U.S. Fish & Wildlife Service

Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California

California clapper rail (Rallus longirostris obsoletus)

Suaeda californica (California sea-blite)

Cirsium hydrophilum var. hydrophilum (Suisun thistle)

Chloropyron molle ssp. molle (soft bird's-beak)

Salt marsh harvest mouse (Reithrodontomys raviventris)

Volume II
Appendices

Tidal marsh at China Camp State Park.

VII. APPENDICES

Appendix A

Species Referred to in this Document

Plants

Scientific Name	Common Name
Achillea millefolium	Yarrow
Agrostis exarata	Marsh bentgrass
Amsinckia spectabilis	Coast fiddleneck
Anagallis arvense	scarlet pimpernel
Apium graveolens	Wild celery
Armeria maritima ssp. *californica*	California sea-pink
Aster chilensis	Chilean aster
Astragalus pycnostachyus var. *lanossisimus*	Ventura Marsh milkvetch
Astragalus pycnostachyus var. *pycnostachyus*	Marsh locoweed, Coastal marsh milk-vetch, coast milk-vetch, Brine milk-vetch
Astragalus tener ssp. *tener*	Alkali milk-vetch
Atriplex californica	California saltbush
Atriplex triangularis	Spearscale
Atriplex semibaccata	Australian saltbush
Atriplex watsonii	Watson’s saltbush
Baccharis douglasii	Douglass’ or salt marsh baccharis
Baccharis pilularis	Coyote-brush
Batis maritima	Saltwort
Calystegia sepium	Morning-glory
Cardaria draba	White-top
Cardaria pubescens	White-top
Carduus acanthoides	Spiny plumeless thistle
Carduus nutans	Musk thistle, Nodding plumeless thistle
Carex aquatilis var. *dives*	Black-head water sedge
Carex densa	Dense sedge
Carex obnupta	Slough sedge
Carex praegracilis	Clustered field sedge
Carpobrotus chilense	Sea fig
Carpobrotus edulis	Iceplant
Castilleja ambigua ssp. *ambigua*	Johnny-nip owl’s-clover
Castilleja ambigua ssp. *humboldtiensis*	Humboldt Bay owl’s-clover
Centaurea calcitrapa	Star-thistle
Centaurea solstitialis	Star-thistle
Centaurium trichanthum	Alkali centaury
Centromadia pungens ssp. *maritima*	Maritime spikeweed
Chenopodium chenopodioides	Low goosefoot
Chenopodium album	Lambsquarters
Chenopodium macrospermum	Coast goosefoot

Cicuta maculata var. *bolanderi*	Bolander's spotted water-hemlock
Cirsium andrewsii	Franciscan thistle
Cirsium arvense	Canada thistle, creeping thistle
Cirsium brevistylum	Clustered thistle
Cirsium douglasii	Swamp thistle
Cirsium fontinale	Fountain thistle
Cirsium hydrophilum var. *hydrophilum*	Suisun thistle
Cirsium mohavense	Mohave thistle
Cirsium vulgare	Bull thistle
Chloropyron molle ssp. *molle*	Soft bird's-beak
Chloropyron maritimum ssp. *canescens*	Hoary salt marsh bird's-beak
Chloropyron molle ssp. *hispidum*	Hispid bird's-beak
Chloropyron maritimum ssp. *maritimum*	Salt marsh bird's-beak
Chloropyron maritimum ssp. palustre	Northern salt marsh bird's-beak, Point Reyes bird's beak
Chloropyron palmatus	Palmate-bracted bird's-beak
Cotula coronopifolia	Brass-buttons
Cressa truxillensis	Alkali-weed
Croton californicus	California croton
Cuscuta salina	Salt marsh dodder
Cupressus macrocarpa	Monterey cypress
Distichlis spicata	Saltgrass
Downingia pulchella	Flatface calicoflower, Flatface downingia
Echinochloa spp.	Millets
Eleocharis parvula	Least spikerush
Ericameria ericoide	Mock-heather
Eriophyllum staechadifolium	Woolly sunflower
Eryngium aristulatum	Coyote-thistle
Eryngium armatum	Coast eryngo
Eucalyptus globulus	Tasmanian blue gum
Euthamia (=Solidago) occidentalis	Western goldenrod
Festuca rubra	Red fescue
Foeniculum vulgare	Fennel
Frankenia salina	Alkali-heath
Glaux maritima	Sea-milkwort
Grindelia stricta var. *angustifolia*	Suisun gumplant, Marsh gumplant
Grindelia stricta ssp. *blakei*	Humboldt gumplant
Grindelia paludos (=G. camporum)	Gumplant
Hainardia cylindrica	Barbgrass
Heliotropium curassavicum	Seaside heliotrope
Hemizonia parryi ssp. *congdonii*	Congdon's spikeweed
Hemizonia parryi ssp. *parryi*	Parry's spikeweed
Hutchinsia procumbens	Prostrate hutchinsia
Isocoma veneta ssp. *vernonioides*	Jimmyweed
Jaumea carnosa	Fleshy jaumea

Juncus ambiguus	Saltmarsh toad-rush
Juncus balticus	Wire-rush, Baltic rush
Juncus bufonius	Toad rush
Juncus effusus var. *brunneus*	Brown bog rush
Juncus lesueurii	Rush
Juncus phaeocephalus	Brown-headed rush
Juncus xiphioides	Iris-leaved rush
Lasthenia conjugens	Contra Costa goldfields
Lasthenia glaberrima	Rayless smooth goldfileds
Lasthenia glabrara ssp. *coulteri*	Coulter's goldfields
Lasthenia glabrata ssp. *glabrata*	Smooth goldfields
Lasthenia platycarpha	Alkali goldfields
Lathyrus jepsonii var. *jepsonii*	Delta tule pea
Layia chrysanthemoides	Smooth layia
Lepidium dictyotum	Alkali peppergrass
Lepidium latifolium	Perennial pepperweed, Broadleaf peppercress
Lepidium latipes	Dwarf peppergrass
Lepidium oxycarpum	Sharp-fruit peppergrass
Leymus triticoides	Creeping wildrye
Lilaeopsis masonii	Mason's lilaeopsis
Limonium californicum	Sea-lavender
Limosella spp.	Mudworts
Lolium multiflorum	Ryegrass
Lotus corniculatus	Birdsfoot trefoil
Lythrum salicaria	Purple loosestrife
Monanthochloe littoralis	Shoregrass
Myoporum laetum	Myoporum
Myrica californica	Wax myrtle
Oenanthe sarmentosa	Water celery
Parapholis incurva	Sickle grass
Phragmites australis	Common reed
Plagiobothrys glaber	Smooth popcornflower
Plagiobothrys mollis ssp. *vestitus*	Petaluma popcornflower
Plantago coronopus	Buckshorn plantain
Plantago elongata	Coast plantain
Plantago maritima	Seaside plantain
Plantago subnuda	Mexican plantain
Pluchea odorata	Marsh fleabane
Pleuropogon californicus	California semaphore-grass
Polygonum marinense	Marin knotweed
Polypogon monspeliensis	Beard grass, rabbitsfoot grass
Potentilla anserina	Silverweed
Potamogeton	Pondweed
Puccinellia nutkanensis	Alaska alkali goosegrass
Pyrrocoma racemosa	Clustered goldenweed

Rosa californica	California rose, Wild rose
Ruppia maritima	Ruppia, Widgeon-grass
Sarcocornia europaea	Annual pickleweed
Sarcocornia subterminalis	Parsh's glasswort
Sarcocornia pacifica	Pickleweed
Salsola soda	Mediterranean saltwort
Salsola tragus	Russian-thistle or tumbleweed
Sanicula maritima	Adobe, Marsh sanicle
Scirpus acutus	Hardstem tule
Scirpus americanus	Olney's bulrush; threesquare bulrush
Scirpus californicus	California tule
Scirpus cernuus	Fiber optic grass
Bolboschoenus maritimus	Alkali-bulrush
Scirpus pungens	Threesquare bulrush, common threesquare
Scrophularia californica	California figwort, Bee-plant
Senecia blochmaniae	Blochman's leafy-daisy
Senecio hydrophilus	Salt marsh butterweed
Sium suave	Hemlock water parsnip
Solidago confinis	Southern goldenrod
Sonchus asper	Spiny sowthistle
Sonchus oleraceus	Common sowthistle
Sonchus spp.	Sowthistles
Spartina alterniflora	Smooth cordgrass
Spartina anglica	English cordgrass
Spartina densiflora	Dense-flowered cordgrass
Spartina foliosa	Pacific cordgrass, California cordgrass
Spartina patens	Saltmeadow cordgrass
Spergularia macrotheca	Large-fruited or salt marsh spurrey
Suaeda californica	California sea-blite
Suaeda esteroa	Estuary seea-blite
Suaeda moquinii	Alkali-blite
Suaeda taxifolia	Woolly sea-blite
Symphyotrichum lentum	Suisun marsh aster
Symphyotrichum subulatum var. *ligulatus*	Slim aster
Trifolium depauperatum var. *hydrophilum*	Salt marsh bladder clover
Triglochin concinna	Arrow-grass
Triglochin maritima	Sea-arrow grass
Typha sp. (latifolia, dominguensis, angustifolia)	Cattails
Zostera marina	Eelgrass

Animals

Common Name	**Scientific Name**
Alameda song sparrow	*Melospiza melodia pusillula*
American avocet	*Recurvirostra americana*

American crow	*Corvus brachyrhynchos*
American kestrel	*Falco sparverius*
Barn owl	*Tyto alba*
Bee fly	*Lepidophora* spp.
Beechey ground squirrel	*Spermophilus beecheyi*
Black-bellied plovers	*Pluvialis squatarola*
Black brant	*Branta bernicla*
Black-crowned night heron	*Nycticorax nycticorax*
Black-necked stilt	*Himantopus mexicanus*
Black rail	*Laterallus jamaicensis*
Black shouldered kits	*Elanus caeruleus*
Brine flies	*Ephydra cinerea, Ephydra millbrae, Lipochaeta slossonae, Mosillus tibialis*
Brine shrimp	*Artemia franciscana,* syn. *Artemia salina*
Brown-headed cowbird	*Molothrus ater*
Buckeye butterfly	*Junonia coenia*
Bufflehead	*Bucephala albeola*
Bumblebees	*Bombus californicus, Bombus vosnesenskii*
Burrowing owl	*Athene cunicularia*
Southern sea otter	*Enhydra lutris nereis*
California black rail	*Laterallus jamaicensis coturniculus*
California brackish water snail, mimic tryonia snail	*Tryonia imitator*
California clapper rail	*Rallus longirostrus obsoletus*
California ground squirrel	*Spermophilus beechyii*
California least tern	*Sterna antillarum browni*
California red-legged frog	*Rana aurora draytonii*
California sea lion	*Zalophys califonianus*
California vernal pool tadpole shrimp	*Lepidurus packardi*
California vole	*Microtus californicus*
Canvasbacks	*Aytha valisineria*
Cat (domestic)	*Felix domestica*
Chinook salmon	*Oncorhynchus tschawytscha*
Clam (Asian clam, brackish-water corbula)	*Potamocorbula amurensis*
Clam (Baltic tellin)	*Macoma balthica*
Clapper rail	*Rallus longirostris*
Common mallard	*Anas platyrhynchos*
American crow	*Corvus brachyrhynchos*
Coyote	*Canis latrans*
Curlew	*Numerius americanus*
Delta smelt	*Hypomesus transpacificus*
Dowitcher	*Limnodromus sp.*
Dundlin	*Calidris alpina*
Gopher snake	*Pituophis melaoleucus*

Great blue heron	*Ardea herodias*
Great egret	*Casmerodius albus*
Great horned owl	*Bubo virginianus*
Green-wing teal	*Anas crecca*
Grey Fox	*Urocyon cinereoargenteus*
Gulls	*Larus spp.*
Hog (feral)	*Sus scrofa*
Jamieson's wasp	*Compsocryptus jamiesoni*
Killdeer	*Charadrius vociferus*
King rail	*Rallus elegans*
Leaf cutter bee	*Anthidium edwardsii*
Leaf roller moth	*Platynota stultana*
Least sandpiper	*Calidris minutilla*
Lesser scaup	*Aythya affinis*
Light-footed clapper rail	*Rallus longirostris levipes*
Loggerhead shrike	*Lanius ludovicianus*
Marbled godwit	*Limosa fedoa*
Marsh wren	*Cistothorus palustris*
Morro Bay kangaroo rat	*Dipodomys heermanii morroensis*
Morro shoulderband snail	*Helminthoglypta walkeriana*
Moth	*Perizoma custodiata*
Mudflat tiger beetle	*Cicindela trifasciata sigmoidea*
Mylitta crescent	*Phyciodes mylitta*
Northern anchovy	*Engraulis mordax*
Northern clapper rail	*Rallus longirostris crepitans*
Northern harrier	*Circus cyaneus*
Norway rat	*Rattus novegicus*
Old man tiger beetle	*Cicindela senilis frosti,* *Cicindela senilis senilis*
Opossum	*Didelphis virginiana*
Opossum shrimp	*Neomysis mercedis*
Pacific harbor seal	*Phoca viulina richardsi*
Pacific herring	*Clupea harengus*
Peregrine falcon	*Falco peregrinus*
Pileworm	*Nereis vexillosa*
Pintail	*Anas acuta*
Pipefish	*Syngnathus* sp.
Plains harvest mouse	*Reithrodontomys montanus*
Polychaetes	Annelid worms
Raccoon	*Procyon lotor*
Rat	*Rattus* sp.
Raven	*Corvus corax*
Red fox	*Vulpes vulpes*
Red-tailed hawk	*Buteo jamaicensis*
Ribbed horse mussel	*Ischadium demissum*
Ruddy duck	*Ocyura jamaiensis*

