Estrogenic effects upon fish associated with alkylphenol polyethoxylate-base surfactants are unlikely. Sheahan and Harries (1992) found nonylphenol concentrations between

20 and 50 ppb induced the production of vitellogenin (protein usually found only in sexually mature females) in male rainbow trout. Jobling et al. (1996) found induction of vitellogenin synthesis and reduction in testicular growth for juvenile male rainbow trout continuously exposed to 3 and 10 ppb nonylphenol and octylphenol, respectively, during a 3-week laboratory study. Jobling et al. (1996) also found that the degree of inhibition for testicular growth associated with nonylphenol and octylphenol depended upon the timing of exposure as well as sexual maturity, where inhibition was less pronounced for exposure toward the end the gonad growth phase and no inhibition was found for sexually mature fish. Although Paveglio et al. (1996) found higher average concentrations of nonylphenol polyethoxylates (≤16 ppb) in the leading edge of the first tidal inundation after herbicide application, nonylphenol polyethoxylates were undetectable (≤2.0 ppb) in seawater during the first high tide after treatment.

4.5.2.5 Microbes and Marine Invertebrates

The results of field and laboratory studies indicate that Rodeo® tank mixes applied to *Spartina* likely would not affect marine invertebrates through seawater exposure. Simenstad et al. (1996) found no short- (28 days post-treatment) or long-term (119 days post-treatment) effects to epibenthic invertebrate communities associated with aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) to control *Spartina* in Willapa Bay. Kubena (1996) conducted 96-hour bioassays with marine amphipods native to the Atlantic Coast (*Leptocheirus plumulosus*) and the Pacific Northwest (*Eohaustrorius estuarius*) that were placed in various dilutions (0.1 to 10%) of the herbicide tank mix representing the maximum application rate for aerial control of *Spartina* (8.8 liters/ha for Rodeo® [500 ppm glyphosate] and 2% solution for a nonionic surfactant [25 ppm nonylphenol polyethoxylates {X-77® Spreader}, 40 ppm octylphenol polyethoxylates {R-11® Spreader Activator}, or 22 ppm phosphatidylcholine {LI-700®}]). Amphipod survival was not affected for these 96-hour bioassays up to the highest concentrations tested (50 ppm glyphosate and 2.5, 4.0, or 2.2 ppm for nonylphenol polyethoxylates, octylphenol polyethoxylates, and phosphatidylcholine, respectively). In another series of 96-hour bioassays, amphipod survival was reduced by 30%, and 25 to 80% at 248 ppm glyphosate and 11 ppm phosphatidylcholine, and 124 ppm glyphosate and 6.2 or 9.9 ppm nonylphenol polyethoxylates or octylphenol polyethoxylates, respectively. Bioassays (48-hour) with echinoderm larvae (*Dendraster excentricus*) indicated that glyphosate and nonylphenol polyethoxylates, octylphenol polyethoxylates, phosphatidylcholine concentrations up to the highest concentrations tested (5 ppm and 0.25, 0.40, or 0.22 ppm, respectively) did not affect survival. Kubena et al. (1996) conducted a 96-hour bioassay with Pacific oysters (*Crassostrea gigas*) in which seawater spiked with Rodeo® and R-11® Spreader Activator was added to 2.8 ml chambers with seawater from Puget Sound. For this 96-hour bioassay, glyphosate and octylphenol polyethoxylate concentrations at 250 and 20 ppm, respectively, reduced survival of larval oysters. The maximum average concentration of glyphosate in seawater (25.6 ppb) found on sprayed plots during the first high tide after application in the Paveglio et al. (1996) study was 4,844- and 9,766-

fold less than glyphosate concentrations that reduced survival of amphipods and oysters, respectively, in bioassays.

