3.3 BIOLOGICAL RESOURCES

The biological resources that may be affected directly or indirectly by the Spartina Control Program include the intertidal habitats (mudflats, tidal creeks, sloughs, tidal marshes) of the San Francisco Estuary, shallow subtidal habitats near them (sloughs and nearshore bay habitats), and habitats immediately adjacent to the Estuary, particularly diked baylands where access and staging areas for eradication activities may occur, and the plants and animals that inhabit these places. This section focuses on those aspects of the Estuary’s biological resources that may be affected by the proposed project and alternatives.

3.3.1 Environmental Setting

A recent comprehensive overview of the biological communities and species of the San Francisco Estuary is provided in the Baylands Ecosystem Habitat Goals Project (Goals Project 1999, 2000). The ecological communities (populations of interacting species in different tidal habitats) of the San Francisco Estuary are influenced by position along numerous physical gradients of the Estuary, and the variation in distribution of the species that compose them. An overview of relevant ecological communities, and key species of concern, is presented below. Descriptions of these habitats and species emphasize aspects likely to be most sensitive to changes caused by eradication measures or cordgrass invasions themselves.

Biological Communities

Biological (ecological) communities are the interacting populations of the species associated in particular habitats defined by physical, chemical, geographic, and topographic gradient boundaries. To understand individual environmental impacts to species, it is necessary to recognize their relationships within biological communities in potentially affected areas of the San Francisco Estuary. Many of these biological communities and features that comprise them were shown previously in Figure 1-7.

Tidal Marsh Communities. Tidal marsh essentially consists of herbaceous (non-woody) vegetation that is periodically flooded by tidal waters with varying degrees of salinity. Tidal marshes include areas that are normally waterlogged as well as areas that are infrequently or intermittently flooded. Low marsh cordgrass species (e.g. Atlantic smooth cordgrass, Pacific cordgrass, English cordgrass) typically grow in tidal marsh zones flooded by daily tides. High marsh cordgrasses like Chilean cordgrass and salt-meadow cordgrass typically grow in higher marsh elevations, which are tidally flooded less frequently, often only a few days per month. Tidal marsh can establish on terrestrial substrates (tidally flooded soils which originated in non-tidal lands, especially in high marsh), but most of the tidal marsh in the San Francisco Estuary is established on estuarine sediment mixed with varying proportions of decomposed vegetation (peaty or muck-like organic matter). Most tidal marsh is typically described in terms of the dominant plant species, appearance of the vegetation, and the landforms on which they occur.

Tidal salt marsh vegetation. Tidal salt marshes are prevalent in San Francisco Bay, where the salinity of tidal waters in the summer growing season often approach or even exceed ocean seawater. Tidal salt marsh along channel banks and areas which are submerged twice daily by tides (low marsh zone, below mean higher high water) historically were dominated by a single species, Pacific cordgrass (Spartina foliosa), a colonial marsh grass usually less than one meter tall. Relatively un-
common native annual pickleweed (Salicornia europaea) establishes at the upper portion of this zone in sheltered sites, but low salt marsh was essentially a pure stand of Pacific cordgrass prior to the introduction of non-native cordgrasses.

The upper salt marsh plain, which is flooded only by the higher tides of the month, not daily tides (near the elevation of mean higher high water; the middle or high marsh zone, depending on classification) is dominated in San Francisco Bay by patchy mosaics of perennial pickleweed (Salicornia virginica), saltgrass (Distichlis spicata), jaumea (Jaumea carnosa), and numerous less frequent low-growing salt-tolerant herbs. In young salt marshes, the marsh plain vegetation is sometimes nearly pure stands of pickleweed. The salt marsh plain vegetation in the Estuary is usually less than 30 to 40 centimeters (12 to 16 inches) tall. Pacific cordgrass is sparse or absent on the marsh plain, usually confined to its lowest elevations. In historic salt marsh conditions, grasses such as saltgrass dominated the salt marsh only in local zones (Cooper 1926).

California salt marsh vegetation is relatively diverse and species-rich compared with Atlantic salt marshes, which are generally dominated by either grasses (often pure stands of Atlantic smooth cordgrass) or grass-like plants throughout the marsh. Even higher plant species diversity and vegetation structure occurred in high salt marsh zones of San Francisco Bay, flooded only by the highest tides of the year. These occurred along natural levees at tidal creek banks, bay edges of alluvial fans, and contacts and transitions to other environments such as grasslands, freshwater riparian scrub or woodland near streams or seeps, freshwater marshes, beaches, salt pans, and lagoons (Baye et al. 2000, Holstein 2000). Natural high salt marsh communities are rare today, displaced by weedy flood control levees and shoreline stabilization. Gumplant (Grindelia stricta var. angustifolia), a tall, evergreen subshrub, dominates the narrow high marsh zone along the banks of mature tidal creeks, where it provides critically important high tide cover for marsh wildlife. It also often occurs in high marsh zones along upland edges.”

**Tidal brackish marsh vegetation.** Where the salinity of tidal water is significantly diluted by stream or urban wastewater discharges, the physiological harshness of saline water that restricts the growth of many plant species is eased, and marsh community diversity increases. Marshes that vary between nearly freshwater conditions and salinities about half as strong as undiluted seawater are broadly described as brackish marshes (though many salinity classifications of marshes exist). Brackish marshes in the San Francisco Estuary vary in vegetation composition a great deal, and the relative abundance of dominant brackish marsh plants is highly sensitive to short-term climate changes that influence salinity, flooding, and sediment deposition. Most of northern San Pablo Bay and all of the Suisun Bay region (Suisun Marsh and the Contra Costa marshes) tidal marshes are brackish. Brackish marshes were historically also locally common along the edges of many portions of San Francisco Bay (Cooper 1926, Baye et al. 2000).

Pacific cordgrass thrives in diluted salinity of brackish tidal marshes, growing more productively than in full-strength seawater. Other, larger plants tolerant of lower salinities and even greater immersion in water, also thrive in brackish marshes. Although cordgrasses often establish colonies in brackish intertidal muds, alkali bulrush (Scirpus maritimus and intergrades with S. robustus), tules (S. acutus, S. californica), and cattails (Typha spp.) can invade and overtop lower-growing Pacific cordgrass vegetation in brackish marshes. These taller emergent brackish marsh plants often establish as the dominant pioneers on channel banks and upper mudflats in brackish reaches of the Estuary. The marsh plain in brackish tidal marshes is much richer in plant species and more variable and diverse in structure compared with tidal salt marshes in San Francisco Bay. Many of the rarer plants in the Estuary occur in brackish marsh plains or high brackish marsh.
Tidal marsh animal communities. Animal communities of tidal marshes of the San Francisco Estuary are relatively mobile, and are less often narrowly restricted to a single fixed marsh vegetation zone or patch. They may move according to tides, storm surges, or seasons. Insect communities of the San Francisco Estuary marshes are not well studied, and even basic descriptive information about insect species composition and trophic relationships (food webs) are limited (Maffei 2000).

The terrestrial arthropod fauna of tidal marshes in the Estuary are dominated by brine flies, leaf-hoppers, plant hoppers, mites, and spiders (Resh and Balling 1979). Insects and spiders are abundant in the middle and upper high marsh zones, and crustaceans (including amphipods) are abundant in moist organic tidal litter wracks, and in frequently flooded marsh. Many are important consumers of detritus from decomposing plant litter, a critical link in the tidal marsh food web.

Vertebrate wildlife of tidal marshes is better studied than insects, particularly waterbirds (shorebirds, waterfowl, wading birds, terns and gulls). Short-legged shorebirds seldom roost or feed in thick salt marsh vegetation, but occasionally roost at high tides on smooth wracks (tidal litter mats) in the high marsh. Short-legged shorebirds instead frequent shallow or emergent flats lacking vegetation. Wading birds (egrets, herons) and long-legged shorebirds (e.g. willets, marbled godwits, long-billed curlews, whimbrels) do roost or forage on the marsh plain, along low marsh banks of tidal channels, and in the many shallow ponds and natural salt pans enclosed within the marsh plain. Long-legged shorebirds, however, generally prefer open flats when they emerge from tidal flooding. Rails (clapper rails, black rails, Virginia rails, and sora), in contrast, spend nearly all their time within vegetated areas of tidal marsh and small channels, where they forage on benthic invertebrates in the muddy substrate. Northern harriers (“marsh hawks”) are frequent and characteristic avian predators of San Francisco Estuary tidal marshes. Black-shouldered kites and red-tail hawks also hunt in tidal marshes, as well as osprey. Songbirds (perching birds or passerines) which spend much or most of their lives in San Francisco Estuary tidal marshes include several endemic subspecies of song sparrow (each geographically restricted to part of the Estuary), and the salt marsh common yellowthroat. Many other songbirds are occasional or incidental visitors to tidal marsh habitats.

Emergent tidal marsh plains are often rich in small mammal populations, particularly higher marsh plains. Both non-native rodents (Norway rat, roof rat, house mouse) and native rodents (California vole, western harvest mouse, salt marsh harvest mouse, salt marsh wandering shrew, Suisun shrew, and ornate shrew) inhabit salt marshes seasonally or year-round, depending on the species and ecological conditions in adjacent habitats. They tend to occur mostly in the sub-shrubby perennial vegetation of the marsh plain, not in low cordgrass marsh. Abundant small mammals, in turn, attract raptor foraging in tidal marshes. Small mammals are temporarily displaced from tidal marshes during extreme tidal flooding events, and seek refuge in sheltering debris, tall vegetation, and local high ground with cover to shield them from birds of prey (Johnston 1957).

Large mammals also inhabit tidal marshes in the San Francisco Estuary. Resident bay colonies of harbor seals use some specific tidal marsh localities as “haul-outs”. These are areas above frequent high tides to rest and bask, usually near feeding areas. Haul-outs are also used for pupping. Traditional seal haul-out sites in tidal marshes of San Pablo Bay and San Francisco Bay often are high marsh plains with close access to deeper tidal channels, adjacent to gently sloping unvegetated banks (actually devegetated in places by seal activity). Seals do not move through wide cordgrass marshes on very gentle intertidal gradients (Lidicker and Ainley 2000). Coyotes hunt in North Bay tidal marshes and diked baylands (P. Baye, pers. observ. 2001), and the non-native red fox, a significant predator of California clapper rails, is now widely established in San Francisco Bay and San Pablo Bay, particularly where access to marsh feeding areas is facilitated by artificial levees or up-
lands where they travel or build dens (Harding 2000). Raccoons and skunks also are widespread in modern tidal marshes. Feral cats frequently inhabit marsh areas at the urban interface adjacent to landfills, urban development, and other areas where food and shelter are available.

**Estuarine Beach Communities.** Central San Francisco Bay historically supported extensive sand beaches, and beaches made of shell fragments (mostly fossil oysters) are still widespread along the shores of the South Bay. Sand spits, some approaching the size of marine beaches, prevailed along the bay/marsh interface from what is now Richmond to Alameda, and were also common along the northern San Francisco peninsula. These areas were also the main centers of urban waterfront development, and were destroyed so early after settlement that little is known directly about them. Historic beaches in San Francisco Bay were generally restricted to shorelines where bay waves directly attack and re-work exposed, submerged deposits of sand or shell, or sandy deltas of tributary streams (see Section 3.1, *Geomorphology and Hydrology*).

Physically dynamic estuarine beaches provide naturally open, sparsely vegetated roosting habitats for shorebirds flooded off of preferred feeding areas, such as tidal mudflats. Some shorebirds and terns typically nest on sand beaches, especially sand spits, but there are no records of nesting in the vestigial urban-edge beaches of San Francisco Bay. Instead, the western snowy plover and California least tern exploit today’s extensive artificial playa-like (beach plain and salt flat) habitats, such as emergent artificial salt pan beds and even derelict runways (Page *et al.* 2000, Feeney 2000).

Modern beaches have regenerated at some shoreline positions near those of their historic predecessors, derived from the same sediment sources. Some of these support vestiges of estuarine beach and dune communities. Some modern sand beaches of the bay, such as Crown Beach (Alameda) and Roberts Landing sand spit (San Leandro) are being converted to low-energy tidal salt marsh in the shelter of Atlantic smooth cordgrass and its hybrids.

One endangered plant, California sea-blite (*Suaeda californica*) probably was restricted largely to salt marsh edges of sand and shell beaches of San Francisco Bay, rather than typical salt marshes. Other rare plants are associated with sandy high salt marsh environments (Baye *et al.* 2000). Several rare species of tiger beetles native to San Francisco Bay occur primarily in beach or dry pan habitats (Maffei 2000). Drift-lines and organic debris on beaches provide refuges of high moisture and organic matter, and can produce abundant insect and amphipod populations.

**Communities of Lagoons, Ponds, and Pans.** Within tidal marsh ecosystems, marshes establish in relatively waterlogged soils, but subsurface water movement and drainage to nearby tidal creeks moderates waterlogged soil conditions, providing some gas exchange. Where tidal waters become impounded in poorly drained depressions, wide flats, or behind barrier beaches that act as natural dams for streams, extreme waterlogging or salt accumulation can cause toxic soil conditions. Salt accumulation and sulfide accumulation (indicated by “rotten egg” scent) in very poorly drained areas cause dieback of emergent marsh vegetation, or severely inhibit its establishment. These areas lacking extensive cover by emergent vegetation form distinct and important habitat types in the Estuary. Some types of marsh pans are subject to invasion and modification by at least one non-native cordgrass that can tolerate greater waterlogged soil conditions than native species.

Most of the original tidal marshes in the San Francisco Estuary were rich in small to moderate-sized (fractions of an acre to several acres) pans -- shallow tidal pools embedded in the marsh plain. Tidal marsh pans in the marsh plain lack drainage outlets and are infrequently flooded by tides that overtop the marsh plain. They are often rounded in outline, and have steep banks less than a foot high, with soft muck beds. This type of salt marsh pan is often shallowly flooded for most of the winter and spring, and is intermittently flooded in summer. In its flooded phase, it
often supports extensive colonies of submerged aquatic vegetation, equivalent to eelgrass and other seagrass meadows. Wigeon-grass (*Ruppia maritima*, not a true grass) is the prevalent submerged vegetation of natural salt pans in San Francisco and San Pablo Bays. It tends to become covered by filamentous algae when stagnant pans warm in summer, and is often mistaken for pure algal mats. Wigeon-grass canopies in pans support rich invertebrate communities, providing important habitats for dabbling ducks, diving ducks, and geese. They die back when the pan evaporates in summer between peak high tides, forming saline or hypersaline mats of dried algae and fabrics of dead wigeon-grass foliage.

Some salt pans may be entirely barren of any vegetation. Even these produce rich aquatic invertebrate communities that provide important habitat for some shorebirds (avocets, black-necked stilts, and yellowlegs) which otherwise would find little foraging habitat in vegetated tidal marsh plains. Salt pans are relatively abundant in natural tidal marshes that formed pre-historically, but are usually scarce in recently formed marsh plains that lack complex, irregular tidal creek patterns. In Suisun Marsh, tidal marsh pans are brackish, and these are even scarcer today than natural salt pans. Brackish pans support a greater diversity of submerged aquatic plant species.

The smallest tidal marsh pans (less than 0.25 acre), and marsh pans encroached by emergent vegetation, can produce abundant salt marsh mosquitoes. Larger pans have turbulent open water surfaces (internal wind-generated waves), which discourage survival of mosquito larvae. When tidal marsh pans become invaded by emergent vegetation, they produce very poorly drained marsh and still, sheltered water surfaces that encourage successful mosquito breeding (Balling and Resh 1983, J. Collins, pers. comm.).

Extensive natural salt ponds (evaporation basins producing beds of crystalline salt) no longer exist in San Francisco Bay, but were locally characteristic features of the Hayward shoreline. Similarly, natural lagoons (brackish to saline ponds, infrequently and intermittently tidal) no longer exist in the Estuary. Equivalent habitats are provided by “intake” solar salt evaporation ponds – permanently flooded, shallow saline waters that support soft-bottom benthos, entrapped estuarine fish population, wigeon-grass beds (submerged aquatic vegetation), and large algae. The management of salt ponds depends on tidegates used as water intakes. Sediment accretion and cordgrass growth can obstruct intakes.

Brackish lagoons are also represented by a few permanently flooded waterfowl-managed ponds in Suisun Marsh. Waterfowl-managed ponds depend on operation of water intakes (tidegates) to flood and drain tidal waters, either on artificial seasonal schedules, or partially choked daily tidal flows. The surrogate lagoon habitat represented by early-stage solar salt evaporators is significant in that it excludes the growth of all cordgrasses, even invasive non-native cordgrasses established in adjacent populations. No cordgrass species in San Francisco Bay can tolerate extreme hypersaline soils or prolonged, deep flooding.

**Mudflat Communities.** Intertidal flats in the San Francisco Estuary are mostly soft, unconsolidated sediment habitats made of physically unstable bay mud (fine silt and clay; mudflats) on very gentle gradients. By definition “tidal flats” do not include steeply sloping, consolidated mud banks of tidal channels. A minority of intertidal flats are made of sandy sediments (especially in the Central Bay), or fossil shell deposits and lag surfaces of shell over softer muds.

The permanent bottom-dwelling residents (benthic infauna) of mudflats are invertebrates, such as clams, worms, snails, and crustaceans. These permanent residents of the mudflat are highly dynamic, however, and adjust to the physically unstable surface of the mudflat. Turnover of populations and species is also high following sequences of major pulses of salinity changes. The vast
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majority of total living mass of benthic infauna in the San Francisco Estuary are non-native species introduced through international shipping in San Francisco Bay ports. The principal ecological values of mudflats are not for the resident native biological diversity, but for the estuarine production, trophic (food web) support to fish and wildlife, and biogeochemical “processing” (transformation) of sediment and water provided by mudflats (Goals Project 1999). In contrast with the intertidal fauna of rocky shores, which includes many sessile (physically attached, fixed) invertebrates, the mudflat infauna is composed of mobile invertebrates adapted to the unstable surface of the mudflat, which is subject to daily erosion and redeposition by bay waves and tidal currents.

Disturbed intertidal mudflats are rapidly recolonized by the prevalent infauna.

Mudflats are submerged twice daily and periodically become habitat for a diverse, mobile estuarine fish community. Fish in submerged mudflats feed on benthic infauna (invertebrates living under the mud) epibenthos (invertebrates living on the submerged mud surface), other fish, and drifting detritus or plankton. No eelgrass beds occur in intertidal mudflats in San Francisco Bay; they are restricted to shallow subtidal habitats in areas of relatively less turbid bay tidewaters, where they provide important habitat for benthic invertebrates and fish. Fish assemblages vary with geographic position in the Estuary, often in relation to large-scale and local salinity gradients, abundance of plankton (the foundation of the food web), and habitat structure.

Anadromous fish (species migrating upstream to freshwater rivers to spawn), estuarine fish, and marine fish occur in the submerged intertidal mudflats and tidal marsh channels. Juveniles of anadromous fish (such as salmon and steelhead) use vegetated edges of mudflats and marsh tidal channels as nursery and feeding habitats, providing both food and shelter from predators. Pacific herring and anchovy feed on drifting plankton in shallow or deep open waters. They provide a prey base for many larger fish. Flatfish species (flounder, sole, halibut, turbot), sculpin, and goby species are common bottom fish in both shallow and deepwater habitats. Cartilaginous fish (rays and sharks) are commonly found in shallow submerged mudflats, including leopard sharks, brown smoothhound, and bat rays. Rays are bottom feeders, taking benthic invertebrates by disturbing bottom sediments. Many non-native fish have also permanently established in the San Francisco Estuary.

Most of the San Francisco Estuary’s tidal flats occur today in the South and North Bays; less mudflat area naturally occurs in Suisun Bay. The unvegetated surface of mudflats, combined with their very high productivity (infauna rich in calories and protein), makes their production available to migratory shorebirds and waterfowl of the Pacific Flyway. These waterbirds cannot feed, or feed only marginally, in consolidated (root-bound) emergent tidal marsh substrate and its vegetation. The bare soft bottom of mudflats submerged at high tide also provides rich feeding for diverse native fish populations (Goals Project 1999) and terns, including the endangered California least tern.

The essential unvegetated character of tidal flats in the San Francisco Estuary is due to an interaction between wave energy (forces of erosion and deposition from waves generated by winds blowing across the bay), intertidal slopes, and vegetation. Wave erosion during storms trims back the leading edge of cordgrass clones. Wave erosion also is responsible for maintaining mudflat area as sea level rises (converting the lower intertidal zone to subtidal habitat). The physical limitation of native marsh plants to resist wave-driven substrate dynamics is key to the maintenance of mudflat habitat and its proportions in the Estuary.

Subtidal and Intertidal Channels. A characteristic feature of historic San Francisco Estuary tidal marshes is the very high density of irregular, sinuous, branched tidal channels that extensively

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penetrate the marsh plain. This structure is related to the properties of native marsh plants, especially, the tidal elevations to which they are limited, and the effect their below-ground parts have on the cohesiveness of marsh substrate. Native wildlife, such as California clapper rails, and many native estuarine fish exploit the extensive channel networks in San Francisco Estuary tidal marshes, which provide close proximity of vegetative cover (predator refuge) and productive feeding in narrow channel beds and banks. Diving ducks and bay ducks, in contrast, congregate in larger tidal sloughs to feed or rest. Fish communities in channel habitats are essentially similar to those of mudflats submerged at high tide (see Mudflat Communities, above).

Salt marshes on coasts dominated by larger, robust cordgrass species, such as the Atlantic coastal plain, lack these complex and high densities of tidal channels, and instead develop simpler drainage systems and vast cordgrass meadows.

Eelgrass (*Zostera marina*) canopies provide important habitats for fish (foraging, shelter), and for geese where the vegetation grows intertidally or in very shallow subtidal zones. Establishment of eelgrass beds is also limited by current velocities: high tidal current energy can erode bottom sediments and uproot small colonies. Eelgrass is scarce in the turbid waters of San Francisco Bay and San Pablo Bay. In San Francisco Bay it is limited to subtidal areas, in contrast with low-turbidity, sandy marine estuaries, where it also grows intertidally (Phillips 1984). It is relatively more abundant in tidal channels and subtidal shallows in marine embayments with stabler sandy mud bottoms and clear water.

**Special-Status Species**

The San Francisco Estuary provides habitat for a large number of rare, threatened, and endangered species, and even more declining species of concern for conservation (Goals Project 1999, 2000). Those species that are subject to direct, indirect, or cumulative effects of cordgrass control are described in abbreviated, relevant detail here. Special-status species that occur in affected habitats are summarized in **Appendix F**, and species of particular relevance to this project are discussed in detail below.

**California Clapper Rail** (*Rallus longirostris obsoletus*). The endangered California clapper rail is one of the most important ecological issues related to invasive cordgrass eradication, because of complex and variable short-term and long-term impacts from the cordgrass invasion and the proposed eradication measures. The species, *Rallus longirostris*, is protected under the Migratory Bird Treaty Act, and this subspecies is Federally and State-listed as endangered.