Sacramento splittail	*Pogonichthys macrolepidotus*
Salt marsh common yellowthroat	*Geothlypis trichas sinuosa*
Salt marsh harvest mouse	*Reithrodontomys raviventris*
Salt marsh snout moth	*Lipographus fenestrella*
Salt marsh wandering shrew	*Sorex vagrans halicoetes*
San Pablo song sparrow	*Melospiza melodia samuelis*
Sanderling	*Calidris alba*
Sandy beach tiger beetle	*Cicindela hirticolis gravida*
Scrub jays	*Aphelocoma coerulescens*
Semipalmated plovers	*Charadrius semipalmatus*
Short-eared owl	*Asio flammeus*
Solitary bee	*Melissodes*
Song sparrow	*Melospiza melodia*
Sora rail	*Porzana carolina*
Spiders	*Lycosidae* spp.
Spotted skunk	*Spilogale putorius*
Steelhead	*Oncorhynchus mykiss irideus*
Striped bass	*Morone saxatilis*
Striped shore crab	*Pachygrapsus crassipes*
Striped Skunk	*Mephitis mephitis*
Suisun shrew	*Sorex ornatus sinuosus*
Suisun song sparrow	*Melospiza melodia maxillaris*
Surf scoter	*Melanitta perspicillata*
Sweat bee	*Halictus tripartitus*
Thistle weevil	*Rhinocyllus conicus*
Tidewater goby	*Eucyclogobius newberryi*
Tiger beetles	*Cicindela haemorrhagica, Cicindela hirticollis, Cicindela oregona oregona, Cicindela senilis frosti, Cicindela senilis senilis*
Topsmelt	*Atherinops affinis*
Tule yellowthroat	*Geothlypis trichas scirpicola*
Virginia rail	*Rallus limicola*
Western harvest mouse	*Reithrodontomys megalotis*
Western pond turtle	*Clemmys marmorata*
Western sandpiper	*Calidris mauri*
Western snowy plover, Pacific coast population	*Charadrius alexandrinus nivosus*
Western tanarthrus beetle	*Tanarthrus occidentalis*
Western yellowthroat	*Geothlypis trichas occidentalis*
White sturgeon	*Acipenser transmontanus*
Widgeon	*Anas americana*
Willets	*Catoptrophorus semipalmatus*
Yellow shore crab	*Hemigrapsus oregonensis*

Appendix B

Recovery Priority Ranking System for Endangered and Threatened Species

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C 1
	High	Species	2	2C 2
	High	Subspecies	3	3C 3
	Low	Monotypic Genus	4	4C 4
	Low	Species	5	5C 5
	Low	Subspecies	6	6C 6
Moderate	High	Monotypic Genus	7	7C 7
	High	Species	8	8C 8
	High	Subspecies	9	9C 9
	Low	Monotypic Genus	10	10C 10
	Low	Species	11	11C 11
	Low	Subspecies	12	12C 12
Low	High	Monotypic Genus	13	13C 13
	High	Species	14	14C 14
	High	Subspecies	15	15C 15
	Low	Monotypic Genus	16	16C 16
	Low	Species	17	17C 17
	Low	Subspecies	18	18C 18

"C" indicates some degree of conflict between the conservation needs of the subspecies and economic development

From U.S. Fish and Wildlife Service. 1983. Endangered and threatened species; listing and recovery priority guidelines. Federal Register 48:43098-43105.

Appendix C

Species of Concern or Regional Conservation Significance in Tidal Marsh Ecosystems of Northern and Central California

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A. Tidal Marsh Species of Concern

1. Salt Marsh Wandering Shrew
(*Sorex vagrans halicoetes*)
2. Suisun Shrew
(*Sorex ornatus sinuosis*)

Description and Taxonomy

The salt marsh wandering shrew (*Sorex vagrans halicoetes*) and the Suisun shrew (*Sorex ornatus sinuosis*) belong to the Soricidae family. These two taxa occur exclusively in tidal marsh habitat of the San Francisco Bay Estuary. Very little is known about either species, but they appear to have similar life histories and habitat affinities. They may coexist in tidal marshes with the more widespread California subspecies of the ornate shrew, *Sorex ornatus californicus*. Knowledge of the distribution of shrew species in tidal marshes and other habitats is limited by incomplete species identification (Harding 2000).

Description. The salt marsh wandering shrew is a small, mouse-like insectivore, usually brown or gray, with canine-like upper incisors with red pigment at the tips. It has a long, pointed nose, small eyes, and small external ears. Animals are 86 to 113 millimeters (3.4 to 4.5 inches) in total length with a tail 35 to 44 millimeters (1.4 to 1.7 inches) long (Western Ecological Services Company 1986*a*). Adult weight can range from 4 to 8 grams (0.14 to 0.28 ounce). The hair of typical specimens is very dark compared to the gray or dark brown of most terrestrial shrews. Salt marsh wandering shrews are short-lived; average life spans are less than one year, and seldom exceed 18 months.

The Suisun shrew is similar in appearance to the salt marsh wandering shrew. It is 95 to 105 millimeters (3.7 to 4.1 inches) in total length with a tail length of 37 to 41 millimeters (1.4 to 1.6 inches; Ingles 1965). Adult weight ranges from 3.9 to 9.2 grams (0.14 to 0.32 ounce; Hays 1990). The dark coloration is similar to that of the salt marsh wandering shrew.

Taxonomy. The salt marsh wandering shrew is an endemic species of San Francisco Bay, one of 28 currently recognized subspecies of the vagrant (or wandering) shrew. Grinnell (1913) originally described the salt marsh wandering shrew as a distinct species, *Sorex halicoetes*. The type specimen was collected from a salt marsh near Palo Alto in 1908 by S. Dixon. Although he noted that there appeared to be a close relationship between *Sorex halicoetes* and *Sorex vagrans*, Grinnell separated them based on the darker coat color of the Suisun specimens. Jackson (1928) placed *halicoetes* within the widespread and variable species *Sorex vagrans* at the rank of subspecies. This taxonomic treatment has remained (Hennings and Hoffman 1977, Hall 1981, Williams 1986).

The Suisun shrew is the North Bay counterpart of the salt marsh wandering shrew. It has been considered an endemic subspecies of ornate shrew restricted to the tidal marshes of northern San Pablo Bay and the Suisun Marsh areas (Owen and Hoffmann 1983). The type specimen was collected at Grizzly Island, Suisun Marsh, in January 1912 by A. M. Alexander. Grinnell (1913) originally described the Suisun shrew as a distinct species, *Sorex sinuosi*. Williams (1979) and Brown and Rudd (1981) suggested that this taxon be treated as a subspecies of *Sorex ornatus,* because of evidence of interbreeding between *Sorex sinuosis* and the more widespread, abundant *Sorex ornatus californicus* (Rudd 1955). Recent genetic research indicates that *S. o. sinuosus* is more closely related to and deried from *S. vagrans*. While morphologically similar, *S. o. sinuosus* are not closely related to ornate shrews from south of San Francisco Bay (Maldonado *et al.* 2001). Rudd (1955) postulated that intermediate characteristics, including coloration, were due to hybridization. However, morphological differentiation is not concordant with observed patterns of genetic differentiation (Maldonado *et al.* 2004).

Geographical distribution is an important factor in distinguishing salt marsh shrews. The salt marsh wandering shrew is found in the marshes of the southern portion of the San Francisco Bay. The Suisun shrew, slightly larger and with a flatter cranium, is found only in the marshes of the northern perimeters of San Pablo and Suisun bays. *Sorex ornatus californicus* ranges from the Sacramento Valley southwest to the central California coast (Harding 2000), and occurs around San Francisco Bay in both upland habitats and salt or brackish marshes from Sonoma Creek south to Corte Madera (Western Ecological Services Company 1986*b*), where it may co-occur with the Suisun shrew.

Population Trends and Distribution

Little is known about the distribution and abundance of the salt marsh wandering shrew. Distribution records were developed mainly from museum records and prior salt marsh trapping data.

Historical distribution. The historical geographic range of the salt marsh wandering shrew was limited to tidal marshes of San Francisco Bay (principally Central and South Bay). This probably included the large expanses of salt marsh plains once common along the shorelines of Alameda, Santa Clara, San Mateo, and San Francisco counties, with some populations extending into San Pablo Bay and the Carquinez Straits in Contra Costa and Solano counties (Shellhammer 2000).

The historical distribution of the Suisun shrew is not fully known, but appears to have been limited to the tidal marshes of the north shores of San Pablo and Suisun bays. Records of the Suisun shrew have been cited from the mouth of the Petaluma River to eastern Suisun Marsh near Collinsville, Solano County. However, the western San Pablo Bay records have been re-identified as the more widespread *Sorex ornatus californicus* (Brown and Rudd 1981, MacKay 2000).

Current distribution. **Figure C-1** shows known occurrences of salt marsh wandering shrew and Suisun shrew. There is very little information on the current distributions of these species. Shrews captured inadvertently in traps set for monitoring the salt marsh harvest mouse are often not identified to species. One survey for the salt marsh wandering shrew (Western Ecological Services Company 1986*a*) resulted in no captures but several sightings, verifying the occurrence of populations in only four salt marshes within their historical range. Fifteen additional marshes were identified as likely to support populations. In 1986, populations were known to exist at Bair Island, San Mateo County; Mowry Slough, Santa Clara County; Dumbarton Point, Alameda County; and Alameda Creek mouth, Alameda County.

The current distribution of the Suisun shrew appears to be limited to the isolated tidal salt and brackish marshes on the perimeters San Pablo Bay and Suisun Marsh. Its range is bounded on the west by Tubbs Island in Sonoma County and on the east by Collinsville in Solano County. Ornate shrews outside these boundaries are considered to be *Sorex ornatus californicus* (Brown and Rudd 1981, Williams 1983). Hay and Lidicker (2000) found sizable populations of Suisun shrew at the southeast corner of Rush Ranch (Suisun Marsh). Although the presence of Suisun shrews was recorded in locations throughout this area, more recent efforts to locate the Suisun shrew have generally yielded fewer results. Trapping in 1983 in 23 locations (concentrating on Grizzly Island) resulted in no Suisun shrew captures. A Grizzly Island population was confirmed, however, when one road-killed Suisun shrew was found (Williams 1983). Surveys specifically for Suisun shrew were conducted in 12 locations with no resulting captures or observations (Western Ecological Services Company 1986*b*). One incidental capture during a survey for salt marsh harvest mouse was identified as a Suisun shrew (Western Ecological Services Company 1986*b*); the rest were identified only to genus or species.

In a study of wandering shrews, Hays (1990) trapped 161 individual Suisun shrews in the tidal marsh of Rush Ranch just across from Grizzly Island. The area he trapped had been previously identified (Rudd 1955) as one in which interbreeding occurred between subspecies *Sorex ornatus sinuosis* and *californicus*. Hays found both melanistic and non-melanistic individuals in the same population.

Density and abundance. Densities of tidal marsh shrew populations vary with season and habitat. No data are available to accurately measure population numbers or densities of salt marsh wandering shrews. Johnston and Rudd (1957) determined that shrews represented about 10 percent of the small mammals in the marshes. There are no known recent determinations of abundance. Newman (1970) reported densities of 44 individuals per acre within areas considered optimum habitat for Suisun shrews. Hays (1990) reported aggregations of Suisun shrews, inside which densities reached 40 per acre and outside were 4 per acre.

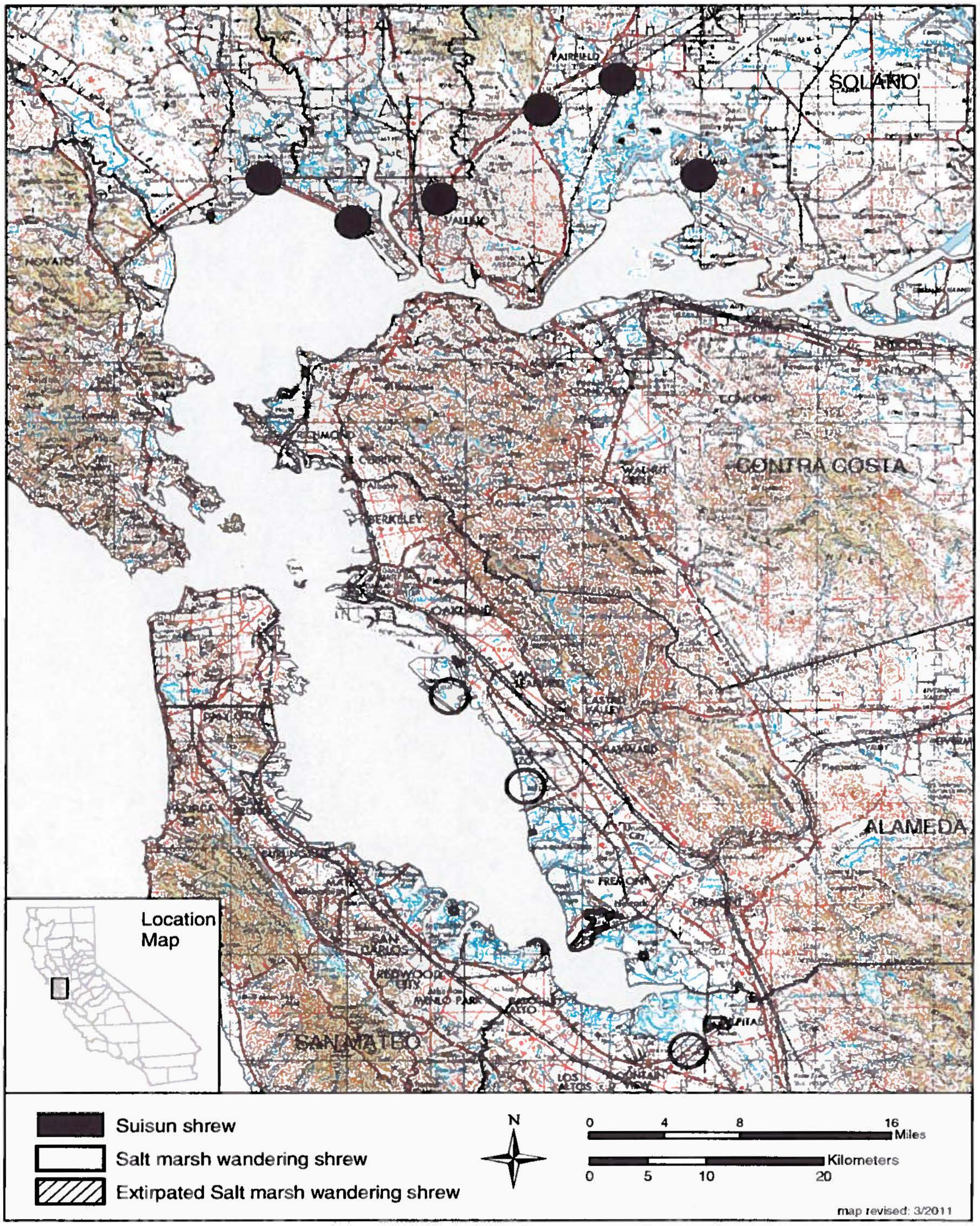

Figure C-1. Distribution of Suisun shrew and salt marsh wandering shrew

Populations of salt marsh shrews are extremely dynamic and show evidence of extreme annual fluctuations in numbers (Johnston and Rudd 1957, Williams 1983). Because of the great sensitivity of species of small body size to random environmental events, small local populations of shrews are expected to have high extinction rates. An annual turnover in age structure in the summer is a common characteristic in all shrew populations. There is evidence indicating that shrews may have home ranges and defend territories for at least part of the year (Hawes 1977, Hays 1990, Ivanter *et al*. 1994, Moraleva and Telitzina 1994). These dynamic territories can range from 360 to 1,700 square meters in area (3,875 to 18,300 square feet; Ivanter *et al.* 1994), or from 11 to 100 meters (36 to 328 feet) in length (Moraleva and Telitzina 1994), depending on sex, age, and season. In Suisun Marsh, dense breeding subpopulations of *Sorex ornatus* exist in the fall with strongly female-biased sex ratios surrounded by a large independent subpopulation of young-of-the-year males (Hays 1990).