The results of field and laboratory studies indicate that Rodeo® tank mixes applied to *Spartina* likely would not affect marine invertebrates through sediment exposure. Simenstad et al. (1996) found no short- (28 days post-treatment) or long-term (119 days post-treatment) effects to benthic invertebrate (infauna and meiofauna) communities associated with aerial application of Rodeo® (4.7 liters/ha) and X-77® Spreader (1.0 liter/ha) to control *Spartina* in Willapa Bay. Kubena (1996) conducted 10-day bioassays with *Leptocheirus plumulosus* and *Eohaustrorius estuarius* in which Refuge (Lewis Unit) sediment spiked with Rodeo® and R-11® Spreader Activator were added to the 1-liter test chambers with seawater from Puget Sound. For these 10-day bioassays, glyphosate and octylphenol polyethoxylates up to the maximum concentrations tested (2,066 and 165 ppm, respectively) did not affect amphipod survival. Kubena et al. (1996) conducted 96-hour bioassays with Pacific oysters in which Refuge sediment spiked with Rodeo® and surfactant (X-77® Spreader, R-11® Spreader Activator, or LI-700®) was added to 2.8 ml chambers with seawater from Puget Sound. For these bioassays, glyphosate and nonylphenol polyethoxylates, octylphenol polyethoxylates, or phosphatidylcholine concentrations at 5,122 ppm and 256, 410, or 224 ppm, respectively, reduced survival of larval oysters. The maximum average concentrations of glyphosate and nonlyphenol polyethoxylates in sediment (2.82 and 0.181 ppm DW, respectively) found on treatment plots in the Paveglio et al. (1996) study were 1,816- and 1,414-fold less than glyphosate and nonylphenol polyethoxylate concentrations, respectively, that reduced survival of oysters in bioassays.

The results of LC_{50} tests with glyphosate or alkylphenol (nonylphenol and octylphenol) polyethoxylates also indicate that Rodeo® tank mixes applied to *Spartina* likely would not affect marine invertebrates. The maximum average concentration of glyphosate in seawater found on sprayed plots during the first high tide after application in the Paveglio et al (1996) study was 25 to 39,000 times less than 96-hour LC_{50}s for fertilized eggs of Atlantic oysters (*Crassostrea virginica)*, fiddler crabs (*Uca pugilator*), grass shrimp (*Palaemonetes vulgaris*), a marine alga (*Skeletonema costatum*), mysid shrimp (*Mysidopsis bahia*), and sea urchins (*Tripneustes esculentus*) tested with glyphosate (Heydens 1991). For alkylphenol polyethoxylates, 96-hour LC_{50}s values of 2.9 to >100 ppm and <5 to >100 ppm were found for marine crustaceans and bivalves, respectively (Talmage 1993:270), but nonylphenol polyethoxylates were not detected (<2.0 ppb) in seawater found on sprayed plots during the first high tide after application for the Paveglio et al. (1996) study. Laboratory studies also indicate that LI-700® is nontoxic to aquatic invertebrates.

Because nonylphenol polyethoxylates did not persist in seawater or sediment after herbicide applications to control *Spartina* (Paveglio et al. 1996), estrogenic effects upon invertebrates associated with alkylphenol polyethoxylate-based surfactants are unlikely.

Of the action alternatives, this alternative would result in the least amount of trampling impact to invertebrates. By preserving and restoring mudflats, eelgrass and macroalgae beds, *Spartina* control would benefit shellfish and other invertebrates associated with these habitats. By reducing seed production in the bay, fewer Spartina seedlings would be expected to sprout on Refuge and neighboring tidelands, thus maintaining more mudflat habitat for invertebrates. In areas still dominated by *Spartina*, many species of shellfish and other benthic macroinvertebrates would either not survive or be reduced in numbers (Washington State 1993, Atkinson 1992, Simenstad and Thom 1995).

4.5.2.6 Biodiversity

With careful procedures to avoid application to non-target organisms and the unlikeliness of toxicological effects of maximum concentrations in the saltwater or sediments, biodiversity should not be directly affected by use of Rodeo® to treat *Spartina*. Control to prevent monotypic stands of *Spartina* would protect biodiversity of plants, wildlife and invertebrates.