The California clapper rail is one subspecies among many geographic “races” of the species in North America. Clapper rails resemble small chickens with long bills and legs, reflected in the common name, “marsh hen”. California clapper rails specifically inhabit tidal salt and brackish marshes. Historically, California clapper rails ranged from Humboldt Bay to Morro Bay, with the core of the species’ population in San Francisco Bay. Today, it is largely restricted to San Francisco Bay and San Pablo Bay, with occasional to regular vagrants reported from Tomales Bay (J. Evans, pers. comm.). Recent known clapper rail nesting locations are shown in **Figure 3.3-1**.

Clapper rails are opportunistic, omnivorous feeders. They feed mostly under or near stands of cordgrass, which shelter many of the food items clapper rails depend on, such as crustaceans, bivalves, insects, and even small mammals or birds. Within a tidal marsh, their “home ranges” and nest sites are usually keyed to small tidal creeks or channel edges. They generally avoid uniform marsh plains lacking tidal creeks, and seek channels or ditches with vegetation overhanging banks or covering the bank slopes.
Figure 3.3-1. California Clapper Rail Presence/Absence Relative to Non-native Cordgrass
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California clapper rails generally avoid exposure outside of dense vegetation cover, where they are vulnerable to predation by hawks (especially northern harriers) or terrestrial predators (especially non-native red fox). The spread of the red fox in the South Bay during the 1980s destroyed many rail populations, and nearly caused the extinction of the species there. California clapper rail populations rebounded following red fox population control efforts, but red fox have since spread to the North Bay as well. Successful clapper rail breeding populations in the South Bay often depend on adequate access for red fox control operations (Harding 2000, Evens and Albertson 2000).

Clapper rails are most vulnerable to predation during extreme high tides, when almost all emergent vegetation cover is submerged, exposing rails visually to predators. During these periods, clapper rails seek cover in almost anything that stands above the flooded marsh vegetation, including debris, tall semi-evergreen native vegetation (particularly gumplant, *Grindelia stricta* var. *angustifolia*), and even invasive tall-form Atlantic smooth cordgrass and its hybrids.

In the San Francisco Estuary, California clapper rails do not construct “floating” nests within Pacific cordgrass stands, as their southern California counterparts do (light-footed clapper rail, *R. longirostris levipes*). They naturally nest in tall, dense pickleweed or gumplant vegetation near small tidal creek banks in San Francisco and San Pablo Bays. However, they have recently been reported to nest locally within tall-form Atlantic smooth cordgrass vegetation in San Francisco Bay (J. Evans, K. Zaremba, pers. comm.).

**California Black Rail (Laterallus jamaicensis coturniculus).** The California black rail also is a relatively secretive tidal marsh resident, more often detected by its calls than actual sightings. The San Francisco Estuary supports the largest coastal population, mostly in northern San Pablo Bay and around Suisun Bay. They have been rare to locally extinct in San Francisco Bay in recent decades. It is now presumed extirpated in San Francisco Bay, but vagrants or new founders may occur. California black rails spend most of its time in dense cover of brackish tidal marshes, and prefer mixed pickleweed vegetation. They sometimes appear in freshwater or salt marshes along the coast. California black rails nest in tall grasses and grass-like vegetation as well as mixed pickleweed vegetation well above ordinary high tides. Like clapper rails and other resident marsh birds, the abundance of black rails corresponds with tidal creeks that dissect the marsh plain, and the availability of adequate, well-distributed high tide escape cover. Its distribution within the San Francisco Estuary suggests affinity for brackish tidal marsh vegetation (pickleweed, bulrush and tule), but it does occur in moderate densities where typical salt marsh dominant vegetation (pickleweed/cordgrass) prevails. Breeding birds do not utilize young cordgrass marshes, but may feed in cordgrass areas outside the breeding season. Black rails are declining in abundance within the Estuary (Trulio and Evens 2000, Evens et al. 1991). The species, *Laterallus jamaicensis*, is protected under the Migratory Bird Treaty Act, and this subspecies is currently listed as endangered in California, but not under Federal law.

**California Least Tern (Sterna antillarum browni).** California least terns are migratory, seasonal inhabitants of the San Francisco Estuary, where they breed in colonies. They arrive at California in April, and establish nests in May and June. Their natural coastal breeding habitats are sand spits and flats with minimal, sparse vegetation. In San Francisco Bay, natural habitats (suitable isolated, large beaches and flats) are now nearly absent, and California least terns have adapted to colonize man-made habitats with similar key features, such as barren levee crests or dry beds of salt ponds, and paved or other isolated areas with extensive, barren, flat artificial surfaces and little human activity. Their principal breeding colony in the region is at the former Alameda Naval Air Station on an abandoned runway, now managed for tern breeding (Feeney 2000). California least terns are ecologically similar to other, larger native terns, some of which (Forster’s tern, Caspian tern) also
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breed in the San Francisco Estuary, and are themselves species of concern. Their nests all are vulnerable to terrestrial predators (rats, fox, skunks, raccoons), and avian predators (hawks, gulls). The species, *Sternula antillarum*, is protected under the Migratory Bird Treaty Act, and this subspecies is Federally and State-listed as endangered.

Like other terns in the San Francisco Estuary, California least terns forage in shallow bay waters for small, slender fish, particularly schools of northern anchovy and silversides. They commonly forage over productive tidal flats when they are submerged at high tide. The E.B. Roemer Marsh, Alameda and Roberts Landing area in San Leandro are established feeding areas: both have extensive sand flats, and both are being invaded by Atlantic smooth cordgrass. California least terns also feed in tidally connected man-made lagoons with low turbidity and abundant populations of small fish (e.g. salt intake ponds). Least terns teach their fledged young how to fish, and some roosts and feeding areas in San Francisco Bay are particularly used as post-fledging feeding sites for juveniles to acquire feeding skills. Rich feeding in San Francisco Bay is important in building energy reserves needed for migration (Feeney 2000).

**Western Snowy Plover, Pacific Coast Population** (*Charadrius alexandrinus nivosus*). There are many subspecies (geographic races) of the small, pale shorebird in the species *Charadrius alexandrinus* (Kentish plover) worldwide (Hayman et al. 1986). The western U.S. subspecies, known as the western snowy plover (*C. alexandrinus nivosus*), inhabits playas (salt flats, dry beds of seasonal saline lakes) of the interior states, and beaches on the Pacific Coast. The population of the Pacific Coast constitutes a relatively distinct breeding unit. San Francisco Bay is one of the most productive breeding sites along the central California coast, while breeding success has often declined at natural beach breeding sites (U.S. Fish and Wildlife Service 2001). Like the California least tern, the western snowy plover has adapted to exploit the artificial playa-like habitats provided by dry beds of solar salt evaporation ponds and bare, linear levees. The natural analogues of these habitats in San Francisco Bay were extensive sand and shell spits, and natural salt ponds, primarily in the Berkeley-Oakland-Alameda shoreline. These were largely destroyed by urban and port development early in the State’s history, (1850s to 1870s) prior to local breeding records for the species. Almost all of the Estuary’s breeding colonies are in the South Bay. The San Francisco Bay population typically ranges around 200 to 300 adult birds. The subspecies is protected under the Migratory Birds Treaty Act and is Federally listed as threatened, but is not currently State-listed.

Western snowy plovers feed on insects and other small invertebrates found in sand or firm mud, edges of saline waters, decomposing algal mats or around moist, rich organic debris. In San Francisco Bay, they feed in salt ponds, levees, and sand flats at low tide. Brine flies are an important component of their diets in salt pond beds and levees. Like California least terns, they nest in small scrapes on relatively barren or very sparsely covered (debris, low vegetation) surfaces, preferring light-colored surfaces which mask their pale tan-gray backs. They are vulnerable to nest predators, including mammals (Norway rat, red fox, skunk, raccoon) and birds (ravens, falcons, hawks, gulls).

**Salt Marsh Common Yellowthroat** (*Geothlypis trichis sinuosa*). The common yellowthroat (*Geothlypis trichis*) is a small warbler with a complex of subspecies. The salt marsh subspecies (*G. t. sinuosa*) is recognized as a distinct breeding population, with geographic distribution, habitats, and morphological traits that subtly grade into some other subspecies. It inhabits tidal salt and brackish marshes in winter, but breeds in freshwater to brackish marshes and riparian woodlands during spring to early summer. Common yellowthroats feed on insects gleaned from vegetation or the ground. Salt marsh common yellowthroats occur in estuarine marshes along the coast from Tomales Bay to Santa Cruz, but the San Francisco Estuary represents the largest area of suitable tidal marsh habitat (Terrill 2000). Recent re-estimates of population size in the Estuary’s tidal
marshes (Nur et al. 1997) have been higher than those of the 1970s (Terrill 2000). The subspecies is a Federal and State “species of concern” due to major decline of both habitat and populations in the past decade, but is not currently listed as endangered or threatened. The common yellowthroat is protected under the Migratory Birds Treaty Act.

**Tidal Marsh Subspecies of Song Sparrows (Melospiza melodia)**

San Pablo Bay song sparrow (*M. m. samuelis*)

Suisun song sparrow (*M. m. maxillaris*)

Alameda song sparrow (*M. m. pusillula*)

Song sparrows are wide-ranging North American perching birds that inhabit a wide range of habitats. Local populations with distinct geographic and ecological affinities have evolved in the San Francisco Estuary, and are treated as subspecies. Each has undergone major declines in tidal marsh habitats, and proportionate declines in populations. The distribution of the region’s three tidal marsh subspecies roughly correspond to San Pablo Bay, Suisun Bay area marshes, and San Francisco Bay. The tidal marsh song sparrow subspecies hold territories in tidal marshes all year, and breed in tidal marshes. They nest in areas of tall, emergent marsh vegetation above ordinary high tides especially in high marsh above tidal creek banks. They feed widely in the tidal marsh, gleaning insects off of vegetation. Within tidal marshes, San Pablo Bay song sparrows favor complex tidal marsh topography formed by marsh plains with dense networks of irregular tidal channels; they avoid homogeneous cordgrass. This habitat preference also applies to San Francisco song sparrows. Their territories follow configurations of tidal channels rather closely (Cogswell 2000). Suisun song sparrows nest in tall tules with local pickleweed. They also frequent tall vegetation along the edges of tidal marshes. Song sparrows are protected under the Migratory Birds Treaty Act. The subspecies are Federal and State “species” of concern, but are not currently listed as endangered or threatened.

**Salt Marsh Harvest Mouse (Reithrodontomys raviventris)**

Southern subspecies (*R. r. raviventris*)

Northern subspecies (*R. r. halicoetes*)

The salt marsh harvest mouse is a small mammal that inhabits salt marshes and brackish marshes only in the San Francisco Estuary. Its ecological distribution is closely (but not always exclusively) associated with vegetation including pickleweed, and its abundance often corresponds with the thickness, height, and continuity of pickleweed cover. It has two ecologically similar but distinct subspecies, one in the South Bay (the most critically endangered populations) and a more widespread and frequent subspecies in the North Bay and Suisun Bay marshes. Both subspecies are Federally and State-listed as endangered.

Though the salt marsh harvest mouse is adapted to tidal salt marshes, the young, small, isolated remnant tidal marshes of the South Bay are often deficient or lacking in salt marsh harvest mouse populations. This may be due to immature marsh topography and elevation, especially lack of well-distributed high marsh topography and vegetation cover, making the populations vulnerable to catastrophic flooding (drowning and excessive exposure to birds of prey) during extreme high tides that submerge the tidal marsh. Many of the largest South Bay populations occur in diked nontidal salt marsh, or diked marshes with limited tidal flows choked by tidegates. Salt marsh harvest mice are seldom if ever found in cordgrass marsh. They chiefly depend on pickleweed, plants associated with pickleweed, and green terrestrial grasses adjacent to tidal marshes, to which they disperse in spring. Environmental factors which constrict the development of tall, thick growth of salt marsh
or brackish marsh above the cordgrass vegetation zone, or limit the development of high tide escape cover, are detrimental to conservation of the species. Prolonged, deep submergence of marsh vegetation at any time of the year is detrimental to the stability of their populations, particularly in smaller salt marsh patches (Shellhammer 2000a, U.S. Fish and Wildlife Service 1984).

**Tidal Marsh Shrews (Sorex species).** The salt marsh wandering shrew (*Sorex vagrans halicoetes*) and Suisun shrew (*Sorex ornatus sinuosus*) are small carnivorous mammals with high demand for abundant prey with high nutritional and energy value, including insects, amphipods (beachhoppers), isopods, and other small invertebrates. Unlike the salt marsh harvest mouse, they do not adapt well to diked non-tidal salt marshes, which are seasonally dry, or to upland grasslands. They tend to occur mostly in low, dense vegetation and under mats of tidal debris in tidal marsh plains. Like the salt marsh harvest mouse and other small mammals, they also depend on the availability of adequate cover during extreme high tides, which submerge vegetation cover and expose them to predators. Wandering shrews and ornate shrews are taxonomically difficult, and local distinct marsh populations or subspecies may intergrade with more widespread types within their species. Currently, the salt marsh wandering shrew is geographically limited to the South Bay. The Suisun ornate shrew occurs in the North Bay and Suisun Marsh (Shellhammer 2000b, MacKay 2000). Though rare and dependent on highly reduced habitat, they do not currently have protected status under State or Federal endangered species laws. The subspecies are Federal and State “species of concern.”

**California Red-Legged Frog (Rana aurora draytonii).** California red-legged frogs are formerly widespread amphibians native to freshwater marsh habitats, subsaline coastal lagoons (stream-mouth estuaries periodically impounded by beach ridges), creeks and riparian habitats, and seasonal ponds. In modern landscapes, their habitats include man-made seasonal wetlands such as stock ponds and ditches. Their limited salt tolerance (around 4 parts per thousand salinity, lower than most of Suisun Marsh in summer) restricts them to wetlands landward and peripheral to tidal marshes in modern San Francisco Bay. They require standing water for breeding, but disperse widely in uplands during summer, remaining inactive in small mammal burrows. They periodically return to freshwater refuges to rehydrate, but they can remain inactive in upland burrows for many weeks. The subspecies is Federally listed as threatened, but is currently not State-listed.

**San Francisco Garter Snake (Thanophilis sirtalis tetrataenia).** Like the California red-legged frog, the San Francisco garter snake inhabits freshwater marshes, riparian habitats, and seasonally disperses to burrows in uplands. One of the largest remaining populations occurs in a freshwater to subsaline non-tidal marsh west of Highway 101, across from the San Francisco International Airport. It is not reported from tidal marsh habitats, but channelized freshwater drainages (flood control channels) along the northern San Francisco Peninsula could provide potential linkages between suitable habitat and tidal marshes, but it has not been detected in creeks discharging to the Bay (Jennings 2000). The subspecies is Federally and State-listed as endangered.

**Harbor Seal (Phoca vitulina richardi), San Francisco Estuary Resident Populations.** Harbor seals are permanent residents of San Francisco Bay and San Pablo Bay. Harbor seals, like all mammals, are protected by the Federal Marine Mammal Protection Act, but they are not listed as endangered or threatened under the Endangered Species Act. They feed on fish in deepwater habitats (channels, open bay), but use emergent shores as “haul-outs,” where they come ashore to rest, and also to pup (give birth to offspring). Several haul-out sites in the Estuary occur on high tidal marshes, such as Tubbs Island/Midshipman’s Point, and Dumbarton Point, and other areas of Newark Slough, Mowry Slough, and Calaveras Point. Haul-outs are necessarily directly connected to deepwater habitats, have gently sloping terrain, and must be free from human disturbances from boats or land (Lidicker and Ainley 2000, Allen et al. 1984). Seals trample and wallow...
vegetation to sparse, low mats. They do not access haul-outs through wide, dense, tall cordgrass marshes.

**Southern Sea Otter (Enhydra lutris nereis).** The historic range of the sea otter extended from Baja California to the Aleutian islands. The species has been fragmented to two isolated population segments by historic hunting, which nearly drove the species to extinction. Sea otters were formerly abundant in San Francisco Bay, which presumably provided rich feeding areas. They feed on bivalves, abalone, urchins, crustaceans, cephalopods (squid relatives) and fish. Along the central California coast, sea otters are established from Point Sur to Pacifica, San Mateo County. Vagrant sea otters are periodically reported in San Francisco Bay (Ainley and Jones 2000). The nearest estuary that supports sea otters is Elkhorn Slough, a historically brackish semi-tidal lagoon and marsh forced to full marine tidal influence by jetties at Moss Landing. Shallow intertidal habitats in San Francisco Bay, which could potentially support recovery and re-establishment of sea otters in San Francisco Bay are subject to invasion by Atlantic smooth cordgrass. Estuarine habitat of sea otters in Elkhorn Slough is also potentially vulnerable to spread of Atlantic smooth cordgrass from San Francisco Bay. The southern sea otter is Federally and State-listed as endangered.

**Tiger beetles (Cicindela senilis senilis, C. oregona, C. haemorrhagica).** Insects of San Francisco Estuary tidal habitats are very poorly understood in terms of both taxonomy (biological diversity of species) and their ecological interactions within estuarine communities. They also are sensitive to changes in tidal marsh habitats. Several species of tiger beetle (Cicindela spp.), large insects with large eyes and toothed, conspicuous mandibles, have become rare (or sub-regionally extinct) in the San Francisco Estuary. *C. haemorrhagica* and *C. oregona* are associated with maritime and estuarine beaches. *C. senilis senilis* is found on high channel banks, levees, and salt pond margins today, and were probably historically dependent on natural habitats between the edges of tidal marsh and large pans (Maffei 2000). Alluvial fans and sandy deltas, now largely eliminated from the urbanized edges of the Estuary, may have been potential habitat as well.

**Winter- and Spring-Run Chinook Salmon (Oncorhyncus tschawytscha).** Chinook salmon populations native to the Sacramento-San Joaquin river systems are segregated into distinct populations, reproductively isolated by different migration times. The winter-run and spring-run Chinook salmon migrate upstream from the sea to spawn in gravel beds of freshwater streams in winter and spring. The winter-run and spring-run populations have been Federally listed as endangered. Loss and degradation of spawning habitat, mass entrainment of young in water diversions, and reduced delta outflows (also due to water diversions) are among the leading threats to the survival and recovery of the species. Smolts (juvenile salmon spawned upstream) move through the Estuary to feed in shallow water habitats, including salt marsh channels and submerged tidal mudflats. Adults also pass through the Estuary during seasonal migrations upstream, and forage in both intertidal and subtidal habitats. They feed primarily on invertebrates and small fish. National Marine Fisheries Service has designated all tidal waters of the San Francisco Estuary as critical habitat for winter-run Chinook salmon. Tidal marsh and other estuarine habitats are reported to have an important role in Chinook salmon life-history. Tidal marshes are important habitats for small juveniles (fry), while older smolts tend to use deeper waters. Fry tend to occur near the shelter of submerged channel bank or marsh edge vegetation at high tide, and retreat with submerged habitat as the tide falls (Maragni 2000, U.S. Fish and Wildlife Service 1996)

**Steelhead (Oncorhyncus mykiss irideus).** Steelhead are trout species in the same genus as salmon, and they have life-histories essentially like those of Chinook salmon. Steelhead in the San Francisco Estuary are among the populations Federally listed as threatened. Adults and juveniles pass through the Estuary and feed in subtidal and intertidal habitats, including tidal marsh channels.
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...and submerged mudflats, as they migrate upstream to freshwater streams or downstream to marine habitats. Steelhead are drift-feeders, consuming a wide range of aquatic invertebrates and small fish. Adult steelhead migrating upstream seldom feed. Small steelhead runs occur in South Bay tributaries (e.g. San Francisquito Creek, Guadalupe River, Alameda Creek), and in many creeks and rivers of the North Bay and Suisun Bay areas. The importance of tidal creeks and other transient estuarine habitats for steelhead is not well understood (Maragni 2000).

**Delta Smelt (Hypomesus transpacificus).** Delta smelt are small, short-lived estuarine fish that migrate between shallow freshwater stream habitats in which they spawn, and brackish reaches of the San Francisco Estuary. Delta smelt also spawn at the terminal ends of tidal creeks in fresh-brackish tidal marshes. Downstream habitat is primarily limited to intertidal and subtidal habitats of Suisun Bay and its tidal marshes, but they occur also in San Pablo Bay, particularly during and after heavy freshwater flows. They may persist in tributaries of San Pablo Bay during periods of reduced salinity. They generally are limited to estuarine salinity below 10 to 14 parts per thousand, and are usually found in tidewater salinity 2 parts per thousand or less. Their abundance in the Estuary is variable, and appears to be related to both Delta outflows and food supplied by plankton production. The species is Federally and State-listed as threatened.

**Sacramento Splittail (Pogonichthys macrolepidotus).** Sacramento splittail is the only species in a unique genus of large, native minnows. It inhabits the Sacramento-San Joaquin river system and the Delta, including the brackish northern reaches of the San Francisco Estuary. The species has been collected in tidal waters as salty as 18 parts per thousand salinity, but splittail abundance is greatest in salinity lower than 10 parts per thousand. Within the Estuary, it occurs primarily in the Suisun Bay area, but reaches northern San Pablo Bay regularly in years of high river discharge. Sacramento splittail have been very rarely collected in San Francisco Bay. They spawn in fresh or nearly fresh, nonsaline shallow waters with submerged vegetation. Within the Estuary, they are reported to be most abundant in small tidal creeks, particularly those with freshwater discharges or partially submerged marsh vegetation (Sommer 2000). The species is Federally and State-listed as threatened.

**Tidewater Goby (Eucyclogobius newberryi).** Tidewater gobies are rare, small estuarine fish related to sculpin. The species is Federally listed as endangered. Tidewater gobies primarily inhabit coastal stream mouths, which become intermittent lagoons dammed by beach ridges, impounding brackish waters. The tidewater goby’s historic geographic range is from Humboldt County to southern California, including San Francisco Bay. They also occur in subtidal brackish estuarine habitats, but little survey information is available from San Francisco Bay. The few historic records from San Francisco Bay are old; no populations have recently been confirmed. Former collection sites include Berkeley Aquatic Park (1950). Greater predation in large estuaries, compared with intermittent habitat of coastal lagoons, may limit them in San Francisco Bay (Swift et al. 1989, U.S. Fish and Wildlife Service 1994). The species is Federally listed as endangered, but northern and central coast populations have been proposed for delisting (U.S. Fish and Wildlife Service 1999).

**California Sea-Blite (Suaeda californica).** California sea-blite is a low, sprawling, fleshy gray-green shrub related to pickleweed. This Federally endangered plant was historically native only to San Francisco Bay and Morro Bay (San Luis Obispo Co.). Habitat of California sea-blite is restricted to the upper edges of tidal marshes or bay shorelines, generally in coarse, well-drained substrate such as sand, sandstone, or shell fragments. Historic records of California sea-blite in San Francisco Bay are known from Richmond, Berkeley, Oakland, Alameda, San Francisco, South San Francisco, and Palo Alto, all locations of historic sand or shell beaches with adjacent salt marsh. The original native San Francisco Bay population of California sea-blite became completely extinct.
some time around or after 1960. A pilot project to re-establish a colony propagated from Morro
Bay stock was initiated at a constructed tidal marsh in the Presidio of San Francisco in 1999. The
recovery of this species in San Francisco Bay would depend on maintenance and restoration of
estuarine sand beaches with salt marsh transition zones, a habitat threatened by Atlantic smooth
cordgrass invasion. Beach-salt marsh transition zones are also a prime habitat for *Spartina patens* in
its native range. The species is Federally listed as endangered, but is not State-listed.