Life History and Ecology

Feeding and metabolism. Shrews are carnivores and predators of small insects, crustaceans, and other invertebrates. They are intense feeders with assimilation efficiencies of 42 to 95 percent (Newman 1970, McNab 1980). Shrews generally are dietary opportunists that eat whatever invertebrates they encounter (Newman 1970). Salt marsh shrews feed primarily on crustaceans present in the middle elevation marsh zone (Newman 1970, Western Ecological Services Company 1986*a*, Hays 1990), and seem to prefer continuously moist soils near the mean high tide level where high densities of amphipods (hundreds per square meter) are present on the soil surface at all seasons (Hays 1990). To compensate for their high activity level and extremely high metabolic rate, shrews must consume large quantities of food (Newman 1970). They can ingest, in a 24-hour period, an amount equal to or exceeding their own weight (Genoud and Vogel 1989). Some lactating females have been found to ingest up to 300 percent of their body weight (Findley 1987). Salt marsh shrews do not appear to be food-limited in the winter, but are probably susceptible to weather-induced stress due to their low heat content and high thermal conductivity (Hays 1990).

Shrews are able to minimize heat loss during the winter months through changes in hair quality and density, which makes their winter coat about 30 percent more effective at retaining heat than the summer pelage (Ivanter 1994). Even so, soricine shrews (excluding water shrews) will perish quickly if their pelage becomes saturated under cold conditions. They actively seek shelter above ground during rainfall (Vickery and Bider 1978). Newman (1970) noted a loss of thermal regulation in Suisun shrews when they were caught in a metal trap. If not dried or removed from such a situation within an hour and a half, the shrews died. How salt marsh and Suisun shrews avoid mortality due to wet winter conditions in a tidal marsh is unknown. Johnston (1957) noted that salt marsh wandering shrews swim well at or below the surface of the water, and dive when pursued by humans.

Activity and movement. Salt marsh shrews are most active during the spring, when reproductive development, breeding, litters, and molting occur. Suisun shrews were found to be active 24 hours a day, with higher activity and metabolic rates at night (Rust 1978). Short bursts of activity were followed by longer periods of stillness. In another study, Suisun shrews averaged 8 to 12 periods of activity lasting from a few seconds to 10 minutes each (Newman and Rudd 1978).

Migration by salt marsh shrews within tidal marshes to avoid spring tides has not been detected. Like other rodents, scientists assume they take refuge from high water in higher vegetation.

Reproduction and mortality. Tidal marsh shrew populations have a high turnover of short-lived individuals. The breeding season for salt marsh shrews extends from late February through June, and most litters are born from May through July with the highest numbers in April. A second peak of breeding occurs in September as the young of the previous spring mature. By May, 77 percent of the Suisun shrew females have fully developed uteri, and nearly all the males are reproductive (Brown 1974). Gestation lasts about 20 days. In the wild, salt marsh wandering shrews produce four to six young per litter (Johnston and Rudd 1957). Young shrews are weaned by 25 days after birth, and remain in the nest up to the fifth week (Rose 1994).

Mortality rates in *Sorex* species can be as high as 75 percent from autumn to spring (Rose 1994). Johnston and Rudd (1957) found that less than half of the salt marsh wandering shrews live 21 days. Causes of mortality include drowning from high tides, death of the mother, starvation, cold, and exposure. Surviving young may produce a litter in the fall and up to two litters the following year.

Salt marsh shrews build nests primarily of dead local plant material, usually placed under or in the cavities of driftwood or planks along the high tide line. The nest is typically placed directly on the soil surface of higher ground where little flooding occurs (Johnston 1957). After the young have dispersed, shrew nests may be utilized by other small mammals such as the salt marsh harvest mouse (*Reithrodontomys raviventri;* Western Ecological Services Company 1986*a*).

Habitat

Salt marsh shrews are associated with the middle salt marsh zone, near the mean higher high water elevation around San Francisco, San Pablo, and Suisun bays. Habitat in brackish marshes may occasionally be used by salt marsh shrews. The physical features of the habitat seem to be more important than the specific plant composition. The upper half of the middle marsh zone is typically inundated only by higher high tides, and contains abundant vegetation cover, surface moisture, and organic detritus, with abundant amphipods and other crustaceans. This appears to be optimum and extremely important habitat for salt marsh shrews (Johnston and Rudd 1957, Owen and Hoffmann 1983, Shellhammer *in litt*. 2010). Thick stands of vegetation and adjacent marsh areas are thought to provide refuge from extreme high tides and Hays and Lidicker (2000) documented Suisun shrews along the ecotone between high marsh and ungrazed annual grassland. Salt marsh wandering shrews, however, have not been detected in grassy upland areas (Newman 1970). Plant material and driftwood or other debris resting directly on the *Sarcocornia pacifica* (pickleweed) is used for nesting cover (Western Ecological Services Company 1986*a*, 1986*b*). Salt marsh shrews have not been trapped in either high tidal marsh or diked salt marsh (Western Ecological Services Company 1986*a*, Hays 1990, Shellhammer 2000). High marsh, however, may provide refuge from tidal flooding, and driftline debris may provide local microhabitats rich in invertebrate prey (Williams 1986, MacKay 2000). Salt marsh wandering shrews may be transient in tall vegetation of the high marsh during extreme high tides that inundate the middle marsh plain. The low marsh zone offers forage for salt marsh shrews during low tides.

Threats

Most species covered in this recovery plan are threatened by similar factors because they occupy the same tidal marsh ecosystem. These general threats, faced by all covered species, are discussed in greater detail in the Introduction section of this recovery plan (section I.D.). Specific threats to salt marsh wandering shrew and Suisun shrew are described below.

The salt marsh wandering shrew and Suisun shrew are threatened by the same factors as the salt marsh harvest mouse, including the loss of most mature tidal marsh plains and high marsh-grassland ecotone to diking, but do not have the benefit of protection under the Federal Endangered Species Act. Diked marshes are generally unsuitable habitat for the shrews.

The greatest current threats are probably the consequences of past reduction in the extent, quality, and continuity of tidal marsh habitat and resident shrew populations. Tidal marsh losses caused by diking have effectively ceased in the San Francisco Bay Estuary. However, remnant populations of the salt marsh wandering shrew and Suisun shrew are now limited to relatively small, discontinuous areas of tidal marshes with limited creek and natural levee development, and steep and narrow levee slopes displacing upland transition zones. Due to lack of recent survey data, it is not known whether populations are small; however, if they are small and exist in these isolated habitats, they are inherently more likely to become extinct than large, widespread populations with extensive, variable habitats and ample tidal refugia. These isolated populations are vulnerable to extreme tidal flooding events and erosion along wave-exposed shorelines. Trapping to accurately determine shrew population levels is extremely difficult.

Already limited to isolated populations, sea level rise threatens to further reduce numbers of tidal marsh shrews. Whereas the pickleweed plain may rise as sea levels rise (unless there is very rapid rise), the high marsh zone, most critical to shrews and already greatly reduced, will likely not (Shellhammer *in litt*. 2010). The ability of tidal marsh restoration projects to compensate for past habitat losses is limited by the rate at which restored tidal marshes mature and form marsh plains near the elevation of mean higher high water. Marsh succession to the *Spartina* stage would have little or no immediate benefit for the recovery of tidal marsh mammals, and development of marsh plains may be slow in the forseeable regime of rising sea level and limited sediment supply. The ability of dredge material deposition to accelerate development of extensive areas of restored tidal marsh is uncertain. This places the conservation and maintenance of existing tidal marsh plains at a premium for protection of tidal marsh shrews.

The effect of contaminants in estuarine sediments may also pose risks for recovery of tidal marsh shrews. Shrews have very high rates of metabolism. They are carnivores that consume invertebrates, which may concentrate contaminants. These factors may make shrews more vulnerable to the effects of toxic substances. Diffuse, non-point sources of contaminants in the estuary, such as some petroleum-derived hydrocarbons, heavy metals, pesticides, and PCBs, may increase as urban development around the region intensifies. Industrial and municipal discharges add to large contaminant loads in San Francisco Bay sediments (Monroe and Kelly 1992, Luoma and Cloern 1982). Pankakoski *et al.* (1994) demonstrated that heavy metal pollution, particularly high levels of lead, could adversely affect the developmental stability of shrew populations. Sublethal effects of contaminants, such as reduced fecundity of adults or reduced viability of young, are probably the most significant potential population-level threats associated with estuarine contaminants. Specific studies relevant to the effects of contaminants on tidal marsh shrews are needed.

Freshwater wastewater discharges from municipal sources have converted extensive areas of salt marsh vegetation to brackish and fresh-brackish vegetation in south San Francisco Bay. Increases in the urban population of the Santa Clara Valley could magnify the intensity and geographic scope of brackish marsh conversion. Conversion to brackish marsh due to wastewater discharges is likely to diminish the relative abundance of *Sarcocornia* habitat for salt marsh wandering shrews.

Conservation Strategy

Past Conservation

The salt marsh wandering shrew and the Suisun shrew currently are neither proposed nor federally listed as endangered or threatened. The U.S. Fish and Wildlife Service removed both species from the former "Category 1 candidate list" in 1995 (U.S. Fish and Wildlife Service 1995). The California Department of Fish and Game considers both tidal marsh shrew species as Mammal Species of Special Concern, an administrative designation that provides no legal protection (California Department of Fish and Game 2009).

The U.S. Fish and Wildlife Service is not aware of any conservation measures that have been undertaken specifically for the benefit of tidal marsh shrew species in this region. Acquisition and management for wildlife in the San Francisco Bay Estuary has presumably provided incidental benefits to conservation of tidal marsh shrews, particularly in the extensive tidal marsh areas owned by the State Lands Commission, California Department of Fish and Game, and the San Francisco Bay National Wildlife Refuge Complex. Large-scale tidal restoration projects in south San Francisco Bay (such as inner Bair Island) are likely to have long-term benefits for salt marsh wandering shrews, but only after several decades or more. Similar benefits are probable for the Suisun shrew in San Pablo Bay (Skaggs Island, Cullinan Ranch, Napa salt ponds, northern San Pablo Bay). Suisun Marsh tidal restoration such as the Hill Slough wetlands restoration project, would probably have similar benefits in the long term for the Suisun shrew. Tidal brackish marsh enhancement along the northern Contra Costa shoreline, such as the Point Edith and Bay Point marshes, may potentially benefit Suisun shrews, although contaminant risks are a long-term concern for this industrialized area. Management of diked salt marsh to conserve salt marsh harvest mouse populations, however, presumably has no value for conservation of tidal marsh shrews; only tidal marsh habitats managed to recover salt marsh harvest mice are likely to benefit shrews.

Current Strategy

Similar to the recovery of the endangered salt marsh harvest mouse, the most important element of the long-term conservation of tidal marsh shrew species is the re-establishment of extensive, well-connected tidal salt and brackish marsh plains with ample high marsh refugia throughout their historical range in the San Francisco Bay Estuary. More specifically, conservation of tidal marsh shrew is sure to hinge on the careful and prompt development and protection of the high marsh zone, including the laying back of levees at a 30 to 1 or gentler slope during rebuilding of necessary levees. In this respect, the conservation of tidal marsh shrews is largely congruent with recovery of the salt marsh harvest mouse, and would entail little conflict or special modification of recovery tasks. Another significant need for both shrew species is better understanding of their distribution, demography, and ecology. The restoration of tidal marsh plains suitable for shrews will in many cases take decades to achieve. Therefore, interim conservation actions are needed to ensure that shrews persist to colonize future restored tidal marsh habitats. Interim conservation actions aim at protecting the viability of remnant populations of salt marsh wandering shrews and Suisun shrews.

The following actions are essential to the conservation of salt marsh wandering shrew and Suisun shrew (tidal marsh shrews):

1) Protect, restore and expand the middle marsh - high marsh ecotone, high marsh, and high marsh-grassland ecotone, where possible.

2) Develop baseline information on the distribution and abundance of endemic tidal marsh shrew species. Conduct region-wide sampling of appropriate tidal marshes with potential for shrew populations. Sample over multiple years to determine the geographic variation of population fluctuations, including at least two years following extreme climate events (*e.g.,* drought, flood).