4.5.3 Social Environment

4.5.3.1 Human Health

Little potential exists for acute toxicity to humans nor long-term health impacts associated with cancer or other maladies from exposure to glyphosate associated with Rodeo® applications to control *Spartina*. Knowledge regarding the acute toxicity of glyphosate to humans comes from a study conducted by Japanese physicians who investigated 56 poisoning cases, most of which were suicides or attempted suicides, involving Roundup®. For the 9 cases in which the suicide attempts were successful, the mean amount ingested was 200 ml (¾ of a cup) of herbicide; however, the polyethoxylated tallowamines (surfactant in Roundup® but not Rodeo®) likely caused the herbicide toxicity (Sawada et al. 1988). Short- and long-term non-cancer health effects were below levels of regulatory concern for adults and children (1 in 1,000,000). Similarly, all risks calculated for cancer effects were also below the regulatory concern level (1 in 1,000,000). Because no carcinogenic effects were found for chronic studies with rats and mice, glyphosate has been classified by the U.S. Environmental Protection Agency as noncarcinogenic to humans (Washington State 1993).

Because alkylphenol polyethoxylates did not persist in sediment and seawater (see subsections 4.5.1.1 and 4.5.1.3) after herbicide applications to control *Spartina* (Paveglio et al. 1996), estrogenic effects upon humans associated with alkylphenol polyethoxylate- based surfactants are unlikely.

There are certain health problems that have occurred with a statistically higher frequency in Pacific County than in the State as a whole. However, there are no indications that any of these health problems are associated with environmental conditions (See 3.4.2.1). The low potential for movement of approved chemical

compounds off of treatment sites, the tendency for these compounds not to persist, and the low toxicity of concentrations found on treatment sites make it unlikely that the Chemical Means Only Alternative would generate an environmental health hazard or contribute to existing health problems.

Health problems associated with *Spartina* pollen production and mosquitos that breed in *Spartina* meadows on the Refuge would be reduced within 10 years by this alternative but to a slightly lesser extent than IPM.

4.5.3.2 Concerns

This alternative would involve exclusive use of a chemical herbicide (glyphosate) and surfactants to control *Spartina*. Current information about these chemicals is provided in other parts of this document. Efforts to find new chemicals that improve efficacy and safety would continue.

Concerns about chemical risk would be greatest under this alternative. Concerns about *Spartina* spread would be reduced.

4.5.3.3 Recreation

Noise from airboats, hovercraft, skiffs, and/or helicopters would be heard by non-motorized boaters on the bay and users of the Long Island and Leadbetter Point units during operations. These sounds would be most noticeable in the immediate vicinity of operations or along transport routes. This could distract from recreational experiences. Disturbance of aquatic migratory birds during the low-tide operations would occasionally interfere with bird watching in the vicinity of control activities. Fishermen would not normally be affected by operations because the operations would be on exposed mudflats during low tides.

In the long term, recreational boating, shellfish gathering, fishing, hunting, and bird watching would benefit by *Spartina* control through maintenance of habitats, access, and navigation capabilities.

4.5.4 Economic Environment

A moderate level of Refuge resources would go to off-Refuge control efforts.

4.5.4.1 Tourism

Tourism would not be expected to be directly affected by proposed actions in this EA. The project would contribute to the overall health of local tourist-related businesses in future years by protecting recreational qualities.

4.5.4.2 Mariculture and Fisheries

Spartina on Refuge tidelands produces seeds that spread to adjacent private and State tidelands, many of which support oyster mariculture and clam harvesting. *Spartina*

inhibits shellfish production by eliminating suitable habitat and thus has a high potential for negatively impacting the shellfish industry. Seed production on Refuge tidelands would eventually be eliminated by this alternative.

NOTE: For more discussion of the consequences of the Chemical Means Only Alternative, see pages 152-161 and the Element E_A, E_B, and F reports of the State FEIS on Noxious Emergent Plant Management, 1993.