**Suisun Thistle (Cirsium hydrophilum var. hydrophilum).** Suisun thistle is among the rarest and
most endangered plants in the San Francisco Estuary. Suisun thistle is a stout, tall short-lived per-
ennial thistle, superficially resembling the weedy European bull thistle. It grows along tidal creek
banks and high brackish marsh plains at very few locations in very old tidal marshes around upper
Suisun Slough, near Rush Ranch and Peytonia Slough. It was historically reported only from Su-
isun Marsh, where it was formerly associated with Bolander’s water-hemlock, once a common and
conspicuous plant there. In addition to loss of nearly its entire original tidal marsh habitat, its sur-
vival is threatened by many biological and physical changes in Suisun Marsh, including an intro-
duced weevil that feeds on its seedheads, an aggressive brackish marsh weed (*Lepidium latifolium*),
and large-scale hydrologic manipulations aimed at salinity control for non-tidal waterfowl pond
management (SEW 1998, Baye et al. 2000). The last remaining habitat for this species is within the
potential invasion range of *Spartina patens* (well-established at Southampton Marsh, the western
extreme of Suisun Marsh), Chilean cordgrass and Atlantic smooth cordgrass. This variety is Feder-
ally and State-listed as endangered.

**Soft Bird’s-Beak (Cordylanthus mollis ssp. mollis).** Soft bird’s-beak is an annual herb with
creamy-yellow flowers and glistening glandular hairs on its foliage that exude salt. It is native only
to the tidal marshes around Suisun Bay and northern San Pablo Bay. Its historic range was very
similar to its modern range, but its abundance has declined severely with the loss of its essential
tidal marsh habitat. It occurs in both salt marsh and brackish marsh, but the vast majority of
populations recorded are in brackish high marsh habitats, where it typically occurs in mixtures of
pickleweed and other associated salt marsh herbs, including edges of pans, terrestrial ecotones, and
tidal creek bank edges (Rugyt 1994). At Southampton Marsh, Benicia, multiple colonies are being
encroached by *Spartina patens* and the highly invasive perennial pepperweed (*Lepidium latifolium*). At
Point Pinole, the locations of former colonies have been colonized by *Spartina densiflora*. Most of
the species’ ecological and geographic range is within the potential range of the aggressive Atlantic
smooth cordgrass hybrid swarm. The subspecies is both Federally and State-listed as endangered.

**Northern Salt Marsh Bird’s-Beak (Cordylanthus maritimus ssp. palustris).** Northern (or Point
Reyes) salt marsh bird’s-beak is a low annual herb of the high salt marsh, typically in low or sparse
vegetation or the edges of pans. In the San Francisco Estuary, it has showy rosy-pink flowers and
purplish gray-green foliage bearing salt crystals, exuded from specialized glands. It occurs in tidal
salt marshes from southern Oregon to San Francisco Bay. It has been locally extinct south of the
Golden Gate in San Francisco Bay for many decades, where it was formerly widespread and abun-
dant as far south as Alviso. A few populations remain only in salt marshes of the Estuary’s Marin
shores (northern Sausalito, Mill Valley, Greenbrae, Bucks Landing [Gallinas Creek], and the Peta-
luma Marsh). Marin County (Greekside Park, Corte Madera) is the center of spread of *Spartina den-
siflora*, and the point of introduction of English cordgrass. Large populations of northern salt
marsh bird’s-beak occur in west Marin’s maritime salt marshes (Bolinas Lagoon, Point Reyes, and
Tomales Bay), many appearing distinct from San Francisco Bay types. Most of the subspecies’
ecological and geographic range is within the potential invasion range of all non-native cordgrasses
of the San Francisco Estuary. It is closely related and difficult to distinguish in most respects from
the Federally listed southern salt marsh bird’s-beak (C. maritimus ssp. maritimus), which ranges from Morro Bay to Baja California. The northern subspecies is treated as a species of concern, but has no special legal status.

Pacific or California Cordgrass (Spartina foliosa). Pacific cordgrass is the Pacific Coast’s ecological equivalent of Atlantic smooth cordgrass, and its close relative. It is the sole historic dominant low salt marsh species from Bodega Bay to Baja California. Though common, the recent discovery of strong and rapid genetic assimilation by Atlantic smooth cordgrass indicates a high risk that this species may become extinct in San Francisco Bay, and eventually throughout its range as the Atlantic smooth cordgrass hybrid swarm disperses and fills out its potential niche in the California coast. It was recently discovered that the overwhelming fertility and abundance of Atlantic smooth cordgrass pollen was causing Pacific cordgrass to reproduce only hybrids, rather than its own species, in the presence of Atlantic smooth cordgrass. Prior to this discovery, Pacific cordgrass was not considered a species of concern (Antilla et al. 1999, Ayres et al. 2001); now it is believed that the species is in danger of extinction. Previously, competition alone was the main threat to this species, which allowed for the possibility of persistent co-existence with Atlantic smooth cordgrass rather than a genetic “winner-take-all” outcome of hybridization between species (Strong and Daehler 1994). The species is not currently Federally or State-listed as endangered or threatened, but is under evaluation because of the rapidly changing genetic threat to the species.

Bolander’s Spotted Water-Hemlock (Cicuta maculata var. bolanderi). Bolander’s spotted water-hemlock is a very rare perennial herb resembling parsnips, closely related to the wider-ranging spotted water-hemlock (C. maculata var. maculata). Historically “conspicuous and abundant” in Suisun Marsh (Greene 1894), it occurs in small, rare populations there today, mostly along banks of tidal creeks (B. Grewell, unpubl. data). It was associated with the Suisun thistle (Greene 1894). Its extreme decline was only recently recognized. Most of the threats that affect Suisun thistle also affect this plant. The variety is not currently Federally or State-listed, but is under evaluation because of its apparent extreme rarity and habitat decline.

Mason’s Lilaeopsis (Lilaeopsis masonii). Mason’s lilaeopsis is a creeping, mat-forming perennial herb with a grass-like appearance. It grows among low, turfy vegetation along eroding marsh banks at the edges of tidal channels or bay-edge marshes, often in peaty marsh soil, or thin sediment deposits. It occurs in scattered populations in the San Francisco Estuary from lower Tubbs Island (Sonoma County) through Suisun Bay and the Delta. Wave-trimming and channel bank erosion are important factors that maintain its dynamic, unstable habitat in some locations. Chilean cordgrass aggressively colonized analogous habitat at Point Pinole, San Pablo Bay, and Atlantic smooth cordgrass has established below wave-cut marsh scarps and eroding channel banks, promoting stabilization and dense cover of vegetation. The species is classified as rare by the State, but is not Federally or State-listed as endangered or threatened.

Salt Marsh Owl’s-Clover (Castilleja ambigua, affinity with ssp. ambigua). Salt marsh owl’s-clover is an annual herb with showy tubular, pouch flowers, related to bird’s-beak. Historically widespread in tidal marshes of the San Francisco Estuary, it is now restricted to salt marsh edges of Point Pinole, near an arrested invasion of Spartina densiflora, and at Southampton Marsh, Benicia, near expanding S. patens colonies. Typical C. ambigua ssp. ambigua, or johnny-nip, is widespread in coastal grasslands of California and Oregon. The distinctive Point Pinole population contains mostly purple-tinged plants and flowers which do not match the diagnostic description for the subspecies C. ambigua ssp. ambigua, and appear distinct from typical yellow-white flowered upland grassland forms of that subspecies in the region. The San Francisco Bay population has no protective legal status.
Other Declining High Marsh Plant Species of Concern. A large number of tidal marsh plants which were historically widespread or at least locally abundant have become either regionally uncommon, rare or locally extinct. Most occur in the high marsh zone, which has been compressed by steep levee slopes in most of the San Francisco Estuary. Some are perennial species that may be mistaken for more widespread species with similar appearance, and others are ephemeral spring annuals that are readily identified during brief flowering periods. Examples include Suisun aster (*Aster lentus*), California saltbush (*Atriplex californica*), centaury (*Centaurium trichanthum*), downingia (*Downingia pulchella*), smooth goldfields (*Lasthenia glabrata* ssp. *glabrata*), maritime spikeweed (*Hemizonia pungens* ssp. *maritima*) and numerous others (Baye et al. 2000). The high marsh zone is subject to periodic storm deposition of tidal litter, which smothers vegetation and creates openings favorable to establishment of some species. Extreme drift-line deposits, however, can accumulate as persistent wracks along steep levees and destroy most high marsh vegetation. This occurs along segments of southern Hayward shoreline where Atlantic smooth cordgrass litter is produced in abundance.

3.3.2 Analysis of Potential Effects on Biological Resources

The impacts evaluation is divided into three parts: First, the criteria used to determine the significance of the project effects on biological resources are described. Then a general discussion of the impacts of the various treatment methods is presented; this discussion is followed by specific enumerated project impacts and mitigation measures. Potential effects and mitigation measures are summarized in Table 3.3-1 and Table 3.3-2, respectively.

Significance Criteria

The thresholds for “significance” of impacts to biological resources are based in part on specific regulatory standards from relevant environmental laws or regional plans, and on interpretation of the general biological context and intensity of effects within the ecosystem.

The principal environmental laws pertinent to evaluation of the level of significance to environmental impacts in the San Francisco Estuary include the California Environmental Quality Act (CEQA), the Clean Water Act (CWA, including specific guidance on evaluation of impacts to wetlands and other special aquatic habitats), the California and Federal Endangered Species Acts (CESA, ESA), and Migratory Bird Treaty Act. Other State government agency plans and laws which apply to the quality of habitats in the San Francisco Estuary include the California Fish and Game Code, the McAteer-Petris Act and San Francisco Bay Conservation and Development Commission’s Bay Plan (BCDC Bay Plan), the Suisun Marsh Preservation Act, the Porter-Cologne Act and the San Francisco Regional Water Quality Control Board’s Basin Plan for San Francisco Bay. The endangered species recovery plans for the California clapper rail and salt marsh harvest mouse, and native fish of the Sacramento-San Joaquin Delta (U.S. Fish and Wildlife Service 1984, 1996) and the multi-agency Baylands Ecosystem Regional Habitat Goals Project (Goals Project 1999) are also important plans specific to habitats and species of the San Francisco Estuary. All of these laws, regulations, and plans recognize the ecological importance of intertidal mudflats, and estuarine salt and brackish marshes, and estuarine fish habitats.

CEQA includes the following mandatory findings of “significance” for biological resources if the project would:

- Substantially reduce the habitat of a fish or wildlife species;
- Cause a fish or wildlife species to drop below self-sustaining levels;
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- Threaten to eliminate a plant or animal community; or
- Reduce the number or restrict the range of an endangered or threatened species.

CEQA also requires consideration of the project’s compliance with local, State, or Federal policies or plans for the protection of sensitive species or habitats. These include Habitat Conservation Plans, Natural Community Conservation Plans, Section 404 of the Federal Clean Water Act, the Migratory Bird Treaty Act, the Bald Eagle Protection Act, and local regulations such as Creek Protection Ordinances.

The Clean Water Act’s section 404(b)(1) guidelines for evaluation of discharges of dredged or fill materials (one incidental aspect of numerous proposed activities considered in this EIS/R) provide specific guidance for evaluating significant impacts to special aquatic sites, including wetlands in Subpart H. These include factors that cause or contribute to “significant degradation of the Waters of the United States,” with emphasis on the persistence and permanence of effects. Determinations essential to determination of “significant degradation” must include:

- Recolonization of indigenous organisms;
- Wildlife and wildlife habitat (reproduction, food supply, cover, resting areas, nurseries, etc.)
- Threatened and endangered species, and their habitats (reproduction, food supply, cover, resting areas, nurseries, etc.)
- Proliferation of undesirable competitive species
- Wetlands and mudflats, and vegetated shallows

The baseline, for determination of a significant impact is the existing San Francisco Estuary ecosystem. The “existing conditions” of an ecosystem are not static, but involve dynamic changes in the status and trends that are reasonably foreseeable over an ecologically meaningful timeframe. As described earlier in this section, a 1-2 year period is the short-term timeframe, a 5-10 year period is the intermediate time frame, and a 50-year period is used as the long-term timeframe for ecological evaluations.

Therefore, for the purposes of the following evaluation, biological effects are considered “significant” within an appropriate time-frame and ecological context if they cause relatively high magnitude, persistent, or permanent changes in the following factors, compared with a dynamic environmental baseline rooted in existing conditions:

- Substantially reduce the population size, distribution, viability, or recovery potential of a rare, threatened, or endangered species, or species of concern;
- Changes in the population size, distribution, viability, or resilience of a native fish, wildlife, or plant species;
- Changes in the range, patterns, or fluctuation (dynamics) of physical or chemical attributes of physical estuarine habitats (tidal waters or substrates);
- Changes in stability or structure of estuarine habitats;
- Conflicts with local, State, or Federal biological resource protection plans, policies, and regulations.

**Variables Affecting Biological Predictions and Analyses**

Major variables affecting the long-term maturation of tidal marshes cannot be determined with high confidence. Future rates of sea-level rise, future sediment budgets, and complex interactions between new dominant invader plant species in new physical estuarine conditions are examples of
such variables. The closest comparable cordgrass invasion, the more advanced spread of Atlantic
smooth cordgrass in Willapa Bay, Washington, occurs in a different tidal marsh plant community
and estuarine setting, one without any native cordgrass species or currently listed endangered resi-
dent marsh plants, fish, and wildlife. The future consequences of continued spread or eradication
of invasive cordgrass in San Francisco Bay can be inferred by comparing San Francisco Estuary
marshes with native marshes of the four introduced cordgrass species and with other estuaries that
have already been colonized by these cordgrasses. Biological impacts of non-native cordgrass
eradication efforts have been assessed in many other estuaries, and provide a range of analogous
environments to help evaluate conditions in the San Francisco Estuary.

Another indeterminate aspect of predicting ecological outcomes of the Invasive Spartina Project is
its nature as a regional coordination program, rather than a single site-specific project with specifi-
cally defined project logistics (time, methods, location, etc.). The following evaluation of biological
impacts addresses the broader regional scope of potential effects and mitigation for adverse im-
acts to biological resources. Ecological evaluations consider various contingencies to cover the
range of eradication methods that would be most applicable to a given type of impact. These ad-
dress different types of local environments (mudflats, mature marshes with creek systems, simple
young marsh strips, beaches, etc.) and different methods of removal (mechanical excavation or
dredging; cropping methods such as repeated mowing or disking; methods which leave a matrix of
killed roots and rhizomes physically in place, such as herbicides, drowning, or smothering; etc.).
Evaluations emphasize biological resource issues that are likely to apply generally to many or most
potential projects, as well as issues that can be addressed only at larger regional scales, beyond indi-
vidual projects.

**General Impacts of Proposed Treatment Methods**

The following overview of cordgrass control methods and materials (the *Spartina* control “tool-
box”) emphasizes some of the operational, physical, and physiological aspects of eradication work
that is particularly relevant to interpretation of biological impacts to species and communities af-

tected.

*Amphibious Vehicles and Equipment.* Various eradication methods depend on use of vehicles
designed to operate in semi-aquatic environments. Some support equipment or attachments for
mowing vegetation, ripping and shredding vegetation and substrate, or excavation of marsh sub-
strate. Amphibious vehicles are usually designed to operate with low ground pressure, distributing
weight on specialized tracks or tires. All amphibious vehicles, however, crush and cause dieback of
marsh vegetation, particularly sub-shrubby vegetation with brittle stems. The amount of vegetation
dieback often depends on the number of vehicle passes, the shear strength of the substrate, and
the season. Vehicles passing over brittle vegetation in summer tend to cause the most dieback. Soft
sediment, which causes ruts or depressions, or shearing of sediment below tires or tracks, often
magnifies the impact of vehicle passes on marsh vegetation. Insects, benthic invertebrates, and
small mammals have a definite but unquantified risk of being crushed by vehicles. Marsh-nesting
birds may be disturbed by vehicles, and abandon territories or home ranges to less suitable (and
competitive) locations. Nests may be destroyed inadvertently by marsh vehicles. The insufficiently
surveyed populations of rare plants, including dormant seed banks or bud banks, are also subject
to destruction by mobilization of marsh vehicles.

The pattern of invasive vegetation colonies in the marsh or mudflat determines the potential for
unavoidable track disturbance if vehicles are used. Also important is the location of potential entry
points to the marsh. Marsh entry points that are close to both target colonies and to maintenance
3.3 Biological Resources

or access roads on the land or levee side help to avoid excess vehicle track formation. This is not always the case for larger marshes far from roads or levees.

Vehicles working in unpredictable patterns of soft marsh substrates with many small tidal creeks run the risk of becoming stuck or mired. This would necessitate the entry of additional equipment to remove stuck vehicles. Such operations cause substantial local marsh disturbance, and may require additional rehabilitation or marsh restoration.

Vehicles working in marshes are seldom if ever refueled in the marsh itself. Such refueling would result in risks of fuel spills. Floating barge-mounted equipment, in contrast, is more likely to require refueling while working in sloughs.

“Mats,” large wooden blocks placed over tough geotextile fabric to distribute the weight of equipment and protect underlying marsh vegetation, are sometimes used in conjunction with heavy equipment in tidal marshes. Mats limit the mobility of equipment to work in a few areas. They reduce, but do not eliminate, damage to marsh vegetation.

Small vehicles are routinely used in tidal marshes of the San Francisco Estuary for monitoring and treating production of mosquitoes. They leave both temporary and persistent tracks, depending on frequency of use. Most vehicle access to tidal marshes in the region is limited to restoration or enhancement of tidal creeks or ditches (improvement of tidal circulation), debris removal, and eradication.

Mechanical Disturbance of Substrates. Some eradication methods involve destabilizing the surface substrates of tidal marshes and mudflats in the course of removing or damaging both above-ground and below-ground parts of invasive cordgrasses. In mudflats, removal of stabilizing root and rhizome systems re-exposes the mudflats to normal patterns of erosion and redeposition by waves and tidal currents. Exposure of deeper, coal-black anoxic (oxygen-starved) muds causes rapid oxidation of chemically reduced substances such as iron sulfide and hydrogen sulfide. In contrast with dredging that occurs in subtidal, deepwater environments, excavation, dredging or similar actions applied to cordgrass necessarily occur in intertidal environments, and generally while exposed to air. Plumes of turbid water or blackened, anoxic suspended sediments in the water column, associated with excavation disturbances under water, are not aspects of upper and middle intertidal disturbances during low tide. If dredging of cordgrass were conducted at high tide when the bottom is shallowly submerged, general immediate impacts would be intermediate between those typical of navigational dredging and intertidal excavation. Smooth cordgrass stems and foliage provide oxygen pathways to its roots and rhizomes, which “leak” oxygen to otherwise oxygen-starved (anoxic) sediments. Removal of above-ground growth of smooth cordgrass results in an acute increase in the severity of root-toxic, anoxic waterlogged sediment conditions.

Dredging or excavation of anaerobic bay mud may expose buried sediments with higher levels of mercury, or more biologically available forms of it. Mercury is a heavy metal present in bay muds from natural and artificial sources, and background levels in San Francisco Bay are very high compared with most estuaries nationally. Biological activity of mercury is dependent in part on microbial transformation of mineral forms of mercury to organic forms, principally methylmercury. Mercury in organic materials can be ingested by benthic organisms, which in turn, may be consumed by fish, birds, and mammals, and can thereby bioaccumulate in higher organisms in the food chain.

The irregular, rough topography left by mechanical disturbances to soft sediments is subject to brief increases in erosion until it is planed off by wave action. Both mudflats and prevailing benthic infauna are adapted to mobility of the upper few centimeters of the mudflat surface, and regularly
move and resettle as sediment is lifted by wave erosion and redeposited. Depressions in exposed mudflats caused by natural bioturbation, such as foraging by bat rays, tend to be ephemeral. Any shallowly buried substances, whether natural biogeochemical products (like toxic sulfides) or artificial contaminants, would be remobilized and dispersed following excavation, digging, or other mechanical disturbance of the substrate.

Dislodged or cut plant material (stems, rhizomes, roots, live or dead foliage) from mechanically disturbed sites is likely to redeposit at more stable positions in the Estuary than open marsh or mudflats. They typically accumulate as drift-lines or debris patches near where the contemporary high tide level is intercepted by emergent vegetation downwind. Debris also collects where coves or angles occur in the shoreline. Much above-ground biomass of cordgrass is shed in winter rather than late summer or fall. Fragments of rhizomes may remain viable in cold Bay water and cold air temperatures, but quickly lose viability if exposed to air at mild or warm temperatures, or exposed to sun. Stem fragments with viable buds may regenerate clones if they are rapidly deposited in shallow mud.

Disturbed mudflat substrates are not more likely to be recolonized by marsh vegetation or non-native invaders after disturbance. Disturbed tidal marsh vegetation and substrate, in contrast, is highly vulnerable to invasion by numerous non-native plants, which take advantage of openings in the vegetation canopy and temporary freedom from interference from established vegetation. Disturbed substrates, such as ditch spoils or recently capped levees, often become nuclei for additional invasions by multiple salt marsh weeds.

Flooding and Draining. Impounding standing water in marshes can cause significant, but reversible, changes in marsh soils. The degree to which conditions are reversible depends on the duration of the impoundment. The extensive segments of the large “strip marsh” of pickleweed along the northern edge of San Pablo Bay impounds shallow water (up to 18” deep) for months in winters of high rainfall and high tides, killing hundreds of acres of pickleweed. The marsh vegetation regenerates in years of reduced marsh flooding. Long-term, persistent impoundment, however, allows marsh organic matter to slowly decompose under extreme oxygen-deficient conditions, causing depression of the marsh surface and accumulation of toxic sulfides, which acidify the soil after marsh drainage is restored (Portnoy 1997). If cordgrass stems are mowed in winter to prevent gas transport from live or dead stems to roots and rhizomes below ground, high mortality is likely to occur by the end of the growing season following flooding treatment. Therefore, marsh impoundments used for cordgrass eradication are likely to be in place for less than one year.

When tidal marshes are diked and drained, rather than flooded, they undergo rapid physical and chemical changes. Organic matter decomposes when microbes are exposed to air; clays shrink when dewatered; and sulfides formed in oxygen-free mud transform to sulfates forming strong acids (Portnoy, 1999). Therefore, diking and draining, although conceivably effective for killing cordgrass, would adversely impact marsh soils and restoration, and the longer salt marsh soils are diked and drained the more difficult these adverse soil changes are to reverse. For these reasons, diking and draining will only be used in critical situations where no other method is feasible, and only after careful evaluation and planned mitigation. Diked salt marsh soils that remain permanently flooded undergo relatively slower and less significant changes. Diked flooded salt marshes would eliminate existing standing vegetation, but are readily re-colonized by youthful salt marsh vegetation if the diking is brief.