3) Conduct focused studies on habitat-population relationships of tidal marsh shrews in the San Francisco Bay Estuary. Quantify variation in abundance and species composition of prey, vegetation composition and structure, tidal flooding regimes, soil characteristics, and abundance of potential predator and competitor species. Apply results to habitat prescriptions for restoration and management of tidal marshes.

4) Routinely assess projects affecting tidal marshes for potential impacts to tidal marsh shrews. Where possible through State law, require focused surveys for tidal marsh shrews when regulated activities are planned or proposed that may affect tidal marshes with appropriate habitat. Apply standard mitigation principles of avoidance, minimization, and (last) compensation for unavoidable adverse impacts to tidal marsh shrews. Revisit impacts of grazing at Rush Ranch on tidal marsh shrews in Suisun Marsh and remediate, if necessary.

5) Conduct research on bioaccumulation and effects of toxic estuarine contaminants on fecundity and viability of tidal marsh shrew species. For contaminants considered most likely to harm shrews, study effects on reproductive success and development, potentially with use of surrogate shrew taxa in any experimental work. Apply results of this research to water quality standards to protect sensitive wildlife of the San Francisco Bay Estuary.

Other actions that would improve the conservation of tidal marsh shrew species include:

6) Investigate natural dispersal and experimental translocation to unoccupied habitat, and determine conditions by which founder populations establish. Evaluate, and if appropriate carry out, introductions of tidal marsh shrew populations to areas of unoccupied, good quality habitat.

7) Assess potential for inbreeding depression and levels of genetic diversity within and among populations of resident tidal marsh shrews as well as potential for inbreeding depression. Conduct genetic studies to determine whether population genetics may significantly constrain long-term growth and persistence of viable populations and at what scale.

3. San Pablo vole
(Microtus californicus sanpabloensis)

Description and Taxonomy

Description. The San Pablo vole (*Microtus californicus sanpabloensis*) is one of several subspecies of California vole (Order Rodentia) found in San Francisco bay wetlands. The California vole is approximately 45 grams (1.6 ounces), and has a short tail, less than one-third its total length (Ingles 1965). *Microtus californicus sanpabloensis* can be distinguished from adjacent populations of *Microtus californicus californicus* by its darker, yellower fur, palatines that are deeply excavated along the posterior borders, a narrow rostrum, and relatively inflated auditory bullae (Goals Project 2000). The State considers the San Pablo vole a Mammal Species of Special Concern (California Department of Fish and Game 2009).

Taxonomy. Data from a recent study by Conroy and Neuwald (2008) suggest two phylogeographic groups that are largely discordant with the boundaries of 17 currently recognized subspecies. Given this finding, reassessment of the genetic identity of San Pablo vole is recommended.

Distribution

The San Pablo vole is an endemic species, known from the salt marshes of San Pablo Creek, Contra Costa County, on the south shore of San Pablo Bay (Hall 1981; **Figure C-2**).

Life History and Ecology

California voles are herbivores; they feed on *Sarcocornia pacifica* (pickleweed) and other marsh vegetation (Goals Project 2000). They make extensive burrows, create runways through the vegetation, and often utilize driftwood for cover. California voles are good swimmers, and can swim underwater for 20 seconds and up to 20 feet (Fisler 1961). California voles in San Pablo and Suisun bays were able to withstand episodes of record flooding during the winter of 1982-1983 (Williams 1983).

The California vole population shows a strong fluctuation in numbers (four orders of magnitude) in the San Francisco Bay region (Goals Project 2000). The population builds up to a peak every 3 or 4 years, then declines rapidly to extremely low density or local extinction, probably due to predation (Ingles 1965). California voles in grassland communities are considered *keystone species* because of their vital role as prey species to mammalian and avian predators (Pearson 1985), and their potentially great effect on vegetation (Lidicker 1989); however, their role in tidal marsh habitats in this regard is not understood.

A population of California voles may increase rapidly. The gestation period is 3 weeks, with breeding throughout the year (Ingles 1965), but mainly in the wet season and especially from February through May (Goals Project 2000). Litters average 4.2, and range from 1 to 9, young. Ovulation and breeding may occur again as early as 15 hours after the young are born. Young are weaned after two weeks (Ingles 1965).

California voles exhibit intriguing interactions with other small rodents. The western harvest mouse (*Reithrodontomys megalotis*) appears to be positively correlated with California vole abundance at moderate densities, possibly because the harvest mice use the vole runways. However, when vole populations irrupt, competition is severe and western harvest mice abundance declines (Heske *et al.* 1984). Similar interactions may occur between voles and salt marsh harvest mice (*Reithrodontomys raviventris*; Geissel *et al.* 1988).

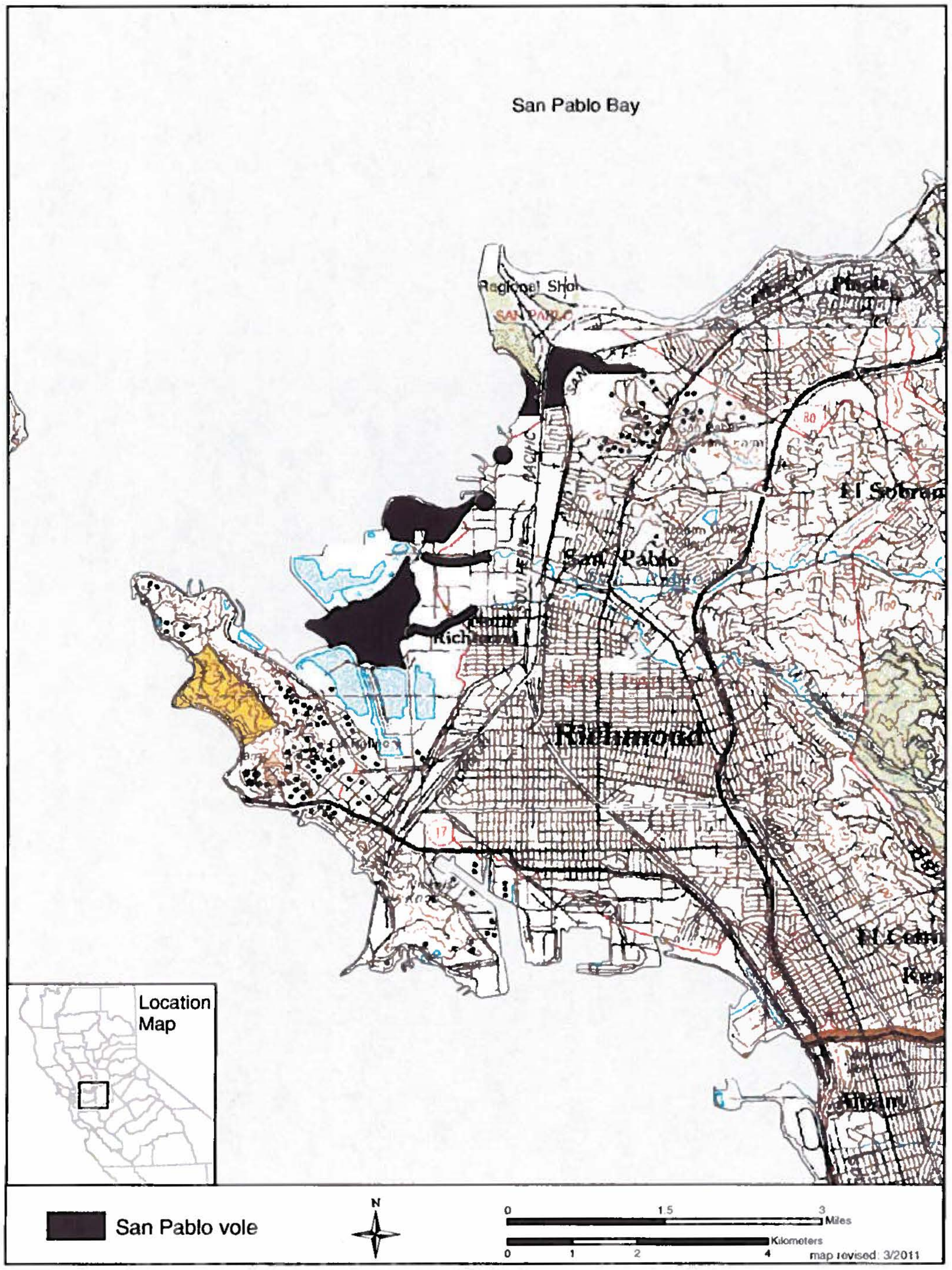

Figure C-2. Distribution of San Pablo vole

Habitat

Voles use habitat that extends from salt and freshwater marshes up to adjacent upland grasslands.

Threats

Most species covered in this recovery plan are threatened by similar factors because they occupy the same tidal marsh ecosystem. These general threats, faced by all covered species, are discussed in greater detail in the Introduction section of this recovery plan (section I.D.).

Conservation Strategy

Little is known about the San Pablo subspecies of California vole, therefore, basic surveys and research must be conducted to determine the conservation needs of the subspecies. Research should quantify population numbers, and examine demographic parameters, habitat requirements, threats, and other issues. Since most of the research on voles has been conducted on grassland populations, little is known about marsh populations of voles (Goals Project 2000). Marsh populations may have very different dynamics (Goals Project 2000) than those of grassland species. Given that recent evidence has suggested the possible division of California voles into two different species (Conroy and Neuwald 2008), genetic analysis is needed to better understand the genetic identity of the subspecies San Pablo vole. Monitoring of San Pablo vole throughout it's its historic range should be a priority. Also, prompt control and continued monitoring of invasive *Spartina* in San Pablo Creek area (Contra Costa County) tidal marshes is needed to prevent degradation of remaining habitat. Any tidal marsh projects in the vicinity should make compatibility with and enhancement of San Pablo vole populations a high priority. A comprehensive management plan for the species should be prepared to mitigate threats if this is found to be necessary.

4. California black rail
(*Laterallus jamaicensis coturniculus*)

Description and Taxonomy

The California black rail (*Laterallus jamaicensis coturniculus*) is relatively small, averaging only 13 centimeters (5 inches) in length, about the size of a large sparrow (**Figure C-3**). It has a wingspread of 25 to 28 centimeters (10 to 11 inches), distinctive red eyes, a short, black bill (1.5 centimeters / 0.5 inch in length), black plumage with white speckling on the back and sides, and a maroon or chestnut nape patch (Cogswell 1977, Trulio and Evens 2000). The California black rail is a subspecies of black rail (*Laterallus jamaicensis*) endemic to California and western Arizona.

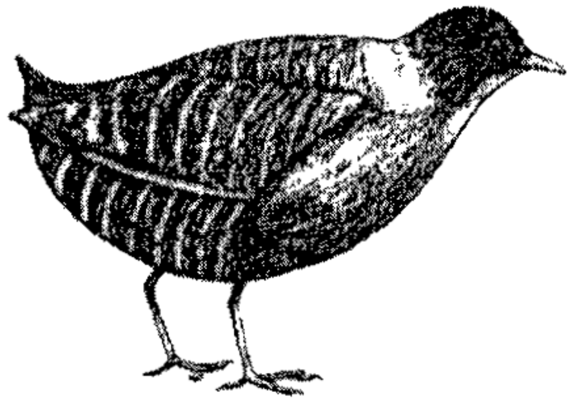

Figure C-3. California black rail (reprinted from Status of Rare, Threatened and Endangered animals and Plants of California [Annual Report 2000], California Department of Fish and Game)

The California black rail is extremely secretive and seldom seen (even less than California clapper rails), so the calls are the best identifiers. There are four distinct calls of the black rail. The most characteristic is the mating call which is described as a "kic-kic-ker" and is repeated several times in succession. It is heard most extensively in the spring during the breeding season. Another call is a low growling "grr-grr-grrr," believed to be a territorial call. It is also repeated several times in succession, and is heard throughout the year. A third call is a "yelp" that is given when the bird is startled, or as a prelude to the "kic-kic-kerr" and "grr" calls. The last, a "croo-croo-croo," is seldom heard (Reynard 1972, Reese 1975, Trulio and Evens 2000).

Population Trends and Distribution

Historical distribution. The historical range of the California black rail has been documented as central and southern California, from Bodega Harbor, Sonoma County, and the San Francisco Bay Estuary south to San Diego Bay in the United States, and Baja California in Mexico (Trulio and Evens 2000, Wilbur 1974, Grinnell and Miller 1944*b*). There are breeding records early in the century from coastal marshes in San Diego, Los Angeles, and Santa Barbara counties, but because of habitat loss associated with urbanization the black rail has been extirpated as a breeding species on the southern coast (Evens *et al.* 1991).

Current distribution. Currently, the majority (greater than 80 percent) of California black rails occur in the northern reaches of the San Francisco Bay Estuary, especially the tidal marshes of San Pablo Bay and associated rivers, and in some areas of Suisun Bay and Carquinez Strait (Evens *et al.* 1991; **Figure C-4**). The only other confirmed locations of breeding populations on the California coast in recent years were at tidal marshes of Morro Bay, Bolinas Lagoon, and Tomales Bay (Evens *et al.* 1991, Nur *et al.* 1997), and a possible small breeding population in Bodega Harbor in 1993 (Evens and Nur 2002).