4.6 CUMULATIVE EFFECTS

Cumulative effects are the environmental impacts resulting from the incremental effect of a proposed action, when added to other past, present and reasonably foreseeable future actions, whether or not they are undertaken by the Refuge and related to *Spartina* control. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. The analysis in this Comprehensive EA focused on the consequences of long-term control of *Spartina* on Refuge-owned tidelands. In order to consider cumulative impacts, the EA also considered this project in light of other control efforts taking place in Willapa Bay, and continued control to be carried out in future years through Refuge efforts. The former actions are covered in detail in the State EIS while the latter are covered in this EA for *Spartina* control by this Refuge. In addition to the incremental reduction in *Spartina* acreage, other substantial, cumulative effects of Refuge *Spartina* control include the incremental restoration and protection of fish, wildlife, their habitats, and associated values and uses on and off Refuge tidelands.

4.6.1 No Action

The cumulative effect would be continued growth and spread of *Spartina* on the Refuge added to existing growth. It should be noted that the rate of growth and spread of *Spartina* from one year to the next is exponential. Therefore, each year of no action compounds the amount of control effort needed in the next year.

If *Spartina* were never controlled, all available tidelands would eventually become occupied. Both shallow mudflats and native saltmarsh would ultimately become *Spartina* marsh. Continued growth and spread of *Spartina* on Refuge lands would provide an incremental increase in the quantity of *Spartina* seed annually on- and off-Refuge. Small changes in topographic relief and estuarine functions would occur each year until the spread of *Spartina* was complete. The cumulative effects of the continued spread of *Spartina* would be the near-total loss of existing intertidal habitat for wildlife, fish, and shellfish, and associated values throughout the bay, including the Refuge.

4.6.2 All Action Alternatives

Cumulative effects would be the effects of control efforts on Refuge lands added to all efforts on State and private lands within Willapa Bay past, present, and future. If

completely successful, the cumulative effect of all control actions in the bay would be the eradication of *Spartina* from Willapa Bay over time. Inherent with *Spartina* eradication would be the restoration and protection of environmentally and economically important tidelands, and all the wildlife, fish, shellfish, mariculture, and other values these areas support. A lesser degree of success would be the elimination of *Spartina* from sensitive and valuable habitats and economically important tidelands and prevention of seed production on the remaining lands.

4.7 UNAVOIDABLE ADVERSE EFFECTS

4.7.1 No Action

The unavoidable adverse effect of the no action alternative is the conversion of open mudflats to *Spartina* marsh with resulting changes in topographic relief and estuarine functions including physical, chemical, and biological modifications, and the social (recreational) and economic implications of those changes.

4.7.2 All Action Alternatives

Unavoidable adverse effects common to all action alternatives are primarily related to access to and from the project sites and among *Spartina* clones, and the aerial application of herbicide. Operation of airboats, hovercraft, weedcutters, and helicopters will create unavoidable noise disturbances to wildlife and possibly humans. Where walking on the mud is required, some level of trampling is unavoidable. Measures to mitigate and/or minimize these adverse effects, where possible, have been incorporated in all action alternatives.

4.8 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

Gasoline will be burned to operate motorized vehicles for access to the site, and weed-cutters used to mechanically remove *Spartina*. Helicopters will burn jet fuel.

5.0 CREDITS

This work draws on previous work from a variety of sources, including those listed in the reference section. Not all sources were directly credited. This is common in documents of this type and does not represent either a lack of appreciation nor an attempt to claim their work as our own. The following staff of the US Fish and Wildlife Service contributed to the preparation of this document:

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6.0 LIST OF AGENCIES AND PERSONS RECEIVING NOTICE OF AVAILABILITY

As part of the National Environmental Policy Act of 1969, the Service distributed a Notice of Availability for this EA to the following agencies, organizations and individuals. The review period for enviromental assessments is 30 days.