Low berms can be constructed by excavation equipment or “inflatable dams” used for dewatering construction sites – tubes of geotextile fabric inflated by pumping water in them. Both methods
3.3 Biological Resources

involve mobilization of equipment in the tidal marsh, which is inherently disturbing to vegetation and wildlife. Earthen berm construction requires excavation of a borrow ditch, and multiple “lifts” (layers of piled mud) to raise elevations as drained mud shrinks. Destruction of berms by backfilling the borrow ditch leaves a depression because of the shrinkage in sediment volume in drained conditions. The drained and rewetted mud also tends to become somewhat to very acidic. Inflatable dams leave less persistent impacts to marsh vegetation and topography.

**Burning.** Burning tidal salt marsh vegetation is difficult. Most vegetation has high water content, salt that absorbs moisture, and some have succulent stems and leaves. Fuel generally has to be added to salt marsh vegetation to ignite it. Brackish marsh vegetation, which has a higher proportion of tall, grass-like plants, is easier to burn. Burning vegetation in the Bay Area can be difficult because of air quality controls. Dikes, salt ponds, and tidal channels typical of the south San Francisco Bay provide natural firebreaks.

**Glyphosate Herbicide Application.** The potential biological and ecological impacts of glyphosate (the active ingredient in the two proposed herbicides, Rodeo and Aquamaster), associated surfactants (detergent-like additives that allow herbicides to penetrate plant tissues to be effective) and inert ingredients resulting from the use of herbicides are addressed below.

**Literature Review.** Much of the general information about physiological effects of glyphosate mixtures on animals has been assembled and reviewed by EXTOXNET (Extension Toxicology Network). EXTOXNET is an independent collaborative information project about pesticides, established by the Cooperative Extension Offices of Cornell University, Oregon State University, the University of Idaho, the University of California at Davis, and the institute for Environmental Toxicology, Michigan State University. EXTOXNET literature review and synthesis regarding biological effects of glyphosate usage is presented in Appendix E-3. EXTOXNET does not produce original research, recommendations, or conclusions about pesticides.

Disagreements occur over interpretation of scientifically peer-reviewed experimental results and field studies dealing with glyphosate and surfactants. Different results from different experimental methods and circumstances, a normal aspect of repeated scientific experimental work, also have occurred over several decades of research on glyphosate. It is possible that future research may further change prevailing scientific opinion about the toxicology and environmental fate of glyphosate mixes. To provide context for interpretation of prevailing scientific views, this EIS/R includes a critical review of the scientific literature by a pesticide reform advocacy group, NCAP (Northwest Coalition for Alternatives to Pesticides), a response to the review by the pesticide manufacturer, and a related article by a toxicologist (Appendix E-1). Like EXTOXNET, NCAP synthesizes literature rather than produce original research, but in contrast to EXTOXNET, NCAP asserts opinions about published scientifically peer-reviewed research. Neither EXTOXNET nor NCAP information and views are specifically endorsed or followed in this EIS/R. This EIS/R summarizes contemporary and comprehensive peer-reviewed scientific literature about the biological toxicity of glyphosate and surfactants approved for aquatic application.

**Terminology.** Direct toxicity refers to both acute and chronic toxicity that occur as a result of direct contact, or dermal exposure, with contaminated media such as water or sediment (as opposed to indirect contact, which occurs through ingestion of contaminated prey or other media). Acute toxicity refers to death of the subject organism (lethality) during short-term exposure (generally up to 96 hours). Chronic toxicity refers to sublethal adverse effects (such as disease, reduced growth, or reproduction) during long-term exposure.
Acute toxicity data are often presented in terms of an LC50, which represents the concentration of the toxin that has been found to result in lethal effects to 50% of the test organisms, or EC50, which represents the concentration that has been found to result in sub-lethal effects to 50% of the test organisms. Data can also be presented in terms of a no-observable-effect concentration (NOEC), the concentration for which no effects were observed, or lowest observable effect concentration (LOEC), the lowest concentration for which effects were observed.

Bioaccumulation is the process by which living organisms can retain and concentrate chemicals directly from their surrounding aquatic environment (i.e., from water, bioconcentration) and indirectly from sediments, soil, and food. Biomagnification is a form of bioaccumulation in which the concentration of a chemical in a higher-trophic-level organism is higher than that in the food that the organism consumes.

Conceptual Exposure Model. The known properties of the herbicides, potential methods of application, and the ecological characteristics of the Estuary were evaluated to develop a conceptual model (Figure 3.3-2) and identify likely receptors and exposure pathways. This model includes identification of primary and secondary herbicide sources, release mechanisms, exposure media, exposure routes, and potential ecological receptors.

For effects to occur, a receptor and a complete exposure pathway must be present. An exposure pathway is only considered complete when all four of the following elements are present: project-related source of a chemical, a mechanism of release of the chemical from the source to the environment, a mechanism of transport of the chemical to the ecological receptor, and a route by which the receptor is exposed to the chemical.

The exposure routes associated with the complete pathways include direct contact with the herbicide mixture during and immediately after application, ingestion of contaminated surface water and sediments, direct contact with contaminated surface water and sediments, and food-web exposure. The conceptual model (Figure 3.3-2) illustrates the links between sources, release and transport mechanisms, affected media, exposure routes, and potentially exposed ecological receptors. Although several complete exposure pathways may exist, not all pathways are comparable in magnitude or significance. The significance of a pathway as a mode of exposure depends on the identity and nature of the chemicals involved and the magnitude of the likely exposure dose. For birds and mammals, ingestion, is generally the most significant exposure pathway.

Dermal contact is expected to be insignificant and unquantifiable due to the nature of the site and frequent movement, ranging habits, and furry or feathery outer skin of most wildlife species. Inhalation may be significant during herbicide application, but is difficult to quantify for ecological receptors, and little toxicity data exists for organisms other than mammals.

Because Project applications of herbicides would occur only once or twice a year and compounds in the herbicide mixture are not expected to persist in significant concentrations for more than several hours, chronic exposure is not likely. Therefore, this evaluation focuses on acute toxicity, which would occur when the compounds are present at relatively high concentrations during and immediately following application.

Food-web exposures become significant only if chemicals with a tendency to bioaccumulate or biomagnify are present. The adverse effects associated with bioaccumulative chemicals relate to their propensity to transfer through the food web and accumulate preferentially in adipose or organ tissue. Basic routes for exposure to bioaccumulative compounds by organisms are the transport of dissolved contaminants in water across biological membranes, and ingestion of contami-
nated food or sediment particles with subsequent transport across the gut. For upper-trophic-level species, ingestion of contaminated prey is the predominant route of exposure, especially for hydrophobic chemicals.

U.S. EPA’s Hazardous Waste Identification Rule (USEPA 1999) identifies compounds that are recognized as having a low, medium or high potential for bioaccumulation. For bioaccumulation in aquatic systems, rankings were determined using bioaccumulation factors in fish, which are indicated in laboratory tests as having low octanol-water partitioning coefficient (or log $K_{ow}$) values for organic compounds. Bioaccumulation potential is defined as follows:

<table>
<thead>
<tr>
<th>Bioaccumulation potential</th>
<th>Bioaccumulation Factor (BAF)</th>
<th>log $K_{ow}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>$BAF \geq 10,000$</td>
<td>$\geq 4.0$</td>
</tr>
<tr>
<td>Medium</td>
<td>$10,000 &gt; BAF \geq 100$</td>
<td>$4.0 &gt; \log K_{ow} \geq 2.0$</td>
</tr>
<tr>
<td>Low</td>
<td>$BAF &lt; 100$</td>
<td>$&lt; 2.0$</td>
</tr>
</tbody>
</table>

All reported bioaccumulation factor values for glyphosate in aquatic organisms are well below 100 (Ebasco 1993; Heyden 1991; Wang et al. 1994). The highest bioaccumulation factor of 65.5 was reported for tilapia (a species of fish) in fresh water (Wang et al. 1994). Other studies report much lower bioaccumulation factors in the range of 0.03 to 1.6 for fish (Ebasco 1993). Most studies report rapid elimination and depuration from aquatic organisms after exposure stops (Ebasco 1993). Therefore, bioaccumulation of glyphosate is considered to be low and food-web transfer is not considered to be a significant exposure route.

Chemicals of Concern. Chemicals of potential ecological concern that may be used in the herbicide mixture include glyphosate and its breakdown products; the surfactants R-11, Agri-dex, and LI 700; and the colorant Blazon. The effects of these chemicals on the biota of tidal wetlands depend on the composition of the solution and the physical, chemical, and biological fate in the environment. The chemical properties of glyphosate, surfactants, and colorants are described in Section 3.2, Water Quality. The ecotoxicological aspects are discussed in this section. Glyphosate. Glyphosate is a non-selective herbicide (it kills all vascular plants regardless of species). Plants vary in their sensitivity to glyphosate exposure mostly by how readily it is absorbed and internally transported by plant tissues. Its action is systemic, meaning that it is transported within plant tissues from surfaces it contacts to affect remote parts of the plant, such as roots and rhizomes. Despite its high toxicity to plants, it is relatively low in toxicity to animals. This is due to its chemical nature and the physiological basis for its activity. Glyphosate is chemically similar to certain types of amino acids (components of proteins) found in plants, but not in animals. When glyphosate interacts with the physiological processes of manufacturing proteins in plants, it disrupts protein synthesis. Proteins are essential to all physiological processes in plants, and thus glyphosate exposure
Figure 3.3-2. Conceptual Model of Possible Exposure of Biological Organisms to Herbicide Mixture Used by the Spartina Control Program
is generally highly lethal to plants. Glyphosate does not poison protein synthesis in animals, because it does not act as an analogue of amino acids metabolized in animals. Glyphosate has other effects on animals, however, as do many of its spray mix additives.

One ecologically significant feature of glyphosate is that it is strongly adsorbed by organic matter and fine sediment, such as clay or silt. Sediment films on plant surfaces strongly interfere with uptake and activity of glyphosate. In its chemically bound, adsorbed state, glyphosate is chemically intact, but physiologically inactive. Actual decomposition of glyphosate in the soil or sediment is distinct from its inactivation by adsorption. Glyphosate also desorbs (releases) from soil particles, but its strong affinity for fine mineral and organic particles maintains the predominantly bound, inactivated form (EXTOXNET, Ebasco 1993, Giesy 2000).

The primary breakdown product of glyphosate is aminophosphoric acid (AMPA), which is generally reported to be nontoxic to animals (EXTOXNET, Ebasco 1993). Glyphosate is decomposed by microbial activity in the soil. The reported rates of glyphosate decomposition and persistence in soil vary a great deal: most studies suggest rapid decomposition, while others detect persistence in the soil for more than a year (Ebasco 1993). Rates of decomposition by soil microbes vary with factors such as temperature, oxygen, and pH. Glyphosate may be used as a food substrate by bacteria, and can stimulate bacterial activity. It has been found to kill or inhibit the growth of some soil fungi in pure cultures, however. Little is known about how glyphosate affects the microflora in realistic soil environments, where important interactions such as soil adsorption can occur (Ebasco 1993).

Laboratory tests of glyphosate generally indicate it to be nontoxic or low in toxicity to mammals and birds, particularly at the concentrations or doses that occur in field conditions (EXTOXNET). Most information about glyphosate toxicity to mammals comes from experiments on rats, mice and rabbits, and some on dogs. Little information is available on toxicity of glyphosate or its breakdown products on most wildlife species. Toxic effects of glyphosate are usually achieved in laboratory animals at very high doses (hundreds or many thousands of times the exposure expected from concentrations and doses applied in field conditions) comparable to portions of animal diets, are often required to generate acute effects (EXTOXNET, Ebasco 1993, Giesy 2000).

Surfactants and Colorants. Three surfactants are approved for use with glyphosate in aquatic environments, and have been used to treat invasive cordgrass. They are known by trade names LI-700, Agri-dex, and R-11. Toxic effects of spray mixes of glyphosate are due primarily to surfactants rather than the active herbicide. These surfactants are non-ionic, meaning they do not dissociate into electrically charged particles in water, as salts do. They contain nonylphenol polyethoxylate (NPE) ingredients.

As described in Section 3.2, Water Quality, the Material Safety Data Sheet indicates that Blazon is non-toxic. Some additional information on surfactants and colorants is included in Section 3.2, Water Quality, and Appendix E-1 and E-2.

Toxicological Effects on Ecological Receptors. Herbicide solutions have the potential to affect organisms that live in the water column, including algae, non-target plants, fish and aquatic invertebrates. While some other receptors such as mammals and birds may spend a considerable portion of their time in the water, they are generally more likely to be affected by other exposure routes, primarily dermal contact during application and incidental ingestion of contaminated sediment during foraging.
**Non-Target Aquatic Plants and Algae.** Glyphosate is ineffective for treating submerged aquatic vegetation. It is likely that factors in the aquatic environment, such as suspended organic matter or sediment, interfere with glyphosate uptake by submerged plant tissues. Glyphosate also is slightly toxic or practically nontoxic to freshwater and marine algae and phytoplankton tested in both laboratory and field studies. Species of algae vary in their sensitivity to glyphosate in terms of population growth (EXTOXNET, Giesy 2000). Field studies indicate the least toxicity to phytoplankton (microscopic floating algae), possibly because of dilution and adsorption in open water and flooded marshes.

Few data are available on effects to marine algae, as most toxicity tests have been performed on freshwater species. Giesy *et al.* (2000) reviewed the data available on glyphosate toxicity to microorganisms, and found that acute toxicity EC50 values ranged from 2.1 to 189 mg/L. NOECs ranged from 0.73 to 33.6 mg/L. Giesy *et al.* (2000) also reviewed the data available on glyphosate toxicity to aquatic macrophytes, and found that acute toxicity EC50 values ranged from 3.9 to 15.1 mg/L. It should be noted that these studies included tests on the (non-aquatic) Roundup formulation as well as other forms of glyphosate. The formulated product known as Roundup (glyphosate plus specific surfactants) is known to be more toxic than the (aquatic) Rodeo formulation (now called Aquamaster). For studies conducted on microorganisms using glyphosate tested as isopropylamine salt, EC50 values ranged from 72.9 to 412 mg/L, and NOEC values ranged from 7.9 to 26.5 mg/L (Giesy *et al.* 2000). The lowest of these NOEC values (0.73 mg/L) is well above the maximum concentration of 0.026 mg/L reported by Paveglio *et al.* (1996) (see Section 3.2) and the immediate maximum geometric mean glyphosate concentration of 0.174 mg/L reported by Patten (2002). Therefore, these data indicate that impacts to non-target submerged aquatic plants or algae are not likely. Impacts in estuarine conditions with high concentrations of suspended sediment, which interfere with glyphosate activity, would be even less likely.

The NEPA Environmental Assessment conducted for Willapa Bay (Washington State 1997) included a review of field toxicity studies for non-target marine plants, which indicated that Rodeo tank mixes have had variable effects on non-target plants. Japanese eelgrass was adversely affected in one of two plots aerially treated with Rodeo and X-77 Spreader in Willapa Bay. Rodeo and X-77 Spreader applied by hand-held sprayer to eelgrass did not affect biomass in an eight-week study conducted in Padilla Bay.

Some adverse effects to non-target plants that are not completely submerged are likely to occur. However, these effects can be mitigated using the methods described in this section.

**Aquatic and Benthic Invertebrates.** Giesy *et al.* (2000) reviewed the data available on glyphosate toxicity to aquatic invertebrates. Few data were available for marine species, and those studies that did use marine species were conducted with glyphosate acid, not salt. Acute toxicity EC50 values for five marine species ranged from 281 mg/L to greater than 1000 mg/L, and NOEC values ranged from 10 to 1000 mg/L. Data compiled by Ebasco (1993) include mortality tests on two marine species, for which EC50 values were found to be 281 mg/L and greater than 1,000 mg/L.

Grue *et al.* (2002) conducted laboratory studies to evaluate reproductive effects of exposure to Rodeo mixed with four different surfactants, including R-11, LI 700, and Agri-dex, on Pacific oysters. The EC50 for glyphosate alone was 68.1 mg/L, the EC50 for the tank mix including Rodeo and R-11 surfactant was 29.9 mg/L, and the EC50 for the R-11 surfactant alone was 1.0 mg/L.

The lowest of these NOEC and LC50 values (10 mg/L) for glyphosate or glyphosate/surfactant mixtures is well above the maximum glyphosate concentration of 0.026 mg/L reported by Paveglio *et al.* (1996) and the immediate maximum geometric mean glyphosate concentration of 0.174 mg/L.
reported by Patten (2002) (see Section 3.2). Therefore, these data indicate that impacts to aquatic invertebrates due to post-application water concentrations of glyphosate are unlikely in experimental conditions. Impacts in estuarine conditions with high concentrations of suspended sediment, which interfere with glyphosate activity, would be even less likely.

Kubena et al. (1997) conducted sediment and water toxicity studies on marine invertebrates (oysters and amphipods). The LC$_{50}$ values for Rodeo and surfactant in water ranged from 200 to 400 mg/L, and the LC$_{50}$ values in sediment ranged from 1000 to 6000 mg/kg. These LC$_{50}$ values are well above the highest measured geometric mean sediment concentrations of 2.3 mg/L reported by Kilbride et al. (2001) and Patten (2002), as described in Section 3.2.

Field studies of glyphosate/surfactant applications to tidal mudflat invertebrate communities in Willapa Bay, Washington, agree with laboratory tests, which indicate low potential for adverse impacts to benthic invertebrates. Sampling of benthic invertebrates in mudflats up to 199 days after glyphosate/surfactant (X-77) applications revealed no short-term or long-term effects. Short-term laboratory tests of amphipods exposed to glyphosate and surfactants did not affect survival even at high concentrations relative to post-spray field conditions (Kubena 1996).

Fish. Giesy et al. (2000) reviewed the data available on glyphosate toxicity to fish. Although some data were available for anadromous species, it appears that all tests were conducted using freshwater test methods. Acute toxicity LC$_{50}$ values for glyphosate tested as isopropylamine salt ranged from 97 to greater than 1,000 mg/L and NOEC values ranged from <97 to 1,000 mg/L. Data compiled by Ebasco (1993) on one-day acute toxicity tests indicate EC$_{50}$ values ranging from 12.8 mg/L to 240 mg/L. The lowest of these NOEC and LC$_{50}$ values (12.8 mg/L) for glyphosate or glyphosate/surfactant mixtures is well above the maximum glyphosate concentration of 0.026 mg/L reported by Paveglio et al. (1996) and the immediate maximum geometric mean glyphosate concentration of 0.174 mg/L reported by Patten (2002) (see Section 3.2). Therefore, these data indicate that impacts to fish due to maximum post-application water concentrations of glyphosate are unlikely in experimental conditions. Impacts in estuarine conditions with high concentrations of suspended sediment, which interfere with glyphosate activity, would be even less likely.

Acute toxicity of X-77, R-11, ad LI-700 to fish can be moderate. Threshold LC$_{50}$ for an anadromous salmonid fish tested (Atlantic salmon, *Salmo salar*) was as low as 0.13 parts per million, and young fish or eggs are generally found to be more sensitive than adults. Despite the low threshold for concentrations of surfactant causing significant mortality, actual concentrations to which fish are likely to be exposed in actual estuarine environments are orders of magnitude lower. Research in Willapa Bay found that the highest average maximum concentrations of surfactant in water dispersed from sprayed estuarine mud with the first flooding tide – the highest concentration for exposure, a “worst case scenario” for fish swimming into freshly sprayed sites – was 16 parts per billion (Paveglio et al. 1996).

Birds. Effects of glyphosate on birds have been tested on mallard ducks (dabbling ducks which ingest wetland sediment along with seeds, insects, and vegetation) and bobwhite quail. As with mammals, very high dietary concentrations of glyphosate (a 4,640 mg/kg dietary concentration) resulted in no adverse reactions such as weight loss or mortality (Ebasco 1993). Little or no data are available on toxicity of surfactants to birds.

Mammals. Ebasco (1993) compiled data on glyphosate toxicity to mammals commonly used in laboratory tests, and reported that LD 50 values (the dose resulting in lethal effects to 50% of
test organisms) ranged between 3,800 mg per kg body weight. Glyphosate is considered to be practically non-toxic to mammals.

The toxicity of the aquatic-approved surfactants to mammals is reported to be very low: greater than 5 grams per kilogram body weight oral dosage of Agri-dex and LI-700 is the threshold for LC$_{50}$, the level at which 50% mortality occurs in laboratory rat tests. The corresponding LC$_{50}$ for R-11 is reported to be 2 to 4 grams per kilogram body weight (Appendix E; USDA and USFS fact sheets). Nonylphenol has been raised as a concern as a potential breakdown product because it exhibits weak estrogen-like hormonal activity, which could alter reproductive physiology of animals exposed at low concentrations (NCAP 2002). There is little evidence that estrogenic effects occur in field conditions, but such activity is possible.

Little is known about potential interactive effects between applied glyphosate/surfactant solutions and cumulative loads of herbicides, insecticides, detergents, perfume agents, and many other organic contaminants in the San Francisco Estuary. It is reasonable to assume that cumulative, interactive effects occur in organisms of the Estuary, but the complexity of multiple interactions in uncontrolled field conditions makes definitive research difficult.

In practice, total dosages of glyphosate/surfactant solutions applied in field conditions (amount of solution applied, and concentration, and the number of re-applications to eradicate survivors) depends on many factors which are independent of the physiology of glyphosate and surfactants themselves. The physiological activity and health of the plant, interference with spray coverage by persistent dead leaves or sediment films, all affect the percent kill of vegetation, and the ability of regenerative buds to survive and re-establish the population. Regeneration requires re-application of herbicide or other eradication methods. Total dosages of glyphosate needed to achieve complete mortality of target vegetation can be minimized by combining its use with prior “knock-down” treatments that reduce vegetation density, mass, attached leaf litter, and regenerative capacity, prior to spray application. Mass-defoliation followed by partial regeneration of sufficient receptive new leaf surface area can make vegetation more exposed and sensitive to glyphosate applications. This can reduce total requirement of spray needed to completely cover foliage and achieve high mortality, and it can minimize the need for follow-up sprays for survivors.

Modes of glyphosate application (other than spraying) include “wicking” (painting wiping solutions with fabric or sponge-like applicators), and application of glyphosate pastes (in carriers such as lanolin) on cut stumps. Wicking often results in both reduced coverage (and effectiveness), and reduced non-target vegetation damage. Cut-stump application is usually used for woody plants, but may be used at a small scale for non-woody species where precise and labor-intensive methods may be used.

**Specific Impacts to Biological Resources**

This section provides a comprehensive evaluation of the impacts to biological resources of each of the project alternatives and describes mitigation measures that will be implemented to reduce impacts to a less than significant level (where feasible). The effects are summarized in Table 3.3-1 and the mitigation measures for each impact are summarized in Table 3.3-2.