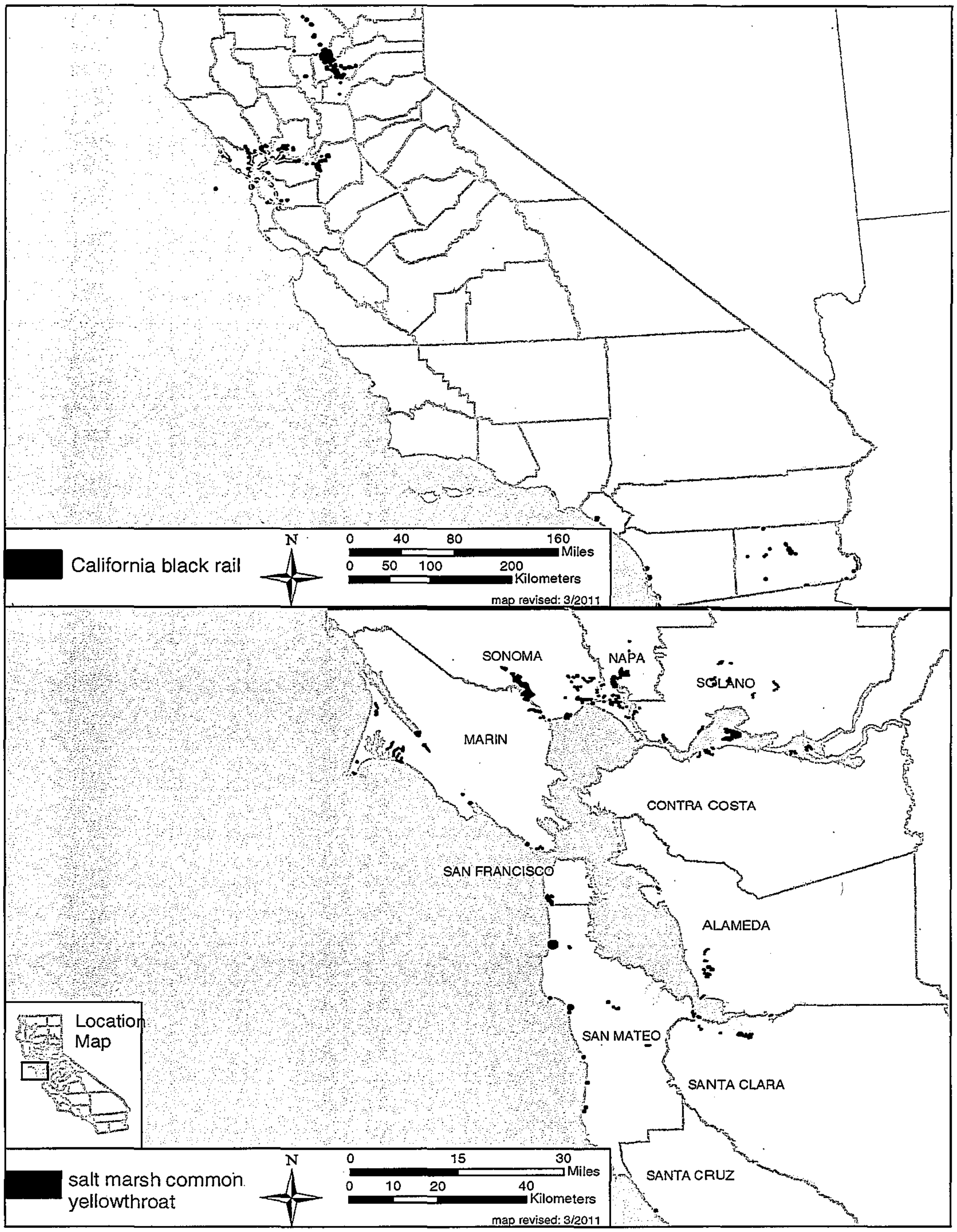

Figure C-4. Distribution of California black rail and salt marsh common yellowthroat

Within the San Francisco Bay Estuary, areas of highest concentrations of black rails are in the northern portions, primarily the brackish tidal marshes of San Pablo Bay and the Suisun Marsh area. Some of the most important marsh habitats of this species include the Petaluma Marsh (California Department of Fish and Game, Petaluma River Wildlife Management Area) along Black John and Fagan sloughs; Coon Island in the Napa Marsh (California Department of Fish and Game); some bayshore marshes of San Pablo Bay; and marshes of Suisun Bay, where they are patchily distributed (Evens *et al* 1989, Nur *et al.* 1997). Evens *et al.* (1989) conducted a survey of the entire estuary from 1986 to 1988, and detected 608 rails at 1,168 stations. All but two rail detections occurred in the northern reaches of the San Francisco Bay Estuary: San Pablo Bay (87 percent), Carquinez Straits and Suisun Marsh (20 percent), the Delta (5 percent), and south San Francisco Bay (less than 1 percent). No detections were made at Central Bay stations, although records suggest black rail presence there. Other field surveys in tidal marshes of Suisun Marsh suggest that black rails may be relatively widespread there, rather than sparsely or patchily distributed (Trulio and Evens 2000). The presence of territorial black rails during the breeding season has been interpreted as evidence that tidal marshes from San Pablo Bay to the western delta are generally occupied breeding habitats of the California black rail.

The distribution of the California black rail in San Francisco Bay itself is more limited than in the northern estuary. Post-breeding dispersal from North Bay area marshes may explain many historical winter records of black rails in south San Francisco Bay (Trulio and Evens 2000). The tidal salt marshes of Dumbarton Point have recently been occupied by black rails in low to moderate numbers, but the black rail population at the Corte Madera Ecological Reserve is believed to be extirpated (Trulio and Evens 2000). Evens *et al.* (1991) suggested that current low numbers in the southern reaches of the estuary may be due to a combination of predation during high tides and insufficient high tide refugia. They also suggested that black rails were formerly more abundant in the South Bay, but were nearly eliminated by the effects of diking and tidal marsh destruction (Evens *et al.* 1991). Re-occupation of suitable habitat is likely for black rails, which are good colonizers of isolated habitats, including recently created habitats (Evens *et al.* 1991, Aigner *et al.* 1995).

Abundance. Spautz and Nur (2002) conducted surveys for California black rails at 34 tidal marshes in San Pablo, Suisun, and northern San Francisco Bays and western Marin County in 2000 and 2001 to determine distribution and abundance, identify vegetation features that predict the presence of balck rails, and summarize information on nesting and nest site characteristics. Comparison of black rail detections in 200/2001 with earlier surveys by Evens and colleagues (Evens *et al*. 1991, Nur *et al.* 1997, and Evens and Nur 2002) indicated no marked trends comparing the 1980’s, 1996, and 2000/2001. Overall density estimates were also very similar to previous surveys at 2.63 birds/ha in San Pablo and 3.43 birds/ha in Suisun, providing further indication of no net population change from 1996 to 2000/2001.

Evens and Nur (2002) derived population estimates for each region: 289 rails in the outer coast marshes, 7,100 in San Pablo Bay and 7,200 in Suisun Bay.

There are no reports of black rails from tidal brackish or salt marshes north of Sonoma County (Doran Marsh, Bodega Harbor) where there may be a small breeding population (Bolander and Parmeter 2000). Black rails occur in tidal marshes of Tomales and Drakes Bay, and Bolinas Lagoon (Evens *et al.* 1991, Shuford 1993), including non-tidal brackish marshes of small lagoons and riparian ecotones (P. Baye pers. observ.). A small breeding population survives at Morro Bay, San Luis Obispo County (Evens *et al.* 1991). The recent status of black rails in smaller estuaries between San Francisco Bay and Morro Bay (Pescadero Creek Estuary, San Mateo County; Elkhorn Slough and Salinas River mouth, Monterey County) is uncertain. These marshes lie within the species historical range, while suitable brackish marsh vegetation, similar to that of San Francisco Bay Estuary and coastal Marin County tidal marshes, is locally abundant (P. Baye pers. observ. 1995-2000). These marshes were not covered in the most recent comprehensive surveys of the species (Evens *et al.* 1991).

There is some evidence that California black rails are migratory, or exhibit wandering activity (Emerson 1904, Brewster 1907, Grinnell and Miller 1944*b*). Records of black rails document the species at a distance from marshes in late summer and fall, suggesting that rails may disperse from breeding grounds (Wilbur 1974). Gill (1977) suggests that Benicia State Recreation Area (Solano County) and Olema Marsh (Marin County) represent wintering areas in the San Francisco Bay. Most vagrant sightings have been in fall and winter, with a wider distribution documented during the winter season (Grinnell and Miller 1944*b*). Wilbur (1974) suggests that the movement of rails is sporadic rather than a true migration, while Gill (1977) suggests that birds considered to be vagrants or migrants may actually be residents. More research on the range and movements of this subspecies is necessary.

Life History and Ecology

Black rails nest from March through June, and lay four to eight eggs that are white or creamy in color with sparse brown spots. The nest is a cup of loosely woven fine grasses in a depression in the ground. It typically rests on damp ground or is elevated in vegetation up to 37 centimeters (15 inches) above the ground surface. Nests are interwoven with surrounding vegetation, which conceals and supports them. Nests have one entrance or opening. They are built slightly above the water level in shallow non-tidal areas, and are often disturbed by high spring tides, after which they are usually rebuilt (Wilbur 1974).

Limited data from the San Francisco Bay Estuary suggest that California black rails lay six eggs per clutch (Wilbur 1974). No incubation data for the San Francisco Bay Estuary populations are currently available. However, in Arizona, both male and female black rails may incubate eggs for approximately 17 to 20 days (Flores and Eddelman 1993). Black rail eggs are described as hatching one at a time, and the hatched chicks leave the nest almost immediately. Black rails have been observed to abandon nests if the nest is disturbed before or during egg laying (Huey 1916, Wilbur 1974). California black rails are territorial during the nesting season (Flores and Eddleman 1993).

Limited observational information is available on the foraging behavior and diet of black rails. They forage on the ground, consuming terrestrial insects, aquatic invertebrates, and possibly spiders and seeds (Trulio and Evens 2000). Black rails seldom leave the refuge of marsh vegetation. When flushed, they typically fly a short distance and return to the point from which they took flight (Huey 1916).

Habitat

California black rails are typically associated with coastal salt and freshwater marshes. Although they occur principally in tidal marshes, they prefer low salinity environments (Eddleman *et al.* 1994), so are characteristically found in brackish marshes. Cogswell (1977) found that black rails are typically associated with *Sarcocornia pacifica* (pickleweed) marshes. In the San Francisco Bay area, black rails use vegetation that varies from salt marsh dominated by *Sarcocornia pacifica*, *Distichlis spicata* (saltgrass), and *Spartina foliosa* (Pacific cordgrass) to brackish marsh assemblages with variable proportions of salt marsh dominants (*Sarcocornia pacifica*, *Spartina foliosa*), bulrushes and tules (*Scirpus californicus, Scirpus acutus, Bolboschoenus maritimus, Scirpus americanus*), and *Typha* spp. (cattails; Wilbur 1974, Manolis 1977, Evens *et al.* 1991, Nur *et al.* 1997, Spautz and Nur 2002). Spautz and Nur (2002) found that black rails prefer marshes that are saline to brackish and have high cover of *Sarcocornia*, *Bolboschoenus maritimus, Typha*, *Lepidium latifolium*, and/or *Juncus*).

Evens *et al.* (1986) identified other habitat variables that correspond to the presence of black rails. In the areas studied, vegetation height, abundance of *Frankenia salina* (alkali-heath), a plant indicator of high salt marsh, insect abundance, and amphipod abundance were the most important indicators of black rail presence. Post and Enders (1969) suggest that black rails may find tidal marshes more attractive than diked marshes with similar vegetation possibly because of higher food availability in tidal marshes, particularly those with sloughs. During particularly high tides, black rails prefer high marsh habitat (Page *et al.* 1989) where the vegetation canopy is free from submergence and provides cover (high tide refugia). Black rails may be able to use a range of vegetation types and plant species to provide high tide cover. At Corte Madera they even used *Foeniculum vulgare* (fennel), a feathery-leaved non-native upland weed that grows at the edge of the marsh (Evens and Page 1985). Evens *et al.* (1986) suggest that marsh elevation, tidal regime, and freshwater influence are important factors that predict the presence of rails and Spautz and Nur (2002) found that black rails prefer marshes that have a high density of plant stems or leaves within 10 cm of the ground; are near water (a bay or river); are large and far from urbanization; and are close to other large marshes.

Threats

Most species covered in this recovery plan are threatened by similar factors because they occupy the same tidal marsh ecosystem. These general threats, faced by all covered species, are discussed in greater detail in the Introduction section of this recovery plan (section I.D.). Specific threats to California black rail are described below.

The principal causes of historical decline of the California black rail are essentially the same as those that endangered the California clapper rail (*Rallus longirostris obsoletus*) and the salt marsh harvest mouse (*Reithrodontomys raviventris*): large-scale loss of tidal marsh habitat, and fragmentation and degradation of remnant tidal marsh habitat, particularly degradation of high tidal marsh. The remnant tidal marshes of San Francisco Bay Estuary serve as the largest refuge for black rails, yet this area equals only 15 percent of its historical range. The tidal marsh habitat that remains continues to be degraded by pressures of urbanization and associated land-use practices. Many areas of salt marsh in the San Francisco Bay have subsided in the past quarter-century because of human removal of groundwater resulting in a lack of suitable high marsh habitat. This may account for the absence of breeding season records in many portions of the bay (Manolis 1978). Further, diking of wetlands has either narrowed and compressed, or entirely eliminated, the high marsh/upland transition zone essential for high tide refugial habitat (Evens *et al.* 1991).

The impacts of predation, especially the bay area invasion of red fox, as well as concentration of tidal marsh habitat in small, fragmented patches, and loss of high marsh tidal refugia, are believed to be among the most significant factors in the decline of California black rails. They are especially vulnerable to predation during high tides when vegetation cover is submerged and they are exposed to predators, particularly in marshes that lack refugia (Evens and Page 1986). Predators include great egrets (*Casmerodius albus*), great blue herons (*Ardea herodias*), northern harriers (*Circus cyaneus*), gulls (*Larus* spp.; Evens and Page 1986), and domestic cats (*Felis catus*) and short-eared owls (*Asio flammeus*; Wilbur 1974). Impacts of predation on rails are probably exacerbated by the absence of transitional habitat between the marsh and upland habitat due to levee systems, and dikes that separate uplands and marshlands, particularly in south San Francisco Bay.

The numerous Bay Area dikes allow feral cats easy access to California black rail, as well as other rare species like California clapper rail, California least tern, western snowy plover, and salt marsh harvest mouse (American Bird Conservancy 2006). Specifically, five areas within the scope of this recovery plan were identified as sites where cat predation is considered a threat to sensitive bird species: Don Edwards San Francisco Bay National Wildlife Refuge, San Pablo Bay wetlands, Benicia State Recreation Area, Eastshore wetlands (Alameda County), and Elkhorn Slough (Monterey County) (American Bird Conservancy 2006).