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American Assoc. of Univ. Women/ Willapacific Branch
Aquatic Habitat Mgt. Corp.
Bay Center Mariculture
Benevolent & Protective Order of Elks, Lodge #1937
Canoe & Kayak
City of Ilwaco
City of Long Beach
City of Raymond
City of South Bend
Columbia Pacific RC&D
Columbia Pacific Resources Center, Inc.
CREST
Eagles Aerie #3602, Ocean Park
Ecotrust
Evergreen State College
Friends of the Earth
Grayland Cranberry Grower's Assoc.
Grays Harbor Audubon
Jolly Roger Oyster Co.
Kiwanis Club, Long Beach/Ilwaco Chapter
Kiwanis Club, South Bend Chapter
Lions Club, Long Beach Peninsula
Long Beach Cranberry Grower's Assoc.
Long Beach Visitor's Center
Naselle Chamber of Commerce
Northwest Outdoor Center
NW Decoy Association
Olympic Outdoor Center
Oregon Ocean Paddling Society
Pacific Coast Oyster Grower's Association
Pacific Conservation District
Pacific Co. Board of Commissioners
Pacific Co. Dept. of Community Development
Pacific Co. Economic Development Council
Pacific Co. Flood Control District
Pacific Co. Weed Board
Pacific Water Sports
Pack & Paddle
Peninsula Moose Lodge #2362
Peninsula Senior Center
Port of Ilwaco
Port of Willapa Harbor
Puget Sound Paddle Club
Raymond Chamber of Commerce
Sea Kayaker
Sea Resources/Chinook Hatchery
Shoalwater Bay Indian Tribe
Shoretrust Trading Group
South Bend Chamber of Commerce
Steelheader's Association
The Mountaineer
The Mountaineers Kayak Committee
The Nature Conservancy
Trade Association of Sea Kayaking
University of Washington
WA Coop Extension Svc
WA Seagrant Program
WA State Dept. of Agriculture
WA State Dept. of Ecology
WA State Dept. of Ecology - Water Quality Program
WA State Dept. of Fish & Wildlife
WA State Dept. of Fish & Wildlife - Hatcheries Program
Vancouver Audubon
WA State Dept. of Fish & Wildlife - Oyster Lab
WA State Dept. of Natural Resources
WA State Weed Control Board

Washington Farm Forestry
Washington Kayak Club
Washington Toxics Coalition
Washington Water Trails Association
Weyerhaeuser Corporation
Willapa Alliance
Willapa Bay Gillnetter's Association
Willapa Bay Oyster Growers Assoc.
Willapa Bay Shellfish Laboratory
Willapa Bay Water Resources Coord. Council
Willapa Hills Audubon Society
Willapa Salmon Enhancement Group
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Jim Hillery
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James Trick
Dennis Tufts
Elmer Turja
Robert Turner
Jim Walls
Larry Warnberg
Miranda Wecker
Fred Weinmann
Neil Weisener-Hanks
Herb Whitish
Andy Wiegardt
Lee Wiegardt
Dobby Wiegardt
Chris Wiegardt
Peter Williams
Dennis Wilson

Richard Wilson
Tim Wilson
Skip Wilson

Libraries

Ilwaco Timberland Library
Naselle Timberland Library
Ocean Park Timberland Library
Raymond Timberland Library
South Bend Timberland Library

Media

Aberdeen Daily World
Chinook Observer
Harbor Herald
KAST
KKEE
KMUN
KSWW
Montesano Vidette
The Daily News
South Beach Bulletin

mudflat That portion of intertidal lands generally found below the native saltmarsh on which eelgrass and algae are the dominant vegetation.

mutagenic Chemicals or other extracellular (outside) agents that are capable of causing mutations.

NP - nonylphenol A phenol with a nine (nonyl) carbon chain attached to it. Nonylphenol results from the complete biodegradation of nonylphenol polyethoxylates (NPEO), which are ingredients of some surfactants.

NPEO - nonylphenol polyethoxylate An ingredient of some surfactants. An alkylphenol ethoxylate with a nine (nonyl) carbon chain and a chain of repeating ethylene oxide groups attached to the phenol.

oncogen A substance which is capable of causing tumors.

ppb parts per billion

ppm parts per million

ppth parts per thousand

propagule A plant shoot which is capable of taking root and growing.

radionuclide A term used to designate the radioactive isotopes of a particular element.

rhizome A plant stem or branch which produces roots and shoots. A means by which plants reproduce vegetatively (without seeds).

subtidal Not exposed by the falling tide; flooded even at low tide.