**ALTERNATIVE 1:** Proposed Action/Proposed Project - Regional Eradication Using All Available Control Methods

**IMPACT BIO-1: Effects of treatment on tidal marsh plant communities.**

Effects of the project on tidal marsh plant communities are evaluated below.
3.3 Biological Resources

**IMPACT BIO-1.1: Effects of treatment on tidal marsh plant communities affected by salt-meadow cordgrass and English cordgrass.**

Salt-meadow cordgrass, which has small, slowly spreading populations to date, would be eliminated and prevented from potential increases in their rates of spread after reaching a critical population size. This would prevent conversion of high tidal marsh plains of brackish and salt marshes from being converted to low-diversity or monotypic stands of salt-meadow cordgrass throughout the Estuary. The small population of English cordgrass would also be rapidly eradicated.

Short-term effects of salt-meadow cordgrass removal at the single confirmed population (multiple colonies) at Southhampton Marsh, Benicia, would probably be limited to localized disturbance of vegetation. Mechanical removal and burning are unlikely to be used in this setting; smothering and glyphosate spraying are probably most suited to the patch size, distribution, and terrain at this location. Potential impacts of eradication method failure may involve movement of geotextile/black plastic covers by wind or tides, smothering non-target vegetation; or spray drift to non-target adjacent vegetation. Dispersal of salt-meadow cordgrass seed or fragments by eradication operations is unlikely, but possible. These impacts, though locally important, are overall less than significant, and are further mitigable.

Long-term biological effects of removal would most likely result in recolonization of cleared patches by native brackish marsh vegetation. It is possible that cleared patches could become invaded by perennial pepperweed (*Lepidium latifolium*), particularly where seed and rhizome sources are adjacent or close to cleared patches.

**MITIGATION BIO-1.1: Vehicle and foot access pathways in marsh invaded by salt-meadow and English cordgrasses, including marsh access to invaded mudflats shall be minimized.** Seasonal timing of glyphosate treatment of *S. patens* shall be adjusted to minimize impacts to non-target native marsh vegetation. When treating small, discrete colonies of salt-meadow cordgrass or English cordgrass, adjacent vegetation shall be buffered against spray drift by temporarily placing geotextile fabric segments (aprons or fence-like fabric barriers) adjacent to colonies at the time of spraying. Adjacent vegetation also could be buffered against spray drift by pre-application of bay mud suspensions to coat leaf surfaces. Oversprayed non-target vegetation could be irrigated with muddy bay water applied by portable pumps or truck tanks. Geotextile covers shall be stabilized by stakes and weights, and monitored after high tides or high wind events. Standard best management practices for herbicide application in wildlands (e.g. field crew training, clear marking of spray boundaries in the field, expert ecological supervision during field operations, restricting operation to optimal low-wind times, nontoxic spray markers, etc.) shall be used to minimize incidental overspray and drift. Cleared patches shall be monitored for recruitment of invasive perennial pepperweed until native vegetation has become dominant. In patches highly vulnerable to spread of contiguous perennial pepperweed, treated areas shall be replanted with saltgrass and pickleweed in the following spring to discourage seedling microhabitats for perennial pepperweed. Salt-meadow cordgrass and English cordgrass mown, cut, or shredded shall be prevented from dispersal by mounding cut debris and on-site composting under heat-retaining geotextile fabric or black plastic in warm weather. Optimal combinations of treatment shall be used to minimize repeat entry to marsh and re-treatment (e.g. mowing or burning followed by spot-application of herbicide to low densities of survivors). Where Atlantic smooth cordgrass is removed from high marshes where native species other than cordgrass are dominant, native vegetation may be replanted.

**IMPACT BIO-1.2: Effects of treatment on tidal marsh plant communities affected by Atlantic smooth cordgrass and its hybrids.**
Eradication work aimed at Atlantic smooth cordgrass colonies may have adverse indirect short-term effects on adjacent, non-target tidal marsh plant communities, where colonies occur within marsh rather than mudflat. The most common incidental effect would be localized destruction of vegetation at the margins of eradication treatments, such as herbicide (glyphosate) spray drift resulting from aerial applications, herbicide overspray resulting from ground-based accidental discharge beyond targeted plants, mechanical damage from vehicles, and locally escaped controlled burns in the marsh. This would be proportionally greater for eradication work aimed at Atlantic smooth cordgrass because of its more extensive coverage and distribution in the Estuary. Indirect short-term impacts to adjacent vegetation are likely to be significant only in large-scale operations.

Mechanical removal techniques which result in severing fragments of rhizomes or buds in viable units capable of regenerating after dispersal could increase invasion of established plant communities and defeat the purpose of eradication. Excavation, dredging, disk- ing, and shredding methods all carry this risk. Equipment that finely shreds all biomass is least likely to cause dispersal of viable fragments. Fragment viability is reduced when air is warm, as in summer months; warm, dry air results in rapid desiccation and loss of viability, especially for fragments that are deposited in high-tide lines. Mechanical removal methods also may generate large volumes of wrack (tidal litter) that is likely to be deposited in high marsh or marsh plain vegetation. Mechanical removal also may promote seed dispersal if ripe seed have matured at the time work is done. This impact would be significant but mitigable. Critically important tall native high marsh vegetation cover (especially gumplant) could be trampled and destroyed by vehicle operations.

An effect on existing infested tidal marsh plant communities would be the release of accreted marsh sediment from dominant, exclusive Atlantic smooth cordgrass cover, allowing succession to native tidal marsh plant communities. This would be a beneficial impact.

**MITIGATION BIO-1.2:** Vehicle and foot access pathways in marsh invaded by Atlantic smooth cordgrass, including marsh access to invaded mudflats shall be minimized. Equipment working in marsh plains shall be restricted to mats and geotextile fabric covers. Non-viable excavated non-native cordgrass and excavated sediment shall be stockpiled and removed from marsh. Non-target vegetation shall be covered with fabric adjacent to areas sprayed with herbicide, or non-target vegetation shall be pre-treated with protective films of silt-clay. Smothering geotextile mats shall be stabilized with stakes and weights, and inspected frequently. Optimal combinations of treatment shall be used to minimize repeat entry to marsh and re-treatment (e.g. mowing or burning followed by spot-application of herbicide to low densities of survivors). Herbicide spray dose requirements for effective treatment shall be minimized by pre-treatments (mowing, crushing, or burning) that reduce live cordgrass density and increase exposure of receptive young growth following pre-treatment. Removal methods other than helicopter applications of herbicide shall be used whenever feasible and less environmentally damaging. If new technology is available and feasible, non-spray application techniques (e.g., modified cut-stump herbicide application or wicking techniques) shall be used to reduce herbicide dose and minimize non-target contact. Dispersal of viable seed shall be minimized by performing removal prior to seed set or maturation, or if natural or artificial conditions constrain seed set prior to eradication.

**IMPACT BIO-1.3:** Effects of treatment on tidal marsh plant communities affected by Chilean cordgrass.

Impacts to adjacent plant communities caused by eradication projects aimed at Chilean cordgrass would be similar to those of salt-meadow cordgrass, which also grows in the middle and high salt marsh zone. The clumped growth habit of Chilean cordgrass would allow for higher feasibility of
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effective manual excavation with only shovels rather than mechanical equipment. Similarly, spot-spraying with herbicide (possibly cut-stump paste methods, too) may be feasible for eradication of some stands. This may reduce impacts to adjacent vegetation compared with salt-meadow cordgrass in some conditions. The greater interspersion of Chilean cordgrass clumps among native salt marsh vegetation may distribute impacts more widely in some dense stands, however. These impacts are considered significant but mitigable.

MITIGATION BIO-1.3: Mitigation BIO-1.1 also would apply to Chilean cordgrass.

IMPACT BIO-1.4: Effects of treatment on submerged aquatic plant communities

Impacts to eelgrass beds are highly unlikely to occur from invasive cordgrass eradication in the San Francisco Estuary. All eelgrass beds, both large permanent colonies and small intermittent colonies establish in subtidal waters of the Estuary, and do not occur in mudflats or marshes where cordgrass eradication would occur. Submerged eelgrass would not be affected by tidal dispersion of glyphosate, because overwhelming dilution and adsorption effects of suspended sediment in tidal waters. Epiphytic algae on eelgrass stems and leaves would further intercept potential exposure. Submerged aquatic vegetation within salt marsh pans is almost entirely wigeon-grass (*Ruppia maritima*). Wigeon-grass is also covered in epiphytic algae during most of its growth and decline, and flooded salt marsh pans are rich in dissolved organic matter rather than suspended mineral sediment. These factors also minimize potential incidental glyphosate impacts, consistent with laboratory test of submerged aquatic plant insensitivity to applied glyphosate. Pondweeds (*Potamogeton* species) in brackish marsh pans found in Suisun Marsh and parts of northern San Pablo Bay would be similarly insensitive to incidental glyphosate exposure. Minor impacts to submerged aquatic vegetation could result from local deposition of cut (mown) cordgrass debris after tidal rafting from marsh to pans. This impact is unlikely because most pans naturally tend to draw down and die back to algal mats in summer. Only accidental direct spillage of bulk herbicide solution would pose a potential substantial risk to submerged aquatic vegetation. No other impacts are expected for submerged aquatic plants.

MITIGATION BIO-1.4: Large deposits of mown cordgrass shall be raked and removed during the growing season if tidal marsh pans supporting submerged aquatic vegetation occur in the vicinity; or temporary water-permeable debris barriers (i.e. silt fences) shall be installed around vulnerable pans. Transporting tanks of spray solution near pans shall be avoided to prevent contact by accidental spills.

IMPACT BIO-2: Effects of treatment on special-status plants in tidal marshes.

Most effects of regional cordgrass eradication on special-status plants would be indirect and long-term consequences of preventing future cordgrass invasion impacts to occupied and potential habitat (altered tidal hydrology, altered sedimentation, competition, massive wracks, etc.). This is because most of the cordgrass invasion currently occurs in subregions of the Bay where special status plants have already become locally extinct (esp. San Francisco Bay), so eradication efforts in the near-term would be focused away from sensitive populations. In the long term, the eradication program would have significant benefits for the long-term chances of survival and recovery of endangered tidal marsh plants. Short-term effects of cordgrass eradication operations on special-status plant species could be adverse, however, particularly for the endangered soft bird’s-beak populations at Southampton Marsh, Benicia (where salt-meadow cordgrass is locally abundant) and Point Pinole (where Chilean cordgrass has been largely eradicated, but regenerates at low levels).
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Soft bird’s-beak at Southampton Marsh grows closely adjacent to one colony of salt-meadow cordgrass. Removal operations may result in trampling of undetected seedlings, since this annual species has a distribution that changes from year to year. Herbicide spray drift may destroy seedlings or reproductive plants. Dislodged geotextile fabric may smother adjacent soft bird’s-beak. Repeated marsh re-entry at Point Pinole near the Whittell Marsh population of soft bird’s-beak to remove regenerated Chilean cordgrass may trample seedlings. Conversely, small-scale trampling disturbances may provide local gaps in salt marsh vegetation suitable for establishment of new subcolonies of soft bird’s-beak in subsequent years.

Incidental impacts to other plant species of concern could result from mobilizing equipment and marsh vehicles in tidal marshes where invasive cordgrass eradication projects are implemented. In San Francisco Bay, where the largest proportion of the non-native cordgrass invasion occurs, this is least likely to occur because most rare plants and all endangered plants are either extirpated or do not occur in affected marshes. Eradication operations are unlikely to adversely affect any of these species because their natural distribution is remote from sites where non-native cordgrass invasion is in progress. North Bay and Suisun marshes have richer tidal marsh floras, and eradication work there is more likely to impact rare plants. This is a potentially significant but mitigable impact.

MITIGATION BIO-2: Pre-project spring surveys for sensitive plants shall be conducted the same year as eradication work at treatment sites (for annual species), or at least the prior year (for perennial species). GPS data and stake locations of sensitive plant populations shall be recorded, and field crews on foot or in vehicles shall be instructed to avoid and protect sensitive populations. Qualified, experienced on-site botanical supervision shall be required if sensitive plants occur in the vicinity of eradication work. If sensitive plant populations occur near the high tide line, rake and large deposits of mown cordgrass shall be removed during the growing season. Burning in marshes supporting sensitive plant species shall be prohibited. Smothering geotextile mats shall be stabilized with stakes and weights, and inspected frequently. Non-target vegetation shall be covered with fabric adjacent to areas sprayed with herbicide, or spray-drift barriers made of plastic or geotextile (aprons or tall silt fences) shall be installed. If accidental exposure to spray drift occurs, affected plants shall be thoroughly irrigated with silt-clay suspensions.

Refrain from rapid replanting Pacific cordgrass (native *Spartina foliosa*) in both new restoration sites or invasive cordgrass-eradicated sites, until pollen flow and seed rain from hybrid Atlantic smooth cordgrass to the site is confirmed to be minimal for purposes of subsequent detection and control. Use natural cordgrass seedling recruitment rates to monitor “invasion pressure” (ratio of non-native to native cordgrass seedlings) to determine both eradication effectiveness for a tidal marsh subregion, and the earliest date for active replanting with native clones, if needed. In patches highly vulnerable to spread of contiguous perennial pepperweed, treated areas shall be replanted with saltgrass and pickleweed in the following spring to discourage seedling microhabitats for perennial pepperweed.

IMPACT BIO-3: General effects of treatment on shorebirds, waterfowl, and marshland birds

Short-term impacts of cordgrass eradication operations are likely to be disturbance of shorebirds present within about 500 to 1,000 feet from operations of field crews. Shorebird flocks are likely to relocate to other mudflat areas at low tide, or alternate high tide roosts. Relocation sites may provide inferior food resources or roost capacity. Waterfowl are less likely to be disturbed by crews working at low tide, since they are most likely to occupy shallow water. This impact would usually be less than significant, but could become significant for exceptionally large eradication projects with operations that last for many days over a wide area of mudflat.
If dredging or excavation is used to remove non-native cordgrass in mudflats foraged by shorebirds, exposure to elevated levels of mercury is a potential issue. Shorebirds may be exposed to mercury through foods they consume. Most shorebirds forage over a wide area of the Bay, or further, in the case of migratory birds. For these birds, it is unlikely that any potential exposure from a dredged or excavated treatment site would cause a significant increase in mercury ingestion. An exception would be rails, which forage almost exclusively near their nesting locations. Mitigation measures for possible exposure to California clapper rails are discussed below.

If large swards of Atlantic smooth cordgrass hybrids are removed from large flood control channels or major sloughs by operation of a floating dredge (barge and crane), waterfowl in the vicinity of dredging operations would be disturbed. The typical attraction to gulls and terns provided by subtidal dredging for navigation purposes would probably not occur with dredging in the cordgrass zone (near mean sea level elevation), since it would not generate turbidity plumes in the channel water column that force fish to the surface.

Field crews working on marsh plains would probably disturb wading birds and long-legged shorebirds in pans and small tidal channels (egrets and herons, avocets, stilts, yellowlegs, willets, marbled godwits) and long-legged shorebirds on the marsh plain roosting at high tide. Following mechanical disturbance at cordgrass removal sites, feeding by these species would be increased, because disturbances increase exposure of invertebrates. Repeat-cropping methods such as mowing or disk would increase the incidence of shorebird disturbances, and spread them over longer periods of time. Only in cases of large-scale, recurrent disturbances from repeated marsh operations would shorebird disturbance be a significant impact, because it would be likely to alter routine bird behavior and selection of feeding and roost areas. Single or infrequent disturbance events would generally not be significant impacts.

Glyphosate sprays on low marsh colonies of Atlantic smooth cordgrass on mudflats or channels probably would not have direct contact with shorebirds, even if drift occurs, since field crew activity would cause shorebird flocks to flee from active spray areas. Aerial (helicopter) applications of spray (potential method for very large, isolated cordgrass stands) would increase potential amount and distance of drift, but this potential would be partially offset by the increased hazing of shorebirds by helicopters. Dispersal of spray by subsequent tidal flooding, dilution, and inactivation of glyphosate in bay sediment would render sprayed areas and adjacent areas effectively harmless to shorebirds.

Accidental spray spills could be temporarily hazardous to shorebirds and waterfowl. Hazards would be mainly due to locally high concentration of surfactants, which could be ingested as shorebirds probe mud. This would be a very localized and short-term impact, and due to the very low toxicity of the herbicide solution to shorebirds, any impacts are expected to be less than significant.

**MITIGATION BIO-3:** treatment activities occurring within 1,000 feet of mudflats shall be scheduled to avoid peak fall and spring Pacific Flyway stopovers. Optimal combinations of treatments shall be used to minimize repeated entry to sites near sensitive shorebird roosts or preferred foraging areas, and to minimize the need for re-treatment. Field crews shall be mobilized to project sites soon after high tide, before mudflats emerge. Field crews shall haze shorebird flocks downwind of spray sites to minimize potential of direct contact with drifted glyphosate spray mixes. Hazing shall be maintained in buffer areas until flood tide to minimize potential indirect contact with shorebirds returning to sprayed or drift-exposed areas. Spilled herbicide, surfactant, or solution on marsh or mudflats shall be immediately remediated by application and removal of adsorb-
ent materials, suction using portable wet vacuum or pumping equipment, or by other suitable method. Shorebirds will be kept away from the spill area by hazing until the spill is remediated. Broadcast spraying by helicopters shall be restricted to meadows and large stands of cordgrass, or where there is no other reasonable access. Targeted helicopter application of herbicide by “spray ball” will be a preferred treatment option to reduce all negative treatment impacts to shorebirds. Helicopters will not be operated within 1,000 feet of active major roosting or foraging sites.

**IMPACT BIO-4: Effects of treatment on special status mammals**

**IMPACT BIO-4.1: Effects of treatment on the salt marsh harvest mouse and tidal marsh shrew species.**

Because small mammals do not generally inhabit cordgrass stands, direct effects of eradication on small mammals would be minimal or lacking. Indirect effects to the salt marsh harvest mouse and tidal marsh shrew species could occur through marsh vehicle disturbance of vegetation (habitat degradation), crushing of mice or shrews beneath tracked vehicles while accessing infested marsh areas, destruction of high tide flood refugia (debris or tall broadleaf vegetation), and exposure of mice and shrews to glyphosate/surfactant solutions drifted from cordgrass to adjacent mixed pickleweed vegetation. Trampling of marsh plain vegetation by field crews is unlikely to crush small mammals or significantly degrade habitat quality.

The risk of these potential impacts is low for the salt marsh harvest mouse in the vast majority of potential eradication project sites in San Francisco Bay: trapping (detection) studies of the species have repeatedly confirmed that their populations are usually very low and intermittent in tidal marsh plains in San Francisco Bay subject to prolonged, deep flooding during high tides. This is the typical condition of the majority of potential eradication sites. Furthermore, the salt marsh harvest mouse is presumably extirpated from most tidal marshes in central San Francisco Bay. But because of the severe endangerment of the southern subspecies, any potential substantial risk of “take” of this species is significant.

High densities of salt marsh harvest mice are found in some North Bay marshes with relatively high elevations and heavy cover of tall pickleweed. Cordgrass-infested marsh plains in the North Bay are limited to Whittell Marsh, Point Pinole (historically lacking the salt marsh harvest mouse), Creekside Park, Corte Madera (possible occurrence in treatment areas of *Spartina densiflora*), and Southampton Marsh, Benicia (probable occurrence in or around treatment areas of salt-meadow cordgrass). At Creekside Park and Southampton Marsh, the risk of adverse indirect impacts to the salt marsh harvest mouse is greater. This is a significant but mitigable impact.

Because the distribution and abundance of tidal marsh shrews is poorly known, it is reasonable to presume that undetected shrew populations may occur in any treatment sites, including relatively lower elevation pickleweed-dominated tidal marsh. This is consistent with their high demand for invertebrate food items, which are abundant in moist intertidal marsh zones. High rates of food consumption may also mean relatively greater potential exposure to moderate toxicity of surfactants drifted to marsh adjacent to sprayed areas. This is a significant but mitigable impact.

Marsh wildlife, including salt marsh harvest mice, are unlikely to come into contact with colorants in spray mixes. Spray crew operations would generally disturb wetland birds and cause them to disperse away from areas being sprayed. Salt marsh harvest mice and other small mammals generally remain under dense vegetation cover at ground level except during extreme tides (when no spraying would occur) and would not be exposed to sprays applied to vegetation surfaces. Even if
wildlife were exposed to colorants, risk of predation would not increase if background vegetation
were also exposed to colorants.
The effect of eradication of existing non-native cordgrass from high marsh sites would be benefi-
cial in terms of restoring pickleweed tidal marsh (essential to the recovery of the salt marsh harvest
mouse).

**MITIGATION BIO-4.1:** Even where environmental conditions indicate low probability of pres-
ence, and low potential abundance of the salt marsh harvest mouse, the species shall be presumed
to be present in project areas containing mixed pickleweed vegetation. This presumption is a pre-
cau tion against avoidable “take” of this endangered species. Use of vehicles in potential tidal marsh
habitat of the salt marsh harvest mouse and tidal marsh shrew species shall be minimized. Shortest
possible access paths shall be determined prior to marsh entry, and shall be flagged to limit travel
patterns of vehicles to areas with mats or geotextile covers. Use of optimal combinations of treat-
ment shall be implemented to minimize repeat entry to marsh and re-treatment (e.g. mowing or
burning followed by spot-application of herbicide to low densities of survivors). When possible,
work shall be scheduled in suitable small-mammal habitat soon after natural mass-mortality events
caused by extreme high tides.

If site-specific evaluations indicate that potential take of salt marsh harvest mouse individuals is
excessive, or degradation of habitat is unacceptable despite avoidance and minimization measures,
then compensatory mitigation shall be planned and implemented. Appropriate compensatory miti-
gation may include construction of pickleweed marshes (acreage and location to be determined) at
or slightly above the plane of contemporary mean higher high water, to increase the resilience of
resident salt marsh harvest mouse populations to natural extreme tidal flooding and sea level rise.
Providing tidegates to choke tidal circulation to optimal levels needed to maintain optimal salt
marsh harvest mouse habitat quality (with reduced risk of tidal flooding mortality) is an additional
mitigation option, depending on mitigation site conditions. These and/or other options shall be
proposed as mitigation in consultation with the U.S. Fish and Wildlife Service and California De-
partment of Fish and Game.

**IMPACT BIO-4.2:** Effects on resident harbor seal colonies of San Francisco Bay

Short-term effects of eradication methods on harbor seals due to repeated disturbance could be
significant near haul-out sites with substantial infestations of Atlantic smooth cordgrass in the vi-
cinity, such as Dumbarton Marsh, Mowry Slough, and Newark Slough. Methods that require re-
peated entry of field crews in the marsh would have the most significant impact, and could poten-
tially cause or contribute to mortality of pups or abandonment of a haul-out site. Mechanical
removal methods would also have significant impacts because of noise and duration of operations.
Disturbances from helicopter or ground applications of herbicides would be briefer, but still would
be significant, especially for pups.