Introduced foxes are abundant in urban and rural areas of San Francisco Bay, and are known predators of the California clapper rail and other tidal marsh species (Foerster and Takekawa 1991), so the highly opportunistic red fox (*Vulpes vulpes*) presumably is also a predator of black rails. No direct evidence of black rail predation by red fox is currently available.

Oil spills pose a threat to the quality of marsh habitat in the San Francisco Bay area, although the degree of impacts to black rails is unknown. Examples of oil spills in San

Francisco Bay include long-term leaks from the SS *Jacob Luckenbach* along the northern California coast since 1953; the Martinez Manufacturing Complex of Shell Oil Company, Peyton Slough, California, 1988; Tosco Corporation Avon Refinery spill, Martinez, California 1980; the Cape Mohican oil spill, San Francisco, 1998; chronic releases by Chevron from Castro Cove near Richmond, Contra Costa County; the Kinder-Morgan Suisun Marsh oil spill of 70,000 gallons from a pipeline rupture in April 2004; and a major spill of 58,000 gallons of oil from the *Cosco Busan* in San Francisco Bay, November 2007 (see **Appendix E**). Although high marsh habitat of black rails is less often inundated by high tides, buoyant oil tends to accumulate near the tidal marsh high tide lines for days or weeks after a spill so direct impacts and clean-up operation impacts may be severe for black rails. Clean-up operations are particularly likely to degrade high tide refugial cover for black rails, and activities would be likely to disturb or displace the secretive birds. Contamination of food items (insects, amphipods) within the diurnal intertidal zone by petroleum hydrocarbons may have toxic sublethal effects on black rails, however, no data are available.

Conservation Strategy

Past Conservation

Surveys for black rails have been conducted to better understand the distribution, status and habitat requirements of the black rail (Nur *et al.* 1997, Evens *et al.* 1991, Estrella 2008). Knowledge of black rail distribution and abundance is supportive of many conservation and planning efforts. California Department of Fish and Game and several non-profit conservation organizations, such as the Marin Audubon Society and Point Reyes Bird Observatory, have provided funding and/or staff time for these surveys.

Tidal marsh restoration and enhancement, particularly in relatively freshwater-influenced reaches of the San Francisco Bay Estuary, have substantial benefits for California black rails. Many tidal marsh restoration projects have provided improvements to habitat for the California black rail, particularly in brackish reaches of the northern parts of the estuary. The California Department of Fish and Game's Toy Marsh, along the lower Petaluma River, has established dense low brackish marsh with interspersed high marsh, and supports both black and clapper rails (P. Baye pers. observ. 1999). The recent tidal marsh restoration on the opposite bank of the Petaluma River, Carl's Marsh (Sonoma Land Trust and the California Department of Fish and Game) is rapidly developing suitable low marsh and has already re-established high marsh on the re-graded remnants of the bayfront dike; at least one black rail was detected there in 1999 (P. Baye pers. observ. 1999). Black rails have been detected in surveys of the largest and most rapid tidal marsh restoration in the estuary, Pond 2A (222 hectares [550 acres], California Department of Fish and Game, Napa Marsh), where they occur in mixed low marsh vegetation (*Typha*/*Bolboschoenus*/*Spartina*; Takekawa *et al.* 2001) which developed within a few years after the site's dike was breached. Numerous black rails were also detected from the 1980s through the 1990s in the brackish Lower Tubbs Island Marsh (near Midshipman Point at Tolay Creek mouth, San Pablo Bay National Wildlife Refuge; J. Evens *in litt.* 1998, L. Vicenzio pers. comm. 1999), which has been managed with tidegates that restrict but do not eliminate tidal flows.

The prospects of tidal restoration in units of hundreds to thousands of acres are currently greatest in San Pablo Bay, in salt to brackish marsh areas where black rail habitat potential is among the highest (and likely to develop fastest) in the San Francisco Bay Estuary. Sites currently acquired for restoration or under restoration planning in this estuarine subregion include Hamilton Wetlands, the former Bel Marin Keys Unit V site, the former Redwood Landfill north parcel, Cullinan Ranch and Pond 3, and Montezuma Wetlands. The largest single potential tidal marsh restoration site in the estuary, Skaggs Island on Sonoma Creek (3000+ acres), is being transferred from the U.S. Navy to the San Pablo Bay National Wildlife Refuge, and has great potential to support a large new black rail population.

Current Strategy

This conservation strategy pertains to the populations and habitats of California black rails found in tidal marsh ecosystems within the geographic limits of this recovery plan, from Morro Bay to Humboldt Bay, California; it does not consider black rail recovery in other ecosystems (southern California and Mexican tidal marshes, interior western states). In comparison to the recovery strategy for California clapper rails, the strategy for California black rail conservation places greater emphasis on the more brackish, freshwater-influenced reaches of the estuary instead of more saline reaches.

The most important near-term conservation action for California black rails is to protect and manage the largest remaining tidal and microtidal marshes of the San Pablo Bay and Suisun Bay areas. These marshes are critical to provide enough habitat and refuge to maintain viable populations. They also are essential to maintain robust, resilient source populations for eventual colonization of restored marshes.

The long-term conservation of California black rails in the San Francisco Bay Estuary depends on enlarging and spreading populations over more of the historical breeding range of the species, in extensive contiguous blocks of tidal brackish marshes with ample high marsh and upland transition refugial habitat to provide additional breeding habitat. Control of non-native predators (notably red fox and Norway rats), as proposed for the clapper rail, also is presumed to be an important conservation requirement for black rails.

Conservation of California black rails should aim to sustain and extend populations throughout its historical range. Tidal marsh restoration in southern Tomales Bay (former Giacomini Ranch), planned by the Golden Gate National Recreation Area (Philip Williams and Associates *et al*. 1993), is important for improving the viability of the population there. The spontaneous increase in tidal marsh in Morro Bay and Bolinas Lagoon during the last century suggests that tidal marsh restoration is not needed for black rails there, but population monitoring, predator monitoring, and marsh management (as necessary), especially for brackish marshes, would enhance conservation of black rails.

Elkhorn Slough and Pescadero Creek estuaries should be surveyed periodically for black rails. If detected, management of these areas should be adapted to support black rails.

Adaptive management actions should consider control of non-native predators if these are determined to be possible impediments to rail population establishment or viability. At Pescadero, adjustment of hydrology in diked brackish marshes (or portions of them) managed principally for California red-legged frogs (*Rana aurora draytonii*) should be evaluated to determine if both rare species can be managed without conflicts.

At Bodega Harbor, black rails should be monitored and protected against recreational disturbance, such as off-leash dogs. There are good opportunities to expand potential rail habitat by restoring tidal marsh along the armored banks of Cheney Gulch Creek in southeastern Bodega harbor. The feasibility of establishing tidal creeks within the flat alluvial fan and dredge spoil spill site adjacent to Cheney Creek should be investigated by qualified experts (a team of ecologists, hydrologists, and geomorphologists with expertise in regional tidal marshes and black rails), and implemented if it is feasible and likely to be beneficial to black rails.

There are other general conservation actions that should be taken to reverse the decline of the black rail in coastal California. These include: research into the causes of its decline in maritime salt marshes, and development of methods to stabilize, augment, or re-establish populations; studies into nesting success and nest site characteristics to determine factors that promote reproductive success and surveys at a wide range of marsh types, including muted, managed, and restoration sites, so that factors associated with black rail presence in those areas can be better studied; protection of populations against impacts from recreational water use such as boat-launching sites, inappropriately aligned marsh trails, noise and trampling impacts related to hunting, or dog-walking; continuatione and expand expansion of field surveys for black rails throughout the San Francisco Bay region (including the estuary and maritime tidal marshes) in order to better define the distribution, breeding status, and relative density of black rail populations; promotion of the need to protect and monitor black rails and their habitat in local and regional planning affecting tidal marshes; and; inclusion of black rails as high priorities for habitat management and restoration, to the greatest extent compatible with the greater needs of the ecosystem and other sensitive species.

Conservation criteria for California black rails are to protect existing populations, restore and enhance tidal marshes, and control non-native predators such that at least three black rail pairs occur and are reproductively successful per 2.5 acres of appropriate habitat throughout the San Francisco Bay. This density is based on current estimates for San Pablo Bay and Suisun Bay. Upon implementation of habitat restoration efforts, as proposed in this recovery plan, the overall black rail population is expected to expand. A further target for the species is that it should persist or be re-established in at least 75 percent of maritime tidal marshes where it once occurred within the plan area.

Song sparrow subspecies of the San Francisco Bay Estuary *(Melospiza melodia spp.)*
5. Alameda song sparrow, *Melospiza melodia pusillula*
6. San Pablo song sparrow, *Melospiza melodia samuelis*
7. Suisun song sparow, *Melospiza melodia maxillaris*

Description and Taxonomy

Three subspecies of the song sparrow (*Melospiza melodia*) are endemic to the San Francisco Bay Estuary (**Figure C-5**): Alameda song sparrow (*Melospiza melodia pusillula*), which occurs in salt marshes bordering south San Francisco Bay; San Pablo song sparrow (*Melospiza melodia samuelis*), found in salt marshes around San Pablo Bay (also sometimes called Samuel's song sparrow); and Suisun song sparrow (*Melospiza melodia maxillaris*), which inhabits the Suisun Marsh area. The Alameda song sparrow was first described in 1899, San Pablo song sparrow was first recognized as distinct in 1858, and the Suisun song sparrow was first described in 1909.

In general, song sparrows are small birds with a rounded outline, large feet, a conical bill, short rounded wings, and a long rounded tail that is pumped in flight (**Table C-1**). The eyebrow stripe is grayish, and a broad dark stripe borders the whitish throat. The body is a dull brown, gray and buff on the back, and is longitudinally streaked with black stripes that align into rows on the back and gather into an irregular spot on the chest. The lower belly is unstreaked. The coloration between the black streaks of the back is the best distinguishing feature of the three races: the Alameda song sparrow is yellowish gray or plain gray with yellow underparts, the San Pablo song sparrow is blackish olive-brown, and the Suisun song sparrow is dark reddish brown. Suisun song sparrows are nearly as large as typical terrestrial song sparrows (National Geographic Society 1983, Cogswell 2000).

Population Trends and Distribution

Historical distribution. At the turn of the century salt marsh song sparrows were distributed continuously over broad areas around Suisun Bay, most of San Pablo Bay, and the southern portion of San Francisco Bay. They were also distributed continuously along portions of central San Francisco Bay (Jurek 1974). Habitat loss has resulted in greater separation between the main portions of the range of each race, particularly between the San Pablo and Alameda races (Jurek 1974).

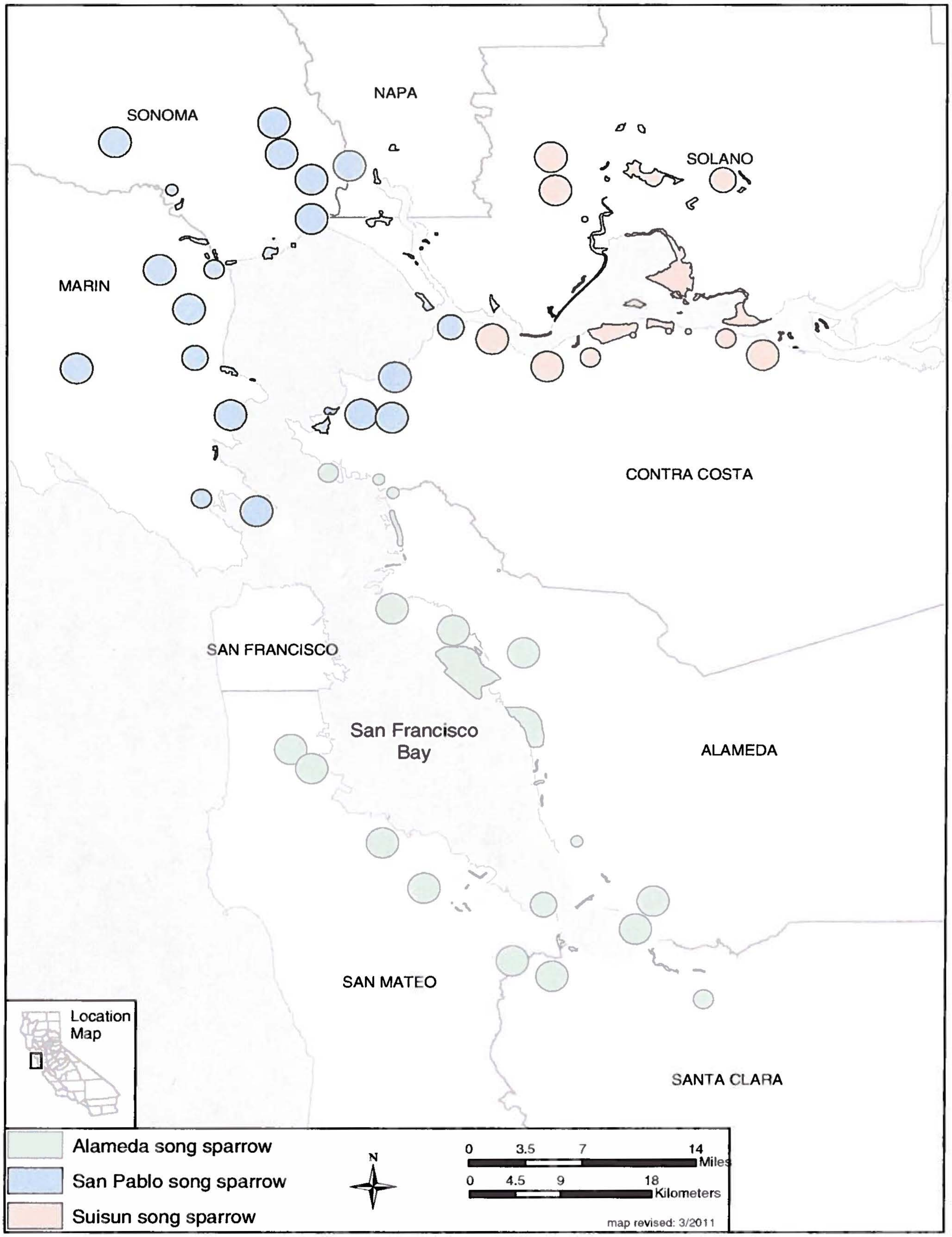

Figure C-5. Distribution of Alameda, San Pablo, and Suisun song sparrows

Table C-1. Physical characteristics of the three saltmarsh song sparrow races of the San Francisco Bay area.