surfactant Surfactants are composed of organic (e.g., carbon chains) and inorganic components (e.g., ethylene oxide chains) that form a bridge between the plant (organic) and the herbicide (inorganic). Surfactants are used in conjunction with herbicides to increase plant absorption through lowering surface tension of the spray solution, which spreads the herbicide more readily than water over the plant surface.

tank mix A mixture of a herbicide and one or more adjuvants that is applied to a target species such as *Spartina* by spray equipment.

technical glyphosate Commercially produced glyphosate.

teratogenic Tending to cause developmental malformations.

use days (birds) The number of birds using an area multiplied by the number of days they were present.

wrack A mass of seaweed that is floating or washed up on shore.

GLOSSARY

acute toxicity The capacity of a chemical to cause injury or mortality of organisms within a short period (hours to several days) after exposure.

adjuvant Any chemical, in addition to water, added to a herbicide tank mix. Adjuvants are used for a variety of reasons that include the following: improve the wetting or spreading of spray drops; increase penetration of the herbicide into plant cells; reduce herbicide losses from evaporation; retard foaming in spray tanks; increase the viscosity of a tank mix to reduce drift, prevent/reduce over spray or multiple treatment of sprayed areas (dyes), and buffer the pH of diluting water.

aerobic Free oxygen is present.

algae Chiefly aquatic one-celled or multicellular plants that lack true stems, roots, and leaves. Many seaweeds are algae.

alkylphenol ethoxylates A general term used to describe an active ingredient within some nonionic surfactants. The name represents the following three components of its chemical structure: "alkyl" for a carbon chain, "phenol" for a benzene ring, and "ethoxylate" for a repeating chain of ethylene oxide groups (-CH2CH2-O-).

anaerobic Free oxygen is absent.

benthic, benthos Refers to the organisms living on or in the bottom of the bay.

benthic macrofauna The larger animals living on or in the bottom of the bay. Oysters and clams, for example.

bioaccumulate The capacity for a chemical to build up (accumulate) within a plant or animal as a result of long-term exposure to an environmentally persistent contaminant or repeated introduction of a nonpersistent one.

biodegradation The process of decomposition by natural biological means.

biota The animal and plant life of a region.

bivalve A mollusk having a shell consisting of two hinged parts. An oyster or clam, for example.

clone One or more organisms descended asexually (by means other than seeds) from a single

parent. In this document, clone refers to the round stands of Spartina plants in which all of the stems are descended from a single seedling.

cogener A member of the same genus of plant or animal.

crustacea A class of arthropods having a segmented body, a chitinous exoskeleton, and paired, jointed limbs. Includes lobsters, crabs, shrimps, and barnacles.

detritus Disintegrated matter such as pieces of plants.

diurnal Having a daily cycle. Also, occurring or active during the daytime.

drift The airborne movement of a herbicide tank mix from a target to a non-target area, which occurs during spray operations.

epibenthic Refers to organisms associated primarily with the surface of the bottom but also with the water directly above the bottom. Includes a wide variety of zooplankton, amphipods, and worms, as well as oysters and barnacles.

epifauna Animals that live on the surface of the bottom or on elevated or floating surfaces. See **epibenthic**, above.

infauna Animals that live beneath the sediment surface. Clams and nematodes, for example.

intertidal Flooded at some parts of the tide cycle and exposed at others.

invertebrate An animal without a backbone - worms, oysters, clams, and insects, for example.

isostatic rebound - the gradually uplifting or rebounding of the earth's crust in response to release of downward surface pressure (as with the retreat of glaciers).

LC_{50} A statistically derived concentration of a chemical that results in mortality of 50% of the organisms during a toxicity test. Terms such as 48- or 96-hour will usually precede LC_{50} to indicate the length of continuous exposure. LC_{50} values provide a means to convey the relative hazard of different chemicals.

macroalgae Larger kinds of algae.

macroinvertebrate Larger kinds of invertebrates - oysters, for example.

monospecific, monotypic These terms, as used in this document, refer to a stand of plants, all the individuals of which are of the same species or type.

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