Indirect contamination of waters or fish by glyphosate/surfactant solutions applied to cordgrass
probably would not have acute or chronic adverse toxic effects on seals, since reported mammalian
toxicity of glyphosate is generally very low, and dispersal of spray would require transport by turbid
bay water, which inactivates glyphosate. Concentrations of surfactants diluted by transport in tidal
water from marsh to sloughs would probably be well below levels that could cause sensitive reac-
tions to seals. Atlantic smooth cordgrass infestations near the Mowry/Dumbarton marshes are
discrete colonies, and would not involve mass loading of the intertidal zone with spray. Accidental
tank spills of solution from boats or barges transporting spray mixes to field crews could cause
significant acute skin and eye irritation from surfactant concentrations, affecting seals following boats, a common behavior.

As described in the General Impacts of proposed treatment methods, harbor seals also could be exposed to elevated levels of mercury from project dredging. This impact is less than significant because concentration in fish prey would not exceed background levels. These impacts are significant and mitigable.

**MITIGATION BIO-4.2:** Vehicle and foot access pathways in marsh within 1,000 feet of seal haul-outs shall be minimized, and approaching haul-outs within 2,000 feet, or any distance that elicits vigilance behavior when pups are present shall be avoided. Marine mammal experts shall be consulted to determine seasonal variation in sensitivity to disturbance. Equipment working in marsh shall be restricted to prescribed paths. Optimal combinations of treatment shall be used to minimize repeat entry to marsh and re-treatment (e.g. mowing or burning followed by spot-application of herbicide to low densities of survivors). Treatment combinations that minimize the need for re-entry of the vicinity of the haul-out shall be used. Low-flying aerial spray helicopters shall be prohibited within 2,000 feet of seal haul-outs. Spray tanks containing pre-mixed solutions of herbicide shall be transported in impact-resistant sealed containers to prevent accidental tank rupture during transport or loading/unloading. In case of herbicide/surfactant solution spill, small volumes of spilled solutions on mudflats shall be remediated to the greatest extent feasible by suction of surface muds, using portable wet vacuum, or pumping equipment.

**IMPACT BIO-4.3:** Effects on the southern sea otter

Invasive cordgrass eradication operations would be highly unlikely to have any direct effect on sea otters, which are vagrants, not residents, of San Francisco Bay, and remain largely in subtidal waters.

*Mitigation Measures:* None required.

**IMPACT BIO-5:** Effects on special-status bird species

**IMPACT BIO-5.1:** Effects on the California clapper rail

In addition to possible impacts described in Impact BIO-3, above, eradication of invasive non-native cordgrass would have unavoidable significant short-term adverse effects on California clapper rails, and potential long-term beneficial effects.

Clapper rails have been reported to nest in young, tall, vigorous stands of Atlantic smooth cordgrass and its hybrids, and at relatively high nest densities in some areas. When Atlantic smooth cordgrass stands are taller than adjacent cordgrass and other vegetation, they are likely to attract clapper rails seeking cover during high tides, when shorter vegetation (including native cordgrass and other species) provide less cover. Where Atlantic smooth cordgrass and hybrids dominate whole marshes or large tracts, such as Cogswell Marsh, Alameda Flood Control Channel or the Whale’s Tail marsh mitigation site (Hayward shoreline), eradication would result in significant adverse impacts to individual rails and the viability of their local populations. Even in marshes where smaller Atlantic smooth cordgrass colonies occur, eradication operations ranging from manual work by field crews to mechanized removal would disturb rails, risk nest destruction or abandonment, or abandonment of home ranges. Clapper rails may also nest in isolated, discrete colonies of Atlantic smooth cordgrass and hybrids. All eradication methods that result in destruction of rail-occupied stands of Atlantic smooth cordgrass would ultimately suffer the same significant impact.
This impact cannot readily be mitigated by incremental, phased projects within an infested marsh, because such phasing would defeat the basic objective of non-native cordgrass eradication: phasing (piecemeal eradication) would be equally ineffective at preventing re-invasion by locally dominant non-native cordgrass. If eradication caused complete local extinction of any clapper rail sub-population, this would be a significant long-term adverse effect as well. Local sub-population extinction distributes the risk of species extinction more heavily on remaining populations, which have independent risks of population failure at different sites. Therefore, invasive cordgrass eradication operations would result in unavoidable adverse impacts to California clapper rails.

Direct toxicity of herbicide and surfactant applications is unlikely to have significant adverse impacts to clapper rails inhabiting stands treated by field crews on the ground. Clapper rails would likely be displaced from areas disturbed by field crew activities, and would flee treatment sites before or during operations, thus avoiding exposure to spray. Helicopter applications of glyphosate/surfactant solutions may result in drift and coverage where clapper rails are present, however toxicity of the drift is low. Rails fleeing treatment sites may be subject to increased predation risks, and surviving rails that disperse would risk significant reduction in reproductive success for the current year.

As discussed in General Impacts of Proposed Treatment Methods, dredging or excavating to remove cordgrass could expose buried sediments with higher levels or more biologically available forms of mercury (methylmercury). Mercury contamination is a concern for clapper rail reproduction, and elevated levels of mercury are related to embryo mortality of clapper rail eggs in the San Francisco Bay (USFWS, unpub. data). Clapper rails, like other animals, are exposed to mercury through foods they consume. Clapper rails feed within and at the edges of cordgrass stands in tidal creeks or marsh edges, and do not stray far into open mudflats, where they would be vulnerable to predators. The risk of clapper rail exposure to possible mercury-contaminated sediments due to dredging or excavating cordgrass colonies on mudflats would be extremely minimal, because the activity would remove suitable rail foraging habitat, and thus prevent exposure from feeding. Dredged/excavated areas restored to pickleweed, open mudflat, or unvegetated channel bank would be unlikely to affect mercury exposure to clapper rails, since these are not areas where these birds typically forage. Excavated areas restored to native Pacific cordgrass would accrete new sediment from ambient (background) sources, and would then not be a risk for foraging birds.

**MITIGATION BIO-5.1:** Although some project impacts on clapper rails cannot be reduced to less than significant levels, the following measures shall be implemented to reduce project impacts as much as possible. This EIS/R includes Best Management Practices for reducing project impacts to California clapper rails in Appendix G. These clapper rail mitigation requirements may be modiﬁed by the US Fish and Wildlife Service in its Biological Opinion.

Treatment projects shall be planned to avoid disturbance outside of treatment areas. Access routes for personnel and equipment shall conform to avoidance protocols. Treatment in occupied clapper rail habitat shall be conducted outside of the clapper rail breeding season. Avoidance measures shall be based on current survey and map data.

For unavoidable significant impacts to clapper rails, compensatory mitigation shall address loss of individuals, population reproductive potential, and population viability (resilience or probability of persistence following perturbations) at both local and regional scales. Compensatory mitigation is based on enhancing or restoring habitat, populations, or reproductive success in the larger regional population.
One method for increasing breeding success in California clapper rail populations offsite (outside of eradication project areas) is to apply rigorous predator population controls to areas invaded by non-native predators such as red fox and Norway rats. Habitat modifications that enhance shelter from predators during high tides, such as replacing annual weeds with tall, native perennial salt marsh edge vegetation, and increasing adult survivorship has a large, positive effect on breeding success: clapper rails are prolific breeders when adult survival is high.

Where tidal marsh can be restored near occupied proposed treatment sites without becoming significantly invaded by additional non-native cordgrass (i.e. where invasion pressures and seed sources are minimal), alternative rail habitat shall be enhanced or restored in advance of eradication operations. Rails affected by eradication operations may be allowed to disperse into newly provided habitat, or if necessary they could be experimentally translocated to suitable alternative habitat, if required by the U.S. Fish and Wildlife Service and California Department of Fish and Game. Where large blocks of habitat are proposed for eradication work, compensatory mitigation for clapper rails must be planned and implemented at larger regional scales. A potentially feasible regional compensation strategy would be to establish accelerated, large-scale clapper rail habitat restoration in the nearest subregion of the Estuary that is subject to minimal invasion pressure from non-native cordgrass. High-impact, large-scale eradication projects would be phased to coincide with or follow successful establishment of viable clapper rail populations of sufficient size in new “rail refuges.” All compensation strategies would be at the discretion of the U.S. Fish and Wildlife Service and California Department of Fish and Game, to be determined by formal consultation.

All dredging proposals would require individual authorization and review by the Dredge Materials Management Office, a multi-agency panel of regulatory agencies (Corps of Engineers, Regional Water Quality Control Board, BCDC, EPA). Sediment screening criteria for contaminants of sediments placed in wetlands, and more recent criteria from the California Toxics Rule, would be used to evaluate sediment samples from proposed cordgrass dredge sites. In addition, the U.S. Fish and Wildlife Service would review and regulate dredging in clapper rail habitat through formal endangered species consultation. These stringent reviews and subsequent authorizations would prevent dredging in areas of excessive contaminant mobilization risk, and reduce the risk of mercury and other contaminant impacts to clapper rails to less than significant levels.

**IMPACT BIO-5.2: Effects on the California black rail**

California black rails would be much less likely to be affected by invasive cordgrass eradication operations because of their geographic and habitat distribution in relation to the current and predicted distribution of invasive cordgrass populations. Black rails are effectively extirpated in San Francisco Bay, and are most frequent in Suisun Marsh and brackish northern San Pablo Bay. Black rails are likely to occur in Southampton Marsh, Benicia, where salt-meadow cordgrass is proposed for eradication. Eradication of salt-meadow cordgrass would not likely displace black rail habitat, since black rails utilize mixed pickleweed vegetation and tall emergent channel vegetation, not dense matted turfs formed by this species. Eradication operations may disturb black rails, and devegetated patches may temporarily degrade habitat quality for black rails where treatment areas occur near tidal creek banks. Any further spread of invasive cordgrasses into black rail habitat is likely to be limited to new detections of small, pioneer colonies. Eradication of small pioneer cordgrass plants or colonies would have minor, localized impacts to black rails. Some unavoidable incidental impacts to black rails may occur as a result of field crews entering black rail home ranges. Therefore, impacts to black rails are considered significant and unavoidable.
MITIGATION BIO-5.2: Protocols for minimization and avoidance of California clapper rails (Appendix G) for work in infested marshes known to support populations of California black rails (currently one: Southampton Marsh, Benicia) shall be adopted, emphasizing pre-project surveys (call detection), minimization of marsh disturbance (Mitigation BIO-1.2), and occupied habitat shall be avoided during the breeding season. In treatment areas within 15 feet of tidal creek banks at Southampton Marsh, treated areas shall be replanted with local gumplant, saltgrass, and pickleweed in the following spring to hasten growth of improved cover for black rails.

IMPACT BIO-5.3: Effects on tidal marsh song sparrow subspecies and the salt marsh common yellowthroat

Resident song sparrow subspecies, particularly the Alameda song sparrow of San Francisco Bay, may suffer short-term adverse impacts by invasive cordgrass eradication operations. Impacts would result from general marsh disturbances by field crews, vehicles and equipment in nesting and feeding areas, as for clapper rails and black rails. Inadvertent nest destruction by vehicles and crews is also a risk. Cordgrass removal also would directly eliminate sources of insects on which song sparrows feed, although cordgrass vegetation is not generally primary foraging habitat for song sparrows. Song sparrows and salt marsh common yellowthroats may be exposed to glyphosate and surfactants by feeding on insects exposed directly to sprays. However, this exposure is not likely to result in significant impacts due to the low toxicity of glyphosate herbicide solutions to birds. Overall impacts to this species are significant and mitigable.

MITIGATION BIO-5.3: Adapt protocols for minimization and avoidance of California clapper rails (Appendix G) for work in infested marshes known to support populations of Alameda song sparrows, San Pablo song sparrows, Suisun song sparrow, and the salt marsh common yellowthroat, emphasizing pre-project surveys, minimization of marsh disturbance (Mitigation BIO-1.2), and avoidance of occupied habitat during the breeding season.

IMPACT BIO-5.4: Effects on western snowy plovers and California least terns

Habitats of western snowy plovers usually would not be directly affected by invasive cordgrass eradication operations, since the species is largely confined to emergent salt pond beds behind dikes in this region. If eradication project sites are accessed by levees that pass through snowy plover nest sites, nests on levee tops could be destroyed.

Most eradication operations applied to Atlantic smooth cordgrass in mudflats would occur during low tides, and would not affect nesting, roosting, or feeding habitats of Californian least terns. Upon re-submergence at high tide, mudflat eradication sites may resume as foraging habitat for least terns. Mechanical excavation or surface-disturbing eradication methods may locally increase surface sediment mobility and local turbidity during rising tides, and could reduce visibility of prey fish of least terns. This would be a localized, temporary, moderate impact. Incidental exposure of California least terns to glyphosate herbicide solution spray residues through fish is unlikely because of strong dilution and dispersion in high-energy tidal mudflat environments, rapid inactivation degradation, and low bioaccumulation potential.

If large stands of Atlantic smooth cordgrass were eradicated by temporary impoundments, shallow saline ponds formed would provide possible minor foraging habitat for least terns, but this is less likely than habitat benefits for dabbling ducks, wading birds, and bay ducks.

If large stands of Atlantic smooth cordgrass were eradicated by dredging adjacent to navigable channels, turbidity impacts could affect feeding of least terns. This would depend on tidal stage:
3.3 Biological Resources

dredging very shallow intertidal areas would have less turbidity impact than dredging subtidal bottoms. Turbidity increases can attract terns by forcing small fish to the surface, or they can interfere with feeding by reducing water clarity and prey fish visibility. In any case, potential turbidity effects from cordgrass dredging or excavation would have moderate impacts on least terns. Overall project impacts on California least terns and western snowy plovers are significant but mitigable.

**MITIGATION BIO-5.4:** Prior to levee access in areas where snowy plovers may breed, levee routes shall be surveyed for potential nests, including nests in salt pond beds near levee roads. Dredging and excavation of cordgrass shall be conducted either after least terns have migrated out of San Francisco Bay, or during middle to lower tidal stages that allow navigation of barge and crane operations, while exposing the maximum extent of cordgrass above standing tides.

**IMPACT BIO-5.5:** Effects of regional invasive cordgrass eradication on raptors (birds of prey)

Some eradication operations may affect raptors, including northern harriers, short-eared owls, white-tailed kites, and black-shouldered kites. Low-flying helicopters used in aerial spray application of glyphosate herbicide solutions may interfere with raptor foraging or nesting. This impact would be less likely for operations on tidal mudflats or low marshes, because raptors forage in tidal marshes mainly over higher marsh plains that support small mammals. Helicopter disruption of foraging would be very short-term (only up to a few hours) and not significant (Granholm, pers. com.) Raptors may ingest small mammals or birds that have been sprayed with herbicide solutions. This is not expected to be a significant impact due to the limited occurrences of spraying and low toxicity of the solutions to birds. Disruption of nesting, however, may be significant if adults are scared away and unable to tend eggs and young. Harriers, owls, and kites frequently nest in or adjacent to the upper marsh edge.

**MITIGATION BIO-5.5:** Use of helicopters to apply glyphosate herbicide solution in mid- and upper-marsh plains shall be minimized during raptor nesting season. If helicopters are used at these locations during the nesting season, a survey for raptors shall be performed by a qualified biologist, and any identified nests shall be provided a buffer of at least 500 feet from spray helicopters.

**IMPACT BIO-6:** Effects on estuarine fish species

**IMPACT BIO-6.1:** Effects on anadromous salmonids (winter-run and spring-run Chinook salmon, steelhead)

Chinook salmon and steelhead juveniles and adults may pass through low marsh, channel bank, and mudflat sites where invasive cordgrass eradication is performed. Most eradication methods occur at low tide, and would indirectly affect salmon and steelhead during later flood tidal stages when contact is possible. Only dredging methods performed at higher tidal stages could have direct impacts to passing salmon and steelhead through exposure to elevated turbidity, depressed dissolved oxygen levels, and mobilization of toxic sulfides. Dredging or excavation of target cordgrass stands when they are emergent (mid to low tide) would have minimal indirect effects on salmonids. These effects would be related to suspension of anoxic subsurface muds from intertidal dredge sites to tidal channels, which would involve less exposure than subtidal dredging used in navigational dredging projects. Excavation of small channels in the marsh plain would occur at low tide, and would have minor impacts to fish. Dredging impacts in larger channels could occur in few locations infested with Atlantic smooth cordgrass, but could be significant for listed salmonids.
Eradication methods based on impoundment and chronic flooding (drowning) of cordgrass would carry risks of entrapment of Chinook salmon and steelhead. This method would potentially apply mainly to Atlantic smooth cordgrass in San Francisco Bay. Entrapment impacts could be similar to those routinely practiced for salt pond intakes, without fish screens, for the last century. Entrapment impacts of this type would occur in the case of large tidally restored diked salt marshes refitted with new tidegates and intake invert elevations near mean low water. The cumulative impact of such intakes would be minimized by the proposed reduction in salt production by the region’s sole industrial salt producer. Entrapment impacts would lower for small, shallow impoundments that are flooded by a combination of extreme high tides that overtop both the marsh plain and berm or dam crest, and rainfall. Total entrapment impacts caused by impoundments used for cordgrass eradication, even if used commonly (which is not likely because of cost and feasibility constraints), would be minor compared with the large number of unscreened intakes in Suisun Marsh (over 100 in this subregion alone), and the Napa-Sonoma Marshes, where Chinook salmon are likely to be more frequent than in San Francisco Bay.

Applications of glyphosate/surfactant solutions to marsh and mudflat surfaces may result in low-level exposure of Chinook salmon and steelhead to toxic effects during subsequent tidal reflooding. Spray solution concentrations of glyphosate and surfactants may be moderately toxic to salmonids, but effective exposure would dilute spray solution with bay water. Exposure even in “worst case”, maximum exposure conditions during the first tidal reflooding following application is unlikely to have toxic effects because of rapid, strong dilution in turbulent tidal currents, rapid and thorough inactivation of glyphosate in high concentrations of suspended fine sediment, low inherent toxicity of glyphosate to fish, and the likelihood of very brief exposure times. Steelhead and Chinook salmon are not bottom feeders, so their feeding behavior would minimize rather than magnify their potential exposure to residual spray-contaminated sediment concentrated on the submerged mudflat surface. Accidental spills of glyphosate/surfactant solutions on mudflats would cause greater local concentration and higher levels of exposure. Overall project impacts on anadromous salmonids are considered significant but mitigable.

**MITIGATION BIO-6.1:** Dredging of infested intertidal channels shall be limited to: (1) tidal stages when target areas are emerged above water level, and (2) during seasons when winter- and spring-run Chinook salmon and steelhead migration times minimize their risk of exposure at project sites, particularly juveniles. Water intakes for impoundments shall have intake elevations limited to tides above mean high water (extreme tides overtopping marsh plain) to minimize entrainment and trapping. Alternatively, fish screens shall be installed on any new tidegates used to impound and drown large cordgrass-infested marshes in former diked baylands. Herbicide methods shall be minimized or avoided near channels and mudflats during migration periods of winter-run and spring-run Chinook salmon and steelhead. Glyphosate/surfactant spray application requirements shall be minimized by pre-treating target cordgrass stands with mechanical methods that reduce cordgrass biomass and density, increase receptivity and coverage of spray, and increase mortality response to glyphosate. In case of herbicide/surfactant solution spill, small volumes of spilled solutions on mudflats shall be remediated to the greatest extent feasible by suction of surface muds, using portable wet vacuum or pumping equipment.

**IMPACT BIO-6.2:** Effects on delta smelt and Sacramento splittail

Delta smelt and Sacramento splittail occur in the San Francisco Estuary mostly in the Suisun Bay area and northern reaches of San Pablo Bay, where cordgrass eradication operations are likely to be few and small in scope for the foreseeable future. Splittail are known to have inhabited Coyote
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Creek, a tributary to San Francisco Bay, in the late 1800s, but were thought to be extirpated in the early 20th century (Aceituno, et. al. 1976). However, in 1983, splittail again were captured in Coyote Creek (Kinetic Labs, Inc., and L.W. Associates, 1987). These fish may have migrated to Coyote Creek during the high flows of Winter 1983 that created low salinity conditions in shallow waters throughout San Francisco Bay. The winters of 1995, 1997, and 1998 produced similar low-salinity conditions. No other records of splittail from Coyote Creek are known. No significant impacts for these species are expected. Minor, temporary impacts could occur at Southhampton Marsh, in the Carquinez Strait. Salt-meadow cordgrass here occurs only in the high marsh plain, so direct and indirect effects of cordgrass eradication work would have minimal contact with these species. Potential indirect effects of glyphosate/surfactant solutions would be negligible in high marsh, which is not submerged during September-October tides, when clapper rail non-breeding season would most likely allow such work to be performed.

MITIGATION BIO-6.2: For work in infested North Bay marshes where delta smelt or Sacramento splittail may occur (currently only Southhampton Marsh, Benicia), impoundment techniques shall be eliminated and spray drift near tidal creeks shall be minimized (Mitigations BIO-1.1, 1.2). Any intertidal excavation or dredging in tidal creeks shall be restricted to tidal stages when target areas are emerged above water level.

IMPACT BIO-6.3: Effects on the tidewater goby

No impacts are expected to occur to tidewater gobies in San Francisco Bay because they are not known to occur in intertidal mudflats or marsh tidal creeks in San Francisco Bay. All records of this species in the Estuary are old, and limited to the Central Bay. Even if they were present, impacts would be improbable for most of the same reasons pertinent to steelhead and Chinook salmon (see BIO-6.1).

Mitigation Measures: None required.

IMPACT BIO-6.4: Effects on estuarine fish populations of shallow submerged intertidal mudflats and channels.

Many estuarine fish feed in intertidal mudflats that may be exposed to glyphosate/surfactant solutions that may be moderately toxic to fish at applied concentrations. Bottom-feeding fish, which contact sediments to capture invertebrates on or below the mud surface, have relatively greater risk of exposure to glyphosate and surfactants in sediments. Exposure risks are offset by physiological inactivation of glyphosate upon contact (adsorption) with clay, silt, and organic matter, strong dilution effects in energetic, turbulent conditions of rising tides and wind-generated waves, and rapid resuspension of surface sediment in contact with spray. Mechanical disturbance of mudflat or channel surfaces may expose fish populations to elevated levels of mercury in the water column and in prey species. Although elevated, these levels would still be below those likely to adversely affect fish because of the limited and infrequent treatment occurrences, and low organic content (hence limited methylation potential) of exposed sediments.

Only dredging methods performed on target cordgrass stands at higher tidal stages could have direct impacts to estuarine fish by exposure to elevated turbidity, depressed dissolved oxygen levels, and mobilization of toxic sulfides. Dredging or excavation of target cordgrass stands when they are emergent (mid to low tide) would have minimal indirect effects on fish. These effects would be related to suspension of anoxic subsurface muds from intertidal dredge sites to tidal channels, which would involve less exposure than subtidal dredging used in navigational dredging projects. Excavation of small channels in the marsh plain would occur at low tide, and would have minor
3.3 Biological Resources

direct impacts to fish. Dredging impacts in larger channels could occur in few locations infested
with Atlantic smooth cordgrass, but could be significant for estuarine fish.