Alameda (*M. m. pusillula*)	smallest of the subspecies lightest in dorsal ground color coloration on back is gray or yellowish gray yellow coloration over entire ventral surface
San Pablo (*M. m. samuelis*)	blackest in color of the three subspecies coloration on back is blackish, olive-brown
Suisun (*M. m. maxillaris*)	largest of the subspecies black streaks are wider coloration on back is dark reddish brown overall ground coloration is blackish brown sides are swollen and bulged laterally thickest bill

Alameda song sparrow. The main range of the Alameda song sparrow now extends from Coyote Creek (Alameda and Santa Clara counties), at the southern extremity of the bay, northward along the west shore of south San Francisco Bay to Belmont Slough (San Mateo County), and along the east shore to San Lorenzo (Alameda County). Small populations also occur in small marshes at the northeast shore of Richmond Inner Harbor at El Cerrito (Contra Costa County), along the shoreline from Emeryville to the Oakland Bay Bridge Toll Plaza (Alameda County), and at Arrowhead Marsh at the mouth of San Leandro Creek in San Leandro Bay (Alameda County). According to Nur *et. al*. 1997, nest success was approximately 16 percent at the Southampton Bay study site. Surveys indicate that densities of Alameda song sparrows were approximately 1.5 individuals per acre, which was the lowest density calculated for the three races of tidal marsh song sparrows. Compared to the habitat conditions found where San Pablo and Suisun song sparrows occur, the habitat for the Alameda song sparrow is the most fragmented, isolated, and is smallest in total area. The current breeding population estimate is between 13,400 and 20,000 birds, on the basis of the estimate of 4.2 to 6.3 birds per hectare and the assumption that 20 percent of adults are floaters (Nur *et. al*. 2000).

San Pablo song sparrow. San Pablo song sparrows currently are distributed in marshes around San Pablo Bay continuously from Gallinas Creek (Marin County) in the west, along the northern San Pablo bayshore, and throughout the extensive salt and brackish tidal marshes along the Petaluma, Sonoma, and Napa rivers (Marin, Sonoma, Solano counties), where they maintain high concentrations. Formerly more widespread from Richardson Bay to San Rafael Bay (Marin County), only small populations remain in small isolated marshes at the western extremity of Richardson Bay, along Madera Creek, and at the lower end of San Rafael Creek. Along the southeast shoreline of San Pablo Bay, isolated populations occur in small marshes between Wilson Point and Pinole Point (Contra Costa County), and at the mouths of San Pablo Creek and Wildcat Creek (Contra

Costa County). The current breeding population estimate is between 81,000 and 90,000 birds in 6,824 hectares of available habitat (PRBO Conservation Science, unpublished data).

Suisun song sparrow. Suisun song sparrows are distributed over most of their original range, in marshes from Martinez (Contra Costa County) eastward along the south bayshore of Suisun Bay to Pittsburg (Contra Costa County), then north of Suisun Bay throughout the extensive Suisun marshlands (Solano County). The large network of sloughs in the northern portion of the range is subject to daily tidal flows, and provides extensive areas of suitable habitat. The most recent estimate of the total number of Suisun song sparrows is 43,000 to 66,000 breeding birds on the basis of 5,578 hectares of tidal and muted tidal marsh in Suisun Bay (PRBO Conservation Science, unpublished data).

Each of the above-mentioned population estimates is derived from point count survey data and computer models. Nur *et al.* (1997) describes the calculations and models on which these estimates are based.

Reproduction and Ecology

These three tidal marsh song sparrows breed from March to June. They breed earlier than upland subspecies of song sparrows and thereby avoid inundation of nests during the highest spring tides (Johnston 1954, Johnston 1956*a*, Larsen 1989). Nests are typically placed in vegetation above the elevation of maximum tides. Nest building takes approximately four days, incubation 12 to 14 days, the young are in the nest nine to 12 days, and parental care takes five to eight more days, for a total brood attention period of approximately 26 to 34 days (Bent 1968). Clutch size averages 3.2 eggs per nest (Johnston 1956*b*). The productivity of all three races averages approximately 30 percent nest success (nest success defined as producing at least one fledgling; Nur *et al.* 1997).

Some specifics are available for Suisun song sparrows. Suisun song sparrows can have more than one brood per year. They can build up to three nests per year, but typically only two are attempted if the first is successful. Productivity per pair varies from 2.0 to 5.8 fledglings per pair per season (Johnston 1956*a*).

Tidal marsh song sparrows are known to eat small molluscs and other marine invertebrates in the intertidal mud, maturing heads of *Grindelia stricta* var. *angustifolia* (gumplant) flowers, and the fleshy fruits and tiny seeds of perennial *Sarcocornia pacifica* (pickleweed; Cogswell 2000). In spring and early summer, the young are fed almost entirely on insects. Preferred forage sites are under the muddy edges of small channels, but tidal marsh song sparrows also obtain food from marsh plant surfaces. These three subspecies of song sparrows are able to drink brackish water, up to a maximum salinity 50 percent of seawater (approximately 17 parts per thousand; Bartholomew and Cade 1963).

Tidal marsh song sparrows are highly sedentary. Individuals seldom move more than 9 meters (30 feet) from cover, and once a territory is established adults occupy it for their lifetime, seldom moving more than 100 meters (328 feet) away (Johnston 1956*b*). Juvenile dispersal is the main means by which individuals transfer between salt marsh song sparrow populations. Young birds are not as attached to their birth places as breeding adults are to their territories. Juvenile dispersal occurs between one and two months of age, and birds disperse independently of their siblings.

Habitat

The races of song sparrow occupy several habitats, such as riparian (freshwater streambank) vegetation and salt marsh. Marshall (1948) and Cogswell (2000) summarize the habitat requirements for all three subspecies of saltmarsh song sparrow as: (1) presence of nearby open water, (2) adequate exposure (open vegetation), (3) presence of a matrix of low vegetation with patches of taller plants (*Sarcocornia* and *Grindelia*) as perches, (4) exposed ground or leaf litter for foraging, and (5) piles of twigs or dense shrubs for concealed foraging and hiding. Song sparrows forage primarily along small tidal creeks with tall high marsh vegetation along the edges of banks. Pure *Spartina* marshes are not known to be used as habitat. Large *Sarcocornia* marsh plains along northern San Pablo Bay support high densities of song sparrows.

Song sparrows use freshwater marsh, riparian vegetation along stream courses, coastal scrub, brackish marsh and salt marsh (Marshall 1948, Cogswell 2000). Non-tidal seasonal wetlands may be used for foraging, but much less than fully tidal marsh. Non-tidal salt marshes are not known as nesting habitat. During the breeding season song sparrow pairs occupy small territories strung singly along the edges of sloughs and bays. Each territory must have enough area for nesting and foraging, including tidally exposed mud, water, light and vegetation (Walton 1975). Vegetation is required for nesting sites, song perches, and concealment during foraging. The vegetation must also produce or harbor food, which is picked up on the ground in the form of seeds or invertebrates. In a 1996 study the mean number of song sparrows detected was higher as percent cover of vegetation increased, with the highest number of detections associated with 90 to 100 percent cover (Nur *et al.* 1997). While vegetation cover seems to be positively correlated with song sparrow abundance, no particular plant seems to affect abundance, although data suggest that *Spartina* may decrease suitability of marsh habitat and thus song sparrow abundance. Further, channel density in marshes is positively correlated with salt marsh song sparrow abundance. Marsh area seems to be more important in determining song sparrow abundance when marshes are isolated (greater than 1 kilometer [0.6 mile] apart). In six isolated marshes, density increased with marsh area (Nur *et al.* 1997).

Threats

Most species covered in this recovery plan are threatened by similar factors because they occupy the same tidal marsh ecosystem. These general threats, faced by all covered species, are discussed in greater detail in the Introduction section of this recovery plan (section I.D.). Specific threats to each of the song sparrow species of San Francisco Bay are described below.

Alameda song sparrow. The Alameda song sparrow has been affected by urbanization and habitat loss throughout its range. Few remaining areas of complex salt marsh exist, and only about 10 percent of its original habitat area remains (Marshall and Dedrick 1994). This subspecies is the most threatened of the three subspecies. Threats to the Alameda song sparrow are significant because its population size is low and much of its habitat is highly fragmented, consisting of small, isolated marshes that support low densities of song sparrows. Reproduction rates are fairly low at 16 percent nest success (Nur *et al.* 1997), which may not be adequate for long-term population stability.

San Pablo song sparrow. The San Pablo song sparrow has been affected by urbanization in the southern portion of its range. In this area, the salt marsh has been filled, and much of the remaining vegetation occurs in narrow fringes along landfills. Remnant populations of song sparrows in this area rely on upland vegetation for food and cover. Throughout the *historic range* of the San Pablo song sparrow, diking to form pasture, agricultural lands, and salt evaporation ponds has destroyed much of the original marshland. Only 22 percent of the original tidal marsh area remains (Marshall and Dedrick 1994). Diking may not have as grave an effect on this subspecies, however, as San Pablo song sparrows appear to be abundant in diked habitat and nearby uplands (I. Pisani pers. observ.). Research is necessary to quantify habitat use, and the extent to which use of diked habitats affects reproductive success or survival.

Suisun song sparrow. The Suisun song sparrow has also been affected by urbanization and industrial development in the southern portion of its range. Only 13 percent of the estimated original marsh area remains (Marshall and Dedrick 1994). In the northern portion of the range, habitat has been extensively modified and degraded by diking and channelizing for agriculture and seasonal marsh management (Larsen 1989). The population in this area is reduced to isolated groups of individuals in remaining marsh patches. Management of the marsh occasionally eliminates sparrow habitat when *Sarcocornia* or tule flats are allowed to dry out or flood.

All three subspecies. Risks are high for each of the three subspecies due to their highly sedentary nature and severely fragmented habitat. For example, in the case of the Suisun song sparrow, isolated pockets of small populations presently exist with little or no gene flow between them (Larsen 1989). Small isolated populations, in general, are vulnerable to local extinction resulting from chance catastrophic events (*e.g.,* prolonged drought). Habitat modification, such as discing behind levees or urbanization, may amplify this vulnerability.

A study of Suisun and San Pablo song sparrows at Rush Ranch and China Camp State Park indicated that while nest survival of both species showed a significant increase at Rush Ranch between 1997-2005 (and was higher than at China Camp State Park in 2005), population density at China Camp State Park has been significantly higher than at Rush Ranch (Point Reyes Bird Observatory 2007).

A high rate of predation by diurnal birds of prey during high tides, when song sparrows are exposed at the tips of vegetation and on the tops of levees, poses a serious threat to survival of individuals of each subspecies. Other predators include voles (*Microtus californicus*), shrews (*Sorex* spp.), skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), feral house cats (*Felis catus*), scrub jays *(Aphelocoma californica*), common crows (*Corvus brachyrhynchos*), ravens (*Corvus corax*), gulls (*Larus* spp.), herons, and egrets (Larsen 1989). Mortality of egg and nestlings is about 50 percent in the first three weeks; the major agents are rodents and high water (Johnston 1956*b*). Mortality rates for the Suisun song sparrow are fairly high at 80 percent during the first year of life, and 43 percent per year for adults (Larsen 1989).

Conservation Strategy

Past Conservation

Numerous habitat acquisitions and restoration projects aimed at improving conditions for the California clapper rail (see species account; also Introduction) have incidentally provided benefits to the three subspecies of saltmarsh song sparrows. In the North Bay, restoration of Muzzi Marsh (Corte Madera) and north White Slough (Vallejo) have improved habitat extent and quality for San Pablo song sparrow. Ongoing restoration projects that will probably also benefit San Pablo song sparrow include Pond 2A (Napa Marsh), Carl's Marsh (Petaluma River), Sonoma Baylands, and Tolay Creek. Restoration sites in the South Bay that have improved habitat conditions for the Alameda song sparrow include the Faber Tract, Outer Bair Island, and Hayward shoreline. The management of portions of Suisun Marsh by California Department of Fish and Game has increased suitability of some areas for the Suisun song sparrow.

The State California Fish and Game Commission was petitioned to list the Suisun song sparrow as endangered in 1988 (Marshall and Mewaldt 1988), and the Department of Fish and Game report prepared in response to the petition found that the listing was warranted. All three races of song sparrow are currently California Bird Species of Special Concern (Shuford and Gardali (2008).

Current Strategy

Habitat is the limiting factor in the numbers and locations of song sparrow populations in the San Francisco Bay Estuary. Therefore, protecting, enhancing, and expanding habitat should result in an overall increase in population numbers and distribution. Habitat expansion also can help decrease predation on song sparrows individuals and nests by reducing the edge effect. Strategies for conserving this species will be to:

1) protect and maintain breeding and dispersal habitat at and near known population sites for each subspecies of tidal marsh song sparrow, including control of non-native invasive species such as invasive *Spartina;*
2) restore and enhance habitat to allow for maintenance and expansion of the breeding range;
3) increase patch size and connectivity of small or isolated marshes;

4) conduct and apply research on the basic demographicsdemography of each subspecies, including predation and other sources of mortality, on habitat preferences and factors affecting habitat quality, and clarify genetic differentiation between subspecies of song sparrows, and;
5) develop peer-reviewed population viability analyses, with parameter sensitivity analyses, to evaluate the security of each song sparrow subspecies, and apply adaptive management and restoration efforts to improving the viability of each subspecies to at least 95 percent probability of persisting over 100 years.