Impacts of eradication methods based on impoundment and chronic flooding (drowning) of cord-
grass to estuarine fish would be similar to those described above for anadromous salmonids. Total
entrapment impacts caused by impoundments used for cordgrass eradication, even if used com-
monly (which is not likely because of cost and feasibility constraints), would be minor.

MITIGATION BIO-6.4: Dredging of infested intertidal channels shall be limited to tidal stages
when target areas are emerged above water level, or appropriate measures shall be taken to isolate
the dredged area from adjacent Bay or channel waters. Herbicide methods shall be minimized near
channels. Glyphosate/surfactant spray application requirements shall be minimized by pre-treating
target cordgrass stands with mechanical methods that reduce cordgrass biomass and density, in-
crease receptivity and coverage of spray, and increase mortality response to glyphosate. In case of
herbicide/surfactant solution spill, small volumes of spilled solutions on mudflats shall be remedi-
ated to the greatest extent feasible by suction of surface muds, using portable wet vacuum or
pumping equipment.

IMPACT BIO-7: Effects on California red-legged frog and San Francisco garter snake

No impacts are expected to occur to California red-legged frogs or San Francisco garter snakes
from equipment staging, equipment mobilization, eradication operations, or indirect effects of
eradication. No suitable habitat (freshwater to fresh-brackish seasonal ponds, stream channels,
woody riparian vegetation with scour pools, or freshwater marshes) occur in tidal habitats where
eradication operations would occur, and adjacent areas used for access, staging, equipment mobili-
ization, etc. are typically dry saline levees, salt pods, urban developed lands, and flood control levees
far from suitable habitat. Terrestrial habitats in these areas also are unsuitable as aestivation (sum-
mer dormant state) habitat. Potential habitat areas are remote from potential sources of spray drift
in tidal habitats, and are sheltered by urban landscapes bordering the bay.

Mitigation Measures: None required.

IMPACT BIO-8: Effects on mosquito production

Control operations within mudflats and low marsh environments would have no effect on mos-
quito production, since these turbulent, dynamic environments do not support mosquito breeding.
Access to low marsh and creek sites of control work may require vehicles leaving tracks and ruts in
the marsh plain, like the “Argo” vehicles routinely used by mosquito abatement district personnel.
Local undrained marsh depressions in tracks can cause local increases in mosquito breeding habitat
and larval production. This would be a minor adverse impact. Conversely, the spread of Atlantic
smooth cordgrass in tidal marsh pans, or over wide marsh plains with poor drainage (see Geomor-
phology and Hydrology), would also be likely to produce mosquito breeding habitat at a larger
scale.

MITIGATION BIO-8: Access routes in marshes shall be monitored to detect formation of
undrained depressions in tire ruts or foot trails. Access-related shallow marsh depressions shall be
backfilled or incised with narrow drainages so they do not impound small, sheltered areas of
standing water. Where impoundments are used, impoundments shall be of sufficient size and
depth to minimize mosquito breeding habitat.

IMPACT BIO-9: Effects on tiger beetles species of estuarine habitats
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Eradication of existing Atlantic smooth cordgrass at sites of estuarine beaches and intertidal sand flats (mostly in the Central Bay) would restore sediment mobility, sparse vegetation, and beach dynamics. This would increase potential habitat for tiger beetle species with affinity for sand.

Mitigation Measures: None required.

ALTERNATIVE 2: Regional Eradication Using Only Non-Chemical Control Methods

Alternative 2 would involve proportionally greater extent and frequency of treatment methods that involve mechanical disturbance, use of vehicles in tidal marshes, disturbance of marsh wildlife by repeated re-entry for repeat-cropping methods, and impacts of dredging and excavation compared with Alternative 1. Potential effects of herbicide applications, including disturbance from helicopters, toxicity of surfactants, spray drift impacts to non-target vegetation, fish, and wildlife, would not occur. The time required to achieve a given unit of cordgrass reduction or eradication (acreage, population reduction, geographic area covered) would be substantially greater than with integrated, combined treatments that may include use of glyphosate. In particular, the duration of total treatment time and the number of repeat treatments needed to achieve complete mortality for any given target colony would increase, possibly over multiple years for large stands. Prolonged disturbance, and delayed recovery/restoration of marsh at treated sites, would extend impact duration and intensity, particularly for sensitive wildlife around project sites.

The overall slower pace of regional eradication would significantly increase the risk that the rapid and accelerating spread of Atlantic smooth cordgrass and its hybrid swarm would overwhelm the eradication program. The relatively small, slower-spreading populations of other invasive cordgrass species, however, could probably be eradicated by individual projects (though with some doubt about Chilean cordgrass). It is uncertain whether a regional eradication program for invasive cordgrasses in the San Francisco Estuary can avoid being overwhelmed by rates of invasion without integrating at least minimal use of glyphosate methods in local and regional eradication strategies. No successful regional invasive cordgrass programs in Britain, New Zealand, or the Pacific Northwest have excluded all use of herbicides. If population growth of Atlantic smooth cordgrass’ hybrids overtakes the rate of eradication, Alternative 2 would converge towards the same ecological endpoint as the no-action alternative.

ALTERNATIVE 3: No Action – Continued Limited, Regionally Uncoordinated Treatment

Short-term impacts of this alternative would be similar to those described for the treatment methods for Alternative 1, above, however these impacts would be less widespread due to the anticipated smaller areas to be treated under this alternative.

As described in Section 3.1, Geomorphology and Hydrology likely future scenarios of cordgrass invasion are variable and can best be viewed as alternative scenarios more or less likely to occur in the San Francisco Estuary. The most optimistic scenario is one under which species that have been relatively slow to spread from established sites will continue to be poor long-distance invaders. As described in Section 3.1, the optimistic scenario cannot be ruled out, but appears relatively unlikely. Another relatively optimistic scenario would be that the invasive cordgrass species in this region can be confined to the San Francisco Estuary, and controlled by long-term maintenance (weeding) of existing infested marshes, short of regional eradication. As described in Section 3.1, this scenario also is unlikely. A less optimistic, and more likely, scenario is that Atlantic smooth cordgrass progressively dominates the San Francisco estuary. As described in Section 3.1, under this scenario, there is still much uncertainty about the likely future structure of intertidal habitats. If sea level rise continues to accelerate, while sediment supplies become more deficient, extensive low marsh cord-
grass meadows with ample tidal drainage may form, and this would tend to favor tall forms of Atlantic smooth cordgrass. If sedimentation in the San Francisco Estuary is able to keep pace with sea level rise, there is a greater chance that higher marsh plains, with defined drainage patterns, may form. This would increase the risk that smooth cordgrass would behave as it does in the southeastern Atlantic salt marshes, where it forms extensive single-species stands of stunted, short-form cordgrass marsh, and limits the development of small tidal creeks and pans (features typical of Pacific and northeastern Atlantic high salt marsh).

Although all of the scenarios described above are possible, this last scenario is considered the most likely scenario and represents a “reasonable worst case”. As described in Section 2.2.3, Alternatives Description, Alternative 3, selective removal of non-native cordgrass at restoration sites would probably cease when monitoring confirms that no native cordgrass is recruited, and all spontaneous recruits are invasive species, even when natives are planted. Eradication for flood control purposes, however, may continue locally in perpetuity.

If “short-form” Atlantic smooth cordgrass salt marsh establish and spread over time, significant habitat and species population changes would occur.

The most important ecological effect of regional invasive cordgrass eradication on shorebirds and waterfowl would be long-term. This would result from protection and restoration of prime mudflat feeding areas for the Pacific Flyway, which are invaded by Atlantic smooth cordgrass and its hybrids and converted to habitat types that shorebirds and waterfowl cannot use for feeding. A less obvious but important indirect long-term effect would be avoidance of massive cordgrass (tidal litter) production, which would routinely affect tidegate (water intake) operations for managed wetlands, choking them with debris, reducing efficiency, increasing maintenance costs, and elevating risks of recurrent short-term problems with species-sensitive water level management, and water quality. Eradication methods based on impoundment of shallow water (drowning cordgrass) would have short-term, moderately beneficial impacts on dabbling ducks, bay ducks, herons, and larger egrets, by providing shallow, low-turbidity ponds similar to salt intake ponds. These would support feeding habitat and high tide roosts. Shorebirds may roost on temporary berms or inflatable dams that impound water, but water depths would exclude shorebirds.

The density and distribution of California clapper rails would be radically altered compared with both natural and modern tidal marsh conditions. Large new or restored marshes formed under the influence of Atlantic smooth cordgrass in future decades may have significantly less habitat value for California clapper rails than native marshes. Atlantic subspecies of clapper rails scarcely occupy the vast plains of short-form Atlantic smooth cordgrass and nest almost exclusively in tall-form cordgrass along tidal creek banks and marsh edges (Meanley 1985). This suggests that clapper rails in the San Francisco Estuary may be “marginalized” in typical Atlantic marsh structure. Future marsh structure and vegetation structure are critical issues for predicting the future status of California clapper rails in alternative cordgrass scenarios for San Francisco Bay, and these issues are speculative. In natural conditions of San Francisco Bay, clapper rails typically construct nests in pickleweed or gumplant vegetation, not cordgrass. It is uncertain whether Atlantic smooth cordgrass-dominated marshes which accrete to the elevation of Mean Higher High water will “release” marsh plains to pickleweed-mixture vegetation. The typical nesting behavior of California clapper rails may be affected by widespread persistence of cordgrass marsh in what would otherwise be tidal pickleweed marsh. Another long-term effect of invasive cordgrass would be the loss of suitable tidal marsh plain and creek habitats for California black rails.
Long-term adverse effects of spread of Atlantic smooth cordgrass infestations on snowy plovers include the loss of sand and shell beaches in San Francisco Bay. Beaches and sandy foreshores that provide transient roost or feeding habitats for snowy plovers moving between other Pacific coast locations would be lost. The potential for restored estuarine beaches that could potentially support breeding also would be lost.

Invasive cordgrass would adversely affect California least terns in the long term by eliminating intertidal mudflat habitat that is used for feeding at high tide.

Invasive cordgrass spread also would result in the loss of existing marsh plain habitat (most suitable habitat for small mammal prey of raptors).

The recovery of the endangered salt marsh harvest mouse in tidal marsh habitats, and California sea-blite in estuarine beach-marsh edges, would be either precluded or strongly constrained. Harbor seals could not access existing high marsh haul-out sites because they require access with close proximity to subtidal water, and established major seal haul-outs would be isolated and made inaccessible by wide, tall, cordgrass marsh.

An important general cumulative effect of invasive cordgrass spread, is the population growth interaction with region-wide tidal marsh restoration in the San Francisco Estuary, particularly San Francisco Bay. The location and timing of large-scale tidal marsh restoration projects can have an overwhelming effect on population growth of non-native cordgrass by combining source populations with large acreages of new habitat to invade.

All tidal salt marsh restoration in the San Francisco Estuary currently proposed would be either wholly dominated by Atlantic smooth cordgrass hybrids as they reach the low marsh stage of succession, or they would progressively become dominated by them. Extensive conversion of open mudflat to tidal marsh would occur in San Francisco Bay and San Pablo Bay, and gradients in remaining mudflats would steepen. Shorebird habitat in former mudflats would be reduced by displacement to cordgrass marsh (acreage not known, possibly over one-fourth of existing mudflats), and the quality of diked managed shorebird and waterfowl habitat may decline due to indirect effects of cordgrass dominance on water management (debris obstruction of intakes, infilling of intake channels). The recovery of special-status plant species would be impaired by significant increases in frequency, area, and mass of wrack deposition in the high marsh, and altered marsh hydrology. The elimination of Chilean cordgrass and salt-meadow cordgrass in the North Bay and Suisun Marsh would contribute to the recovery of endangered Suisun thistle and soft bird’s beak, and the conservation of northern salt marsh bird’s-beak, salt marsh owl’s-clover, Bolander’s spotted water-hemlock, and Mason’s lilaeopsis, and other species in regional decline. Reduction in the extent and size of highly branched, irregular tidal channels within tidal marsh plains would significantly reduce important nursery and feeding habitat for fish, including endangered delta smelt, California splittail, and Chinook salmon runs, as well as other fish species using the Estuary.

Massive, matted cordgrass litter in the high marsh zone could be detrimental to tiger beetle habitat quality.

Mosquito production and subsequent required abatement activities would likely increase significantly.

As an indirect impact beyond the San Francisco Estuary, the expanded population of hybrid Atlantic smooth cordgrass would annually export large quantities of seed beyond the Golden Gate, and increase the rate of recruitment in highly vulnerable sandy estuaries of west Marin County, where the last refuge of “pure” Pacific cordgrass remains north of Point Conception (see Figure
3.3 Biological Resources

1-5). Similar impacts of invasion would occur there, but with greater significance for marine mammals, mariculture (oyster farms), and shorebirds. Sea otter habitat in Elkhorn Slough, Monterey County may indirectly affected by cordgrass spread. Net conversion of intertidal channels or mudflats to cordgrass marsh would adversely affect habitat availability for the sea otter in Elkhorn Slough.
### Table 3.3-1: Summary of Potential Biological Resources Effects

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<td><strong>BIO-1.1:</strong> Effects on tidal marsh plant communities affected by salt-meadow cord-grass and English cordgrass.</td>
<td>All Alternatives: Local, short-term minor adverse effects would be possible because of incidental trampling by crews.</td>
<td>All Alternatives: Minor to moderate adverse impacts could occur due to any damage from vehicles on mats, trampling of incidental vegetation.</td>
<td>Repeat mowing or smothering treatments would result in local but persistent trampling damage.</td>
<td>All Alternatives: Not applicable: method not feasible for existing infestation, generally infeasible for potential small infestations of this species; no adverse impact.</td>
<td>Alternative 2: No impact.</td>
<td>Alternative 2: No impact.</td>
<td>Alternative 3: Short-term benefits of continued uncoordinated control efforts; no long-term benefits.</td>
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<td>Alternatives 1 &amp; 2: Potential local, persistent (to 2-3 year), adverse impact due to spray drift effect on non-target emergent vegetation. Alternative 3: Significant long-term benefit.</td>
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<td>BIO-1.2: Effects on tidal marsh plant communities affected by Atlantic smooth cordgrass and its hybrids.</td>
<td>Alternative 1: Minor to moderate short-term local adverse impacts due to incidental trampling by crews. Alternative 2: Proportionally more use of this method than Alternative 1, greater impact, but not significantly. Alternative 3: Less regional use and impact than Alternatives 1 &amp; 2.</td>
<td>Alternative 1: Minor to moderate adverse effects if limited to isolated mudflat colonies: potentially significant adverse impacts if applied to extensive colonies within existing tidal marsh. Alternative 2: Proportionally more regional use of this method than Alternative 1, greater impact, potentially significant. Alternative 3: Less impact than Alternatives 1 &amp; 2.</td>
<td>Alternative 1: Minor adverse effects may occur if geotextile fabric is displaced and damages non-target vegetation. Repeat mowing or smothering treatments would result in local but persistent trampling damage. Alternative 2: Proportionally more use of this method than Alternative 1, greater impact, but not significant. Alternative 3: Less regional use of and impact of this method than Alternatives 1 &amp; 2.</td>
<td>Alternative 1: Potentially significant short-term (1-3 year) large-scale impacts due to non-selective eradication caused by impoundment of existing salt marsh vegetation. Alternative 2: Proportionally more use of this method than Alternative 1, greater impact. Alternative 3: Low or no impact if used.</td>
<td>Alternatives 1-3A: Local, short-term adverse impacts to tidal marsh vegetation marginal to burned areas; low potential for inadvertent spread of fire to in tidal marsh vegetation adjacent to smooth cordgrass. Limited potential for use. Alternative 3: No impact.</td>
<td>Alternatives 1, 3A: Local, moderately persistent adverse impacts of herbicide spray drift on tidal marsh vegetation adjacent to treated areas could occur from manual and normal helicopter application. Minimal non-target impacts to vegetation could occur from wick/brush applications. Significant adverse impacts could occur from worst-case helicopter spray drift. Alternative 2, Alternatives 1: Long-term benefit to regional tidal marsh communities due to arrest of invasion. Alternatives 2-3: Temporary local benefits from individual eradication projects; no long-term or significant benefits. Alternative 3: Short-term benefits of continued uncoordinated control efforts; no long-term benefits.</td>
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<td><strong>BIO-1.3: Effects on tidal marsh plant communities affected by Chilean cordgrass.</strong></td>
<td>Alternative 1: Minor to moderate adverse impacts due to incidental trampling by crews. Alternative 2: Proportionally greater use and impact of this method than Alternative 1, but not significant. Alternative 3A: Less trampling impact than Alternatives 1 &amp; 2.</td>
<td>All Alternatives: Unlikely methods for known infestations of this high salt marsh species. Local, short-term minor to moderate adverse impacts could occur because of damage from vehicles on mats, trampling.</td>
<td>Alternatives 1, 3A: Local, short-term minor adverse effects may occur if geotextile fabric is displaced and damages non-target vegetation. Repeat mowing or smothering treatments would result in local but persistent trampling damage. Alternative 2: Greater impact of this method than Alternative 1, but not significant.</td>
<td>All Alternatives: Not applicable: method not feasible for existing infestation, generally infeasible for potential small infestations of this species in the high salt marsh zone.</td>
<td>All Alternatives: Minor to moderate local and short-term adverse impacts due to marginal impacts to non-target salt marsh vegetation. Limited applicability of this method for known infestations.</td>
<td>Alternative 1: Minor to moderate short-term adverse impact due to spray drift from manual applications. Helicopter spray probably infeasible for known infestations of this species. Alternative 2: No impact.</td>
<td>Alternative 1: Probably fastest regional eradication, lowest risk of regional spread. Greatest significant long-term benefit. Alternatives 2, 3 Possibly slower but feasible regional eradication and arrested spread. Significant long-term benefit.</td>
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Table 3.3-1: Summary of Potential Biological Resources Effects

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<tr>
<td>BIO-1.4: Effects on submerged aquatic plant communities.</td>
<td>Alternative 1: No adverse impact. Alternatives 2 &amp; 3: No impact.</td>
<td>Alternative 1: No adverse impact. Alternatives 2 &amp; 3: No impact.</td>
<td>All Alternatives: minimal adverse impact. Leaf litter from mowing could raft on high tides and deposit in pans, causing one growing season of local wigeongrass dieback. Moderate to minor impact. Alternative 2: No impact.</td>
<td>All Alternatives: No adverse impact.</td>
<td>All Alternatives: No adverse impact.</td>
<td>All Alternatives: No adverse impact.</td>
<td>Alternatives 1-2: Short-term increases in habitat due to flooding (impoundment) methods in some cases, potentially significant benefits over life of regional program due to prevention of invasion by smooth cordgrass. Alternative 3: No long-term benefits.</td>
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<tr>
<td>BIO-2: Effects on special-status plants in tidal marshes.</td>
<td>Alternative 1: Local, short-term potentially significant impacts to soft-birds beak due to incidental trampling or disturbance, only with removal of known saltmeadow and Chilean cordgrass infestations. Alternative 2: Greater impact than Alternative 1. Alternative 3: Less impact than Alternative 1.</td>
<td>Alternative 1: Local, short-term potentially significant impacts to soft-birds beak due to incidental trampling or disturbance, only with removal of known saltmeadow and Chilean cordgrass infestations. Alternative 2: Greater impact than Alternative 1. Alternative 3: Less impact than Alternative 1.</td>
<td>Alternative 1: Local, short-term minor adverse effects may occur if geotextile fabric (smothering) is displaced and damages soft birds-beak populations. Repeat mowing treatments would result in local but persistent trampling damage; only with removal of known saltmeadow and Chilean cordgrass infestations. Alternative 2: Greater impact than Alternative 1. Alternative 3: Less impact than Alternative 1.</td>
<td>All Alternatives: This method is unlikely to be applied to any habitats supporting special-status plants (smooth cordgrass only); no impact.</td>
<td>Alternative 1: Potentially significant adverse impacts to soft birds-beak, only with removal of known saltmeadow and Chilean cordgrass infestations. (less than significant with mitigation). Alternative 2: No impact. Alternative 3: Less impact than Alternative 1.</td>
<td>Alternative 1: Pacific cordgrass likely to avoid regional extinction; California sea-blite recovery feasibility increased; threats reduced for other rare species; all significant long-term benefits. Alternatives 2, 3: short- to moderate-term benefits, probably no long-term benefits.</td>
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<th>Beneficial Effects</th>
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<tbody>
<tr>
<td>BIO-4.1: Effects on the salt marsh harvest mouse and tidal marsh shrew species.</td>
<td>Alternative 1: Eradication of non-native cordgrass in high marsh may have significant short-term adverse impacts in few locations, but usually minor or none. Local, short-term minor impacts due to incidental trampling or disturbance. Alternative 2: Greater impact than Alternative 1. Alternative 3: Less impact than Alternative 1.</td>
<td>Alternative 1: Eradication of non-native cordgrass in high marsh may have significant short-term adverse impacts in few locations, but usually minor or none. Local, short-term minor impacts due to incidental trampling or disturbance.</td>
<td>Alternative 1: Method probably not applicable to high marsh habitat of small tidal marsh mammal species; minor impacts of feasible applications. Alternative 2: Proportionally greater, but not significant impacts than Alternative 1. Alternative 3: Method probably infeasible without regionally coordinated mitigation for scale of wildlife impacts; low or no adverse impact if used.</td>
<td>Alternative 1: Eradication of non-native cordgrass in high marsh may have significant short-term adverse impacts in few locations, but usually minor or none. Local, short-term minor impacts due to incidental trampling or disturbance.</td>
<td>Alternative 1: No impact.</td>
<td>Alternative 2: Temporary local benefits from individual eradication projects, not long-term or significant (invasion likely to overtake eradication).</td>
<td>Alternative 1: Probable long-term, widespread cumulative benefit due to arrest of invasions by non-native cordgrass, protection of habitat. Significant long-term benefit. Alternatives 2, 3: Temporary local benefits from individual eradication projects, not long-term or significant (invasion likely to overtake eradication).</td>
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<tbody>
<tr>
<td>BIO-4.2: Effects on resident harbor seal colonies of San Francisco Bay.</td>
<td>Alternative 1: Short-term, local disturbance of harbor seals in vicinity of a few access and treatment areas. Potentially significant adverse impacts at a few potential project sites, minor or no impacts at most project sites.</td>
<td>Alternative 1: Short-term, local disturbance of harbor seals in vicinity of a few access and treatment areas. Potentially significant adverse impacts at a few potential project sites, minor or no impacts at most project sites.</td>
<td>Alternative 1: Short-term, local disturbance of harbor seals in vicinity of a few access and treatment areas. Potentially significant adverse impact. Minor or no impacts at most project sites.</td>
<td>Alternative 1: Short-term, local disturbance of harbor seals in vicinity of a few access and treatment areas. Potentially significant adverse impact. Minor or no impacts at most project sites.</td>
<td>Alternative 1: Short-term, local disturbance of harbor seals in vicinity of a few access and treatment areas. Potentially significant adverse impact. Minor or no impacts at most project sites.</td>
<td>Alternative 1: No impact.</td>
<td>Alternative 1: Long-term stabilization of existing haul-out habitats by preventing isolation from encroaching smooth cordgrass. Significant benefit, especially for Mowry Slough and other south San Francisco Bay colonies.</td>
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<tr>
<td>BIO-4.3: Effects on the southern sea otter.</td>
<td>All alternatives: Negligible or no impact.</td>
<td>All alternatives: Negligible or no impact.</td>
<td>All alternatives: Negligible or no impact.</td>
<td>All alternatives: Negligible or no impact.</td>
<td>All alternatives: Negligible or no impact.</td>
<td>All alternatives: Negligible or no impact.</td>
<td>Long-term reduction of risk that important habitat in Elkhorn Slough will be invaded by pioneers of smooth cordgrass from San Francisco Bay.</td>
</tr>
<tr>
<td>BIO-5.1: Effects on California clapper rail.</td>
<td>All Alternatives. Potentially significant disturbance of clapper rail foraging, mating, nesting, due to treatment activity, resulting habitat destruction, and crew access to rail habitats. Local loss of breeding; risk of mortality. Order of severity: 2 (greatest), 1, 3.</td>
<td>All Alternatives. Potentially significant disturbance of clapper rail foraging, mating, nesting, due to treatment activity, resulting habitat destruction, and crew access to rail habitats. Local loss of breeding; risk of mortality. Order of severity: 2 (greatest), 1, 3.</td>
<td>All Alternatives. Potentially significant disturbance of clapper rail foraging, mating, nesting, due to treatment activity, resulting habitat destruction, and crew access to rail habitats. Local loss of breeding; risk of mortality. Greater severity for Alternative 2.</td>
<td>All Alternatives. Potentially significant disturbance of clapper rail foraging, mating, nesting, due to treatment activity, resulting habitat destruction, and crew access to rail habitats. Local loss of breeding; risk of mortality. Greater severity for Alternatives 1 &amp; 2.</td>
<td>Alternatives 1, 3. Potentially significant disturbance of clapper rail foraging, mating, nesting, due to treatment activity, resulting habitat destruction, and crew access to rail habitats. Local loss of breeding; risk of mortality. Greater severity for Alternative 1. Alternative 2: No impact.</td>
<td>Alternative 1: Long-term protection and restoration of typical tidal creek and marsh habitat structure to which the subspecies is adapted. Alternatives 2, 3: Delayed loss of typical habitat structure, eventual significant net expansion of suitable habitat of uncertain long-term stability.</td>
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<tr>
<td>BIO-5.2: Effects on the California black rail.</td>
<td>All Alternatives: Potentially significant impact foreseeable only at one site; no impacts in San Francisco Bay.</td>
<td>All Alternatives: Potentially significant impact foreseeable only at one site; no impacts in San Francisco Bay.</td>
<td>All Alternatives: Method probably inapplicable to existing or foreseeable San Pablo Bay infestations; no impacts in San Francisco Bay.</td>
<td>All Alternatives: Method probably inapplicable to existing or foreseeable San Pablo Bay infestations; no impacts in San Francisco Bay.</td>
<td>All Alternatives: Potentially significant impact foreseeable only at one site; no impacts in San Francisco Bay.</td>
<td>All Alternatives: Potentially significant impact foreseeable only at one site; no impacts in San Francisco Bay.</td>
<td>Alternative 1: Probable long-term, widespread cumulative benefit due to arrest of invasions by non-native cordgrass, protection of habitat. Significant long-term benefit. Alternatives 2-3: No long-term benefits (invasion likely to overtake eradication).</td>
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<tr>
<td>BIO-5.3: Effects on tidal marsh song sparrow subspecies and the salt marsh common yellowthroat.</td>
<td>All Alternatives: Potentially significant disturbance of foraging, mating, nesting, due to treatment activity, resulting habitat destruction, and crew access to habitats. Local loss of breeding; risk of mortality. Order of severity: 2 (greatest), 1, 3.</td>
<td>All Alternatives: Potentially significant disturbance of foraging, mating, nesting, due to treatment activity, resulting habitat destruction, and crew access to habitats. Local loss of breeding; risk of mortality. Order of severity: 2 (greatest), 1, 3A.</td>
<td>All Alternatives: Potentially significant disturbance of foraging, mating, nesting, due to treatment activity, resulting habitat destruction, and crew access to habitats. Local loss of breeding; risk of mortality. Order of severity: 2 (greatest), 1, 3A.</td>
<td>All Alternatives: Potentially significant disturbance of foraging, mating, nesting, due to treatment activity, resulting habitat destruction, and crew access to habitats. Local loss of breeding; risk of mortality. Order of severity: 2 (greatest), 1, 3A.</td>
<td>All Alternatives: Potentially significant disturbance of foraging, mating, nesting, due to treatment activity, resulting habitat destruction, and crew access to habitats. Local loss of breeding; risk of mortality. Order of severity: 2 (greatest), 1, 3A.</td>
<td>Alternative 1: Long-term protection and restoration of typical tidal creek edge and marsh plain-habitat structure to which these subspecies are adapted. Alternatives 2, 3: delayed loss of typical habitat structure, no long-term benefit.</td>
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<tr>
<td>Alternative 1: Long-term protection and restoration of typical tidal creek edge and marsh plain-habitat structure to which these subspecies are adapted.</td>
<td>Alternative 2: No impact.</td>
<td>Alternative 3: Potentially significant adverse impact if used.</td>
<td>Alternative 1: Long-term protection and restoration of typical tidal creek edge and marsh plain-habitat structure to which these subspecies are adapted.</td>
<td>Alternative 2: No impact.</td>
<td>Alternative 3: Potentially significant adverse impact if used.</td>
<td>Alternative 1: Long-term protection and restoration of typical tidal creek edge and marsh plain-habitat structure to which these subspecies are adapted.</td>
<td>Alternative 2: No impact.</td>
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<tr>
<td>BIO-5.4: Effects on California least terns and western snowy plovers.</td>
<td>Alternative 1: Potentially significant local adverse impacts to levee nest sites due to vehicle access.</td>
<td>Alternative 1: Potentially significant local adverse impacts to levee nest sites due to vehicle access.</td>
<td>Alternative 1: Potentially significant local adverse impacts to levee nest sites due to vehicle access.</td>
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<td>Alternative 1: Potentially significant local adverse impacts to levee nest sites due to vehicle access.</td>
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<td>Alternative 3: If used, impacts may be significant at a few potential project sites, but minor or no impacts at most sites.</td>
<td>Alternative 3: If used, impacts may be significant at a few potential project sites, but minor or no impacts at most sites.</td>
<td>Alternative 3: If used, impacts may be significant at a few potential project sites, but minor or no impacts at most sites.</td>
<td>Alternative 3: If used, impacts may be significant at a few potential project sites, but minor or no impacts at most sites.</td>
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<td>Alternative 3: If used, impacts may be significant at a few potential project sites, but minor or no impacts at most sites.</td>
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Alternatives 1, 2: Long-term moderate potential benefits for additional restored estuarine beach habitats, avoidance of salt pond intake obstruction by massive cordgrass wracks. Alternative 3: Short-term benefits, no long-term benefits.
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<tr>
<td>BIO-5.5: Effects on raptors (birds of prey).</td>
<td>All alternatives: minor short-term or no impact.</td>
<td>All alternatives: minor short-term or no impact.</td>
<td>All alternatives: minor short-term or no impact.</td>
<td>All alternatives: minor short-term or no impact.</td>
<td>All alternatives: minor short-term or no impact.</td>
<td>Alternatives 1, 3: Moderate adverse impacts if helicopters are used, otherwise minor short-term impacts.</td>
<td>Alternative 1: Long-term protection and restoration of typical tidal creek edge and marsh plain-habitat structure to which these subspecies are adapted. Moderate to significant benefit of stabilizing pickleweed-dominated marsh plains. Alternatives 2, 3: Delayed loss of typical habitat structure, no long-term benefits.</td>
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<tr>
<td>BIO-6.1: Effects on anadromous salmonids (winter-run and spring-run Chinook salmon, steelhead).</td>
<td>All Alternatives: minor short-term impact or none.</td>
<td>Alternative 1: Potential minor to moderate adverse impacts of dredging in tidal creeks or channels at low tide, due to elevated turbidity, dissolved sulfides, reduced dissolved oxygen; South Bay only. Alternative 2: Impacts greater than Alternative 1, but less than significant. Alternative 3: Similar to Alternative 1, less impact.</td>
<td>All Alternatives: minor short-term impact or none.</td>
<td>Alternative 1: Minor to moderate potential entrainment and trapping impact within impounded areas, less than ongoing salt pond operations in region; South Bay only. Alternative 2: Impacts greater than Alternative 1, but less than significant.</td>
<td>All Alternatives: minor short-term impact or none.</td>
<td>Alternative 1: Minor to moderate impact due to potential exposure of fish to tidally remobilized herbicide spray solution containing surfactants. Alternative 2: No impact. Alternative 3: Less impact than Alternative 1.</td>
<td>Alternative 1: Long-term stabilization and restoration of natural tidal creek structure and high density of small tidal creeks due to arrested spread of smooth cordgrass, protection of favorable habitat. Alternatives 2, 3: Delayed degradation of tidal creek habitat quality and abundance, no long-term benefit.</td>
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<tr>
<td>BIO-6.2: Effects on delta smelt and Sacramento splittail.</td>
<td>All Alternatives: Minor short-term impact or none.</td>
<td>All Alternatives: Minor short-term impact or none.</td>
<td>All Alternatives: Minor short-term impact or none.</td>
<td>All Alternatives: Method probably inapplicable to North Bay geographic range of these species.</td>
<td></td>
<td></td>
<td>Alternative 1: Long-term stabilization and restoration of natural tidal creek structure and high density of small tidal creeks due to arrested spread of smooth cordgrass, protection of favorable habitat. Alternatives 2, 3: Delayed degradation of tidal creek habitat quality and abundance, no long-term benefit.</td>
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<tr>
<td>BIO-6.3: Effects on the tidewater goby.</td>
<td>All Alternatives: No impact.</td>
<td>All Alternatives: No impact.</td>
<td>All Alternatives: No impact.</td>
<td>All Alternatives: No impact.</td>
<td>All Alternatives: No impact.</td>
<td>All Alternatives: No impact.</td>
<td>All alternatives: No benefits.</td>
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<tr>
<td>BIO-6.4: Effects on estuarine fish populations of shallow submerged intertidal mudflats and channels.</td>
<td>All Alternatives: Minor short-term impact or none.</td>
<td>Alternative 1: Potential minor to moderate adverse impacts of dredging in tidal creeks or channels at low tide, due to elevated turbidity, dissolved sulfides, reduced dissolved oxygen; South Bay only. Alternative 2: Impacts greater than Alternative 1, but less than significant. Alternative 3: Similar to Alternative 1, less impact.</td>
<td>All Alternatives: Minor short-term impact or none.</td>
<td>Alternative 1: Minor to moderate potential entrainment and trapping impact within impounded areas, less than ongoing salt pond operations in region; South Bay only. Alternative 2: Impacts greater than Alternative 1, but less than significant. Alternative 3: Similar to Alternative 1, less impact.</td>
<td>All Alternatives: Minor short-term impact or none.</td>
<td>Alternative 1: Minor to moderate impact due to potential exposure of fish to tidally remobilized herbicide spray solution containing surfactants. Alternative 2: Impacts greater than Alternative 1, but less than significant. Alternative 3: Similar to Alternative 1, less impact.</td>
<td>Alternative 1: Long-term stabilization and restoration of natural tidal creek structure and high density of small tidal creeks due to arrested spread of smooth cordgrass, protection of favorable habitat. Alternatives 2, 3: Delayed degradation of tidal creek habitat quality and abundance, no long-term benefit.</td>
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<tr>
<td>BIO-7: Effects on California red-legged frog and San Francisco garter snake.</td>
<td>All alternatives: No impacts.</td>
<td>All alternatives: No impacts.</td>
<td>All alternatives: No impacts.</td>
<td>All alternatives: No impacts.</td>
<td>All alternatives: No impacts.</td>
<td>All alternatives: No impacts.</td>
<td>All alternatives: No benefits.</td>
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<tr>
<td>BIO-8: Effects of regional invasive cordgrass eradication on mosquito production.</td>
<td>All Alternatives: Minor to moderate production of additional mosquito breeding habitat in topographic depressions in marsh plain left by vehicles, excavation pits.</td>
<td>All Alternatives: Minor to moderate production of additional mosquito breeding habitat in topographic depressions in marsh plain left by vehicles, excavation pits.</td>
<td>Alternative 1: No impact from large impounded or deeply flooded areas; moderate potential for additional new breeding habitat in small, shallow hypersaline impoundments. Alternative 2: Similar to Alternative 1, greater impact. Alternative 3: Similar to Alternative 1, less impact.</td>
<td>All Alternatives: Minor to moderate production of additional mosquito breeding habitat in topographic depressions in marsh plain left by vehicles, excavation pits.</td>
<td>All Alternatives: Minor to moderate production of additional mosquito breeding habitat in topographic depressions in marsh plain left by vehicles, excavation pits.</td>
<td>All Alternatives: Minor to moderate production of additional mosquito breeding habitat in topographic depressions in marsh plain left by vehicles, excavation pits.</td>
<td>Alternative 1: Long-term avoidance of risk that poorly drained smooth cordgrass plains would increase mosquito production, comparable to Atlantic coastal marshes. Potential significant benefit. Alternatives 2, 3: Delay in risk of habitat modification favoring mosquito production, no long-term benefit.</td>
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<td>BIO-9: Effects on tiger beetle species.</td>
<td>All alternatives: No impact.</td>
<td>All alternatives: No impact.</td>
<td>All alternatives: No impact.</td>
<td>All alternatives: No impact.</td>
<td>All alternatives: No impact.</td>
<td>All alternatives: No impact.</td>
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Table 3.3-2: Summary of Mitigation Measures for Biological Resources

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<th>Mitigation</th>
<th>Manual Removal (Hand pulling and manual excavation)</th>
<th>Mechanical Removal (Excavation, dredging, and shredding)</th>
<th>Pruning, Hand-mowing, and Smothering</th>
<th>Flooding (Diking, drowning, and salinity variation)</th>
<th>Burning</th>
<th>Herbicide Application</th>
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<tbody>
<tr>
<td>BIO-1.1: Saltmeadow and English cordgrass. Minimize vehicle and foot access pathways. Restrict equipment working in marsh to mats and geotextile fabric covers. Stockpile non-viable excavated non-native cordgrass and excavated sediment and remove from marsh. Stabilize smothering geotextile mats. Cover non-target vegetation with protective films. Use optimal combinations of treatment to minimize repeat entry to marsh.</td>
<td>Applicable</td>
<td>Applicable</td>
<td>Applicable</td>
<td>Not Applicable</td>
<td>Applicable</td>
<td>Applicable</td>
</tr>
<tr>
<td>BIO-1.2: Atlantic Smooth cordgrass. Minimize vehicle and foot access pathways. Restrict equipment working in marsh plains to mats and geotextile fabric covers. Stockpile non-viable excavated non-native cordgrass and excavated sediment and remove from marsh. Cover non-target vegetation with fabric adjacent to areas sprayed with herbicide, or pre-treat with protective films of silt-clay. Stabilize smothering geotextile mats. Use optimal combinations of treatment to minimize repeat entry to marsh and re-treatment. Minimize herbicide spray dose requirements by pre-treatments. Use removal methods rather than helicopter applications of herbicide whenever feasible and less environmentally damaging. Use non-spray application techniques to reduce herbicide dose and minimize non-target contact.</td>
<td>Applicable</td>
<td>Applicable</td>
<td>Applicable</td>
<td>Applicable</td>
<td>Not Applicable</td>
<td>Applicable</td>
</tr>
<tr>
<td>BIO-1.3: Chilean cordgrass. Identical with Mitigation BIO-1.1.</td>
<td>Applicable</td>
<td>Applicable</td>
<td>Applicable</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>Applicable</td>
</tr>
<tr>
<td>Mitigation</td>
<td>Manual Removal (Hand pulling and manual excavation)</td>
<td>Mechanical Removal (Excavation, dredging, and shredding)</td>
<td>Pruning, Hand-mowing, and Smothering</td>
<td>Flooding (Diking, drowning, and salinity variation)</td>
<td>Burning</td>
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<tr>
<td>BIO-1.4: Submerged aquatic plant communities.</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>Applicable</td>
<td>Not Applicable</td>
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<tr>
<td>BIO-2: Special-status plant species.</td>
<td>Applicable</td>
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<tr>
<td>BIO-3: Shorebirds and waterfowl. For work within 1,000 feet of mudflats, schedule eradication activities to avoid peak fall and spring Pacific Flyway stopovers. Mobilize crews to project sites before mudflats emerge. Use optimal combinations of treatment to minimize repeat entry. Avoid helicopter applications of herbicide to mudflat colonies within 1,000 feet of major habitual roosting or foraging sites. As a last resort, haze shorebirds and waterfowl within 1000 feet of spray operations. Remediate small volumes of spilled solutions on mudflats.</td>
<td>Applicable</td>
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<tr>
<td>BIO-4.1: Salt marsh harvest mouse and tidal marsh shrew subspecies. Minimize vehicle and foot access pathways in potential tidal marsh habitat. Restrict equipment working in marsh to areas with mats and geotextile fabric covers. Use optimal combinations of treatment to minimize repeat entry retreatment. Schedule work in suitable habitat soon after natural mass-mortality events caused by extreme high tides. Compensatory measures for incidental take include restoration of optimal habitat within large tidal marsh restoration projects.</td>
<td>Applicable</td>
<td>Applicable</td>
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<td><strong>BIO-4.2: Resident San Francisco Bay harbor seals.</strong> Minimize vehicle and foot access pathways in marsh within 1,000 feet of seal haul-outs, and avoid approaching haul-outs within 2,000 feet, or any distance that elicits vigilance behavior when pups are present. Consult with marine mammal experts to determine seasonal variation in sensitivity to disturbance. Restrict equipment working in marsh to prescribed paths. Use optimal combinations of treatment to minimize repeat entry to marsh and re-treatment. Refrain from use of low-flying helicopters within 2,000 feet of seal haul-outs. Transport any pre-mixed solutions of herbicide in double-lined containers. RemEDIATE spilled solutions on mudflats to the greatest extent feasible.</td>
<td>Applicable</td>
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<td>Applicable</td>
<td>Applicable</td>
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<td><strong>BIO-5.1: California clapper rail.</strong> To minimize or avoid indirect impacts of eradication operations on clapper rails, follow best management practices in EIS/R Appendix G, as modified by the US Fish and Wildlife Service's Biological Opinion. These protocols are based on (1) current survey and map data to determine distribution and abundance of rails in relation to project sites, and local behavior of rails in occupied habitats; (2) training and expert biological supervision of field crews to detect clapper rails and identify habitat; (3) modification of timing and within-site location of operations to minimize or avoid disturbances to clapper rails. In addition, the mitigation measures generally used to minimize disturbances in MITIGATION BIO-1.2 and BIO-4.1 also apply. For unavoidable significant impacts due to eradication of Atlantic smooth cordgrass and hybrids which provide habitat currently occupied by clapper rails, proportional compensatory mitigation is necessary. Primary components of compensatory mitigation include: (1) large-scale, rapid restoration of suitable tidal salt marsh habitat (including all essential habitat components for colonization by clapper rails) in advance of large-scale habitat destruction, and within the same subregion as impacts, but at locations with low invasion pressure from non-native cordgrasses; (2) significantly increasing reproductive success of clapper rails within the same subregion as impacts, through management which reduces predation from non-native red fox, and enhances flood refugia (cover for rails during extreme high tides).</td>
<td>Applicable</td>
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<td>BIO-5.2: California black rail. Adapt protocols for minimization and avoidance of California clapper rails (Appendix G) for work in infested marshes known to support populations of California black rails (currently one: Southampton Marsh, Benicia), emphasizing pre-project surveys (call detection), minimization of marsh disturbance (MITIGATION BIO-1.2), and avoidance of occupied habitat during the breeding season.</td>
<td>Applicable</td>
<td>Potentially Applicable</td>
<td>Applicable</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>Applicable</td>
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<tr>
<td>BIO-5.3: Tidal marsh song sparrow subspecies and salt marsh common yellowthroats. Adapt protocols for minimization and avoidance of California clapper rails (Appendix G) for work in infested marshes known to support populations of Alameda song sparrows, San Pablo song sparrows, Suisun song sparrow, and the salt marsh common yellowthroat, emphasizing pre-project surveys, minimization of marsh disturbance (MITIGATION BIO-1.2), and avoidance of occupied habitat during the breeding season.</td>
<td>Applicable</td>
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<td>BIO-5.4: Western snowy plovers and California least terns. Prior to levee access in areas where snowy plovers and least terns may breed, levee routes should be surveyed for potential nests, including nests in salt pond beds near levee roads. Dredging and excavation of cordgrass should be conducted either after least terns have migrated out of San Francisco Bay, or during middle to lower tidal stages that allow navigation of barge and crane operations, while exposing the maximum extent of cordgrass above standing tides.</td>
<td>Applicable</td>
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<td>BIO-5.5: Birds of prey in tidal marshes. Minimize use of helicopters to apply herbicides over marshplains where raptors forage.</td>
<td>Not Applicable</td>
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<td>BIO-6.1: Chinook salmon and steelhead (anadromous salmonids). Dredging of infested intertidal channels should be limited to: (1) tidal stages when target areas are emerged above water level, and (2) during seasons when winter- and spring-run Chinook salmon and steelhead migration times minimize their risk of exposure at project sites, particularly juveniles. Intakes for impoundments should be limited to tides above mean high water to minimize entrainment and trapping. Alternatively, fish screens could be installed on new tidegates used to impound and drown large cordgrass-infested marshes in former diked baylands. Herbicide methods should be minimized or avoided near channels and mudflats during migration periods of winter-run and spring-run Chinook salmon and steelhead. Minimize glyphosate/surfactant spray application requirements by pre-treating target cordgrass stands with mechanical methods that reduce cordgrass biomass and density, increase receptivity and coverage of spray, and increase mortality response to glyphosate. In case of herbicide/surfactant solution spill, remediate small volumes of spilled solutions on mudflats to the greatest extent feasible by suction of surface muds, using portable wet vacuum or pumping equipment.</td>
<td>Not Applicable</td>
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<td>BIO-6.2: Delta smelt and Sacramento splittail. For work in infested North Bay marshes where delta smelt or Sacramento splittail may occur (currently one: Southampton Marsh, Benicia), eliminate impoundment techniques and minimize spray drift near tidal creeks (MITIGATION BIO-1.1, 1.2). Restrict any intertidal excavation or dredging in tidal creeks to tidal stages when target areas are emerged above water level.</td>
<td>Not Applicable</td>
<td>Applicable</td>
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<td>BIO-6.4: Shallow-water estuarine fish</td>
<td>Not Applicable</td>
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<tr>
<td>BIO-8: Mosquito production in tidal marshes</td>
<td>Applicable</td>
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Note: Due to summarization, there may be textual differences between the measures in this summary table and the text in the section. The actual mitigation measure is in the text.
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