8. Salt marsh common yellowthroat *(Geothlypis trichas sinuosa)*

Description and Taxonomy

The salt marsh common yellowthroat (*Geothlypis trichas sinuosa*) is a small wetland-dwelling warbler of the subfamily Parulinae. It is also referred to as the San Francisco common yellowthroat (Terrill 2000). Thirteen subspecies of the common yellowthroat are currently recognized (Guzy and Richison 1999). The saltmarsh common yellowthroat was first identified as a distinct subspecies by Grinnell (1901). He described this subspecies as being darker dorsally and laterally, and smaller than the other two subspecies of common yellowthroats found in California: western yellowthroat (*Geothlypis trichas occidentalis*) and tule yellowthroat (*Geothlypis trichas scirpicola*). The wing lengths of subspecies *sinuosa* are significantly smaller than the wing lengths of subspecies *scirpicola* and *occidentalis* (Foster 1977*a*, 1977*b*).

The adult male salt marsh common yellowthroat has a bright yellow throat with a contrasting black facial mask edged with white towards the crown. Its crown, back, wings, and tail are olive-green with a bright yellow breast fading into dull white on the belly, and yellow undertail coverts. The adult female yellowthroat lacks the male’s black mask. It has olive-green on its face, crown, back, wings, and tail, and a pale yellow eye ring. Immatures of 20 to 30 days of age resemble the adult female except that their throats and breasts are olive in contrast to the brighter yellow plumage of the adult bird (Hobson *et al.* 1986). At 30 to 40 days of age, young yellowthroats may be indistinguishable from adult females. Young males molt into adult plumage, including the black mask, beginning in early fall.

Population Trends and Distribution

The breeding range of the salt marsh common yellowthroat is bounded by Tomales Bay, Marin County, and Napa Sloughs, southern Sonoma County, on the north; east to the Carquinez Straits, Suisun Marsh, Solano and Contra Costa counties; and south to the vicinity of San Jose, Santa Clara County and Pescadero, San Mateo County (Grinnell and Miller 1944*a*; Foster 1977*a*, 1977*b*). Within this range, all specimens collected between March and August were subspecies *sinuosa* (Foster 1977*a*, 1977*b*), and, during this period no salt marsh common yellowthroats were collected outside this range. Salt marsh common yellowthroats are considered residents. It appears that the majority of common yellowthroats winter in tidal marsh habitats along the margins of the San Francisco Bay, although the collection of specimens outside the breeding range suggests a migratory element. In fact, salt marsh common yellowthroats have been found on wintering grounds as far south as San Diego County (Grinnell and Miller 1944*a*). While little is known of their migratory or dispersal habits, protection of small tidal marshes in southern California may be important for maintaining sufficient winter and stopover habitat. There is an influx of other races of common yellowthroats into the San Francisco Bay area during migratory periods and in winter.

Historical distribution. Data from a range of sources indicate that the salt marsh common yellowthroat occupied 51 known locations within Alameda, Santa Clara, San Mateo, San Francisco, Marin, Napa, Sonoma, Solano, and Contra Costa counties (Terrill 2000, Hobson *et al* 1986).

Current distribution. The current abundance and distribution of the salt marsh common yellowthroat is largely unknown because of a lack of comprehensive contemporary surveys (**Figure C-4**). Surveys conducted in 1977 and 1985 indicate that the species is present in all counties in which it was known historically (Foster 1977*a*, 1977*b*; Hobson *et al.* 1986, Nur *et al.* 1997). However, salt marsh common yellowthroats were only present at 19 out of 51 historic locations (37 percent) within the counties above. Breeding salt marsh common yellowthroats were absent from many areas where suitable habitat was found, and a few sites occupied in 1975 were not occupied in 1985. These findings suggest that there may be other, unknown limiting factors to population numbers and distribution.

Surveys focused on smaller portions of San Francisco Bay have increased our understanding of the distribution of this subspecies. For example, an abundance of salt marsh common yellowthroats was found along the Napa River and vicinity (Sogge 1989). In this area saltmarsh common yellowthroats used fresh or brackish marsh habitats of tules or *Sarcocornia* (pickleweed) with adjacent areas of upland shrubs. Salt marsh common yellowthroats were documented at Edgerley Island, Mud Slough, Fly Bay, Fagan Slough, Bull Island, Steamboat Slough, John F. Kennedy Park, and at the Tulucay Creek Sewage Disposal Plant (Sogge 1989). They also were found in the northern portions of Hamilton Field, Marin County, including riparian and other wetland areas at Pacheco Creek and areas north of Ammo Hill (LSA 1986). Other site-specific surveys have resulted in documentation of salt marsh common yellow throats and suitable habitat.

The distribution of the salt marsh common yellowthroat is patchy; none were detected at about half of all marshes surveyed (Nur *et al.* 1997). While Hobson *et al.* (1986) detected no yellowthroats in Contra Costa County, their presence was verified in Nur *et al.*'s 1996 surveys (Nur *et al.* 1997). Using the Marshall and Dedrick (1994) estimate of available tidal habitat, total breeding population size was estimated to be approximately 6,000 to 11,000 individuals throughout the San Francisco Bay (Nur *et al.* 1997). These numbers reflect the abundance for tidal marsh habitat only; the breeding population could be higher considering salt marsh common yellowthroat use of brackish, riparian, upland

and freshwater marsh habitats (Hobson *et al.* 1986). Field verification is needed. In 2000, population estimates in tidal marsh were much lower: 500 in San Pablo Bay and 70 birds in Central/South San Francisco Bay (PRBO Conservation Science, unpublished data), but again do not include other suitable habitats.

Life History and Ecology

The nesting season of the salt marsh common yellowthroat extends from early March through late July. Males begin establishing and defending territories by mid-March; females appear in the territories about a week later. The female yellowthroat constructs the nest, which is typically placed no higher than 60 centimeters (23.6 inches) above the ground, close to water, and well concealed in dense vegetation. The nest is constructed of grasses and sedges held firmly to the surrounding vegetation and covered by loosely woven materials (Erlich *et al.* 1988). The first clutch is laid within a week after completion of the nest (Foster 1977*a*, 1977*b*). Yellowthroats lay three to five eggs, which are white or cream colored and speckled with brown or black markings. The eggs are incubated for 12 days. The young stay in the nest for 10 days, and are fed by both parents for at least two weeks after fledging. Their diet is composed almost entirely of insects. Yellowthroats frequently raise two clutches in a year. Fledglings from the first brood often are still being fed by their parents when the second clutch is started.

Yellowthroats are primarily insectivorous. They glean insects on or near the ground (to about 1.5 meters [5 feet] above the ground or water) from low herbaceous vegetation, bushes, and small trees, or from the surface of mud. They appear to forage higher above the ground during the nonreproductive period (Shuford 1993). Yellowthroats in California eat 99.8 percent animal matter (Shuford 1993). The main dietary items in a sample of 114 individuals were ants, wild bees and wasps, true bugs, beetles, caterpillars and moths, flies, grasshoppers, and spiders. Yellowthroats bring food to their young more frequently as the young grow older. Feedings increase from approximately every 20 minutes for hatchlings to roughly every five to seven minutes when nestlings reach a week in age (Stewart 1953; Foster 1977*a*, 1977*b*).

Habitat Characteristics/Ecosystem

Salt marsh common yellowthroats are winter residents of tidal marshes, but occur in other habitats (often wetland ecotones), such as riparian thickets, freshwater marshes, marshy coastal forb vegetation, and brush or scrub near wetlands (Terrill 2000). Preliminary data from the San Francisco Bay indicate that salt marsh common yellowthroats rely on natural and artificial channels in marshes, and that their abundance is significantly greater in marshes with more channels. Salt marsh common yellowthroats are associated with large amounts of brackish marsh vegetation, notably *Bolboschoenus* spp. (bulrush) and *Typha latifolia* (common cattail), and non-native *Lepidium latifolium* (perennial pepperweed). Although *Sarcocornia* spp. is often the dominant plant in tidal marshland, the more *Sarcocornia* present, the fewer salt marsh common yellowthroats (Nur *et al.* 1997).

Yellowthroats frequently use borders between various plant communities, and territories often straddle the interface of riparian corridors or the ecotones between freshwater or tidal marsh and upland vegetation (Shuford 1993). Outside of the breeding season some populations of salt marsh common yellowthroat shift habitat use from brackish or freshwater marshes to more saline marshes dominated by *Sarcocornia* or *Spartina*.

Salt marsh common yellowthroats nest in a variety of habitats around San Francisco Bay wetlands and adjacent uplands. Nesting territories were observed in five habitat types: brackish marsh, salt marsh, riparian woodland or swamp, freshwater marsh, and upland/or grassland (Hobson *et al.* 1986). Most breeding (60 percent in the San Francisco Bay region) occurs in brackish marsh, about 5 percent in salt marsh, and the remainder in other wetland or peripheral wetland habitats. Moisture appears to be the factor common to all types of breeding habitat. Nesting occurs in areas in or next to wet ground and dense vegetation (Hobson *et al.* 1986).

Threats

Most species covered in this recovery plan are threatened by similar factors because they occupy the same tidal marsh ecosystem. These general threats, faced by all covered species, are discussed in greater detail in the Introduction section of this recovery plan (section **I.D.**). Specific threats to salt marsh common yellowthroat are described below.

Extensive reductions in extent and suitability of habitat for tidal marsh species, including the salt marsh common yellowthroat, have occurred in the San Francisco Bay Estuary since the Gold Rush. Only a small portion remains of the historical acreage of tidal salt and brackish marsh, and remaining areas of suitable nesting habitat for salt marsh common yellowthroats are separated by extensive expanses of unsuitable or degraded habitat, such as industrial salt ponds and agricultural diked baylands. Salt marsh common yellowthroat habitat in the modern estuary is now mostly confined to narrow fringing tidal marshes outside of dikes. Some remaining brackish and salt marshes in South San Francisco Bay have been converted to dense tule and bulrush vegetation by wastewater discharges. Habitat fragmentation in the estuary is expected to impede breeding population connectivity for the salt marsh common yellowthroat.

Remaining habitat is threatened by activities ranging from land development to development of diked baylands to removal of riparian vegetation associated with small flood control actions, such as channel maintenance and placement of riprap on stream banks. Many such activities cause loss or degradation of habitat. For example, shore access for recreational uses of water bodies often results in clearing of bankside vegetation and thus reduces suitability of some wetlands for breeding salt marsh common yellowthroats. Decreases in, or changes in location of, freshwater stream inputs cause losses and/or shifts in marsh vegetation, which has resulted in temporary or permanent local extirpations of salt marsh common yellowthroats, since their territories are typically associated with moist conditions or a close proximity to open water (Grinnell and Miller 1944*a*; Foster 1977*a*, 1977*b*; Hobson *et al.* 1986). Untimely heavy streamflows during the breeding season can inundate low-lying nests or topple vegetation causing reproductive failure.

Urban development, grazing, and some recreational land uses that impact salt marsh common yellowthroat habitat also facilitate the proliferation of brown-headed cowbirds (*Molothrus ater*) and predators. Common yellowthroats are known to be hosts to the brown-headed cowbird, brood parasites that lay eggs in the nests of other species, reducing nest success (Mayfield 1977, Brittingham and Temple 1983, Whitfield 1994). Parasitism is known to be a significant mortality factor in yellowthroats elsewhere (Stewart 1953), and researchers at the Kern River Research Center (Kern County, CA) have documented high rates of parasitism of common yellowthroat nests along the South Fork of the Kern River (S. Laymon pers. comm. 1997, H. Spautz pers. comm. 1997). According to Geupel *et al.* (1997), common yellowthroats in the lower Sacramento River region, the San Luis Refuge, and Cosumnes River are at a high risk of brood parasitism. There have been no direct observations of predation or parasitism, but the presence of brown-headed cowbirds in salt marsh common yellowthroat habitats has been documented (Hobson *et al.* 1986). Brood parasitism is hard to detect without careful monitoring of nests.

Salt marsh common yellowthroats may be susceptible to high rates of predation. Reduction of cover, especially in drought years or as a result of human disruption, can increase the incidence of predation. Predators that typically affect passerines include domestic cats (*Felis catus*), raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), red foxes, rats (*Rattus* spp.), crows and ravens (*Corvus* spp.), scrub jays (*Aphelocoma californica*), and snakes and raptors.

Conservation Strategy

Past Conservation

The salt marsh common yellowthroat is a California Bird Species of Special Concern (Shuford and Gardali 2008) and a species of concern to the U.S. Fish and Wildlife Service. These designations do not afford the species legal protection under the California Endangered Species Act or Federal Endangered Species Act. However, this species' habitat is regulated by the Army Corps of Engineers and Environmental Protection Agency through section 404 of the Clean Water Act. The salt marsh common yellowthroat is also a species for which impacts and conservation measures are typically addressed in environmental impact analyses. Federal funding has been allocated towards projects that contribute to the understanding of the status of the salt marsh common yellowthroat. The 1986 survey by the San Francisco Bay Bird Observatory (Hobson *et al.* 1986) was partially funded by the U.S. Fish and Wildlife Service as a means of determining whether the status of the species warranted listing. This species is protected from direct take by the Migratory Bird Treaty Act although this Act is not easily enforced. The Point Reyes Bird Observatory, funded by the Biological Resources Division of the U.S. Geological Survey, conducted a four year study of tidal marsh songbirds including the saltmarsh common yellowthroat (Point Reyes Bird Observatory 2007). The common yellowthroat is listed as a priority in the Audubon Society and

Partners In Flight cooperative effort to develop conservation goals for California riparian obligate species (Evans 1997).

Numerous tidal marsh restorations and enhancements are likely to increase the extent and suitability of habitat for the salt marsh common yellowthroat in the San Francisco Bay region. The mature brackish tidal marsh habitat conditions favorable to this subspecies, however, may take many decades to develop. Grazing management on National Park Service lands has reduced the impacts of grazing on riparian and coastal swale vegetation, increasing habitat suitability for the yellowthroat (*e.g.*, in the Golden Gate National Recreation Area).

Research efforts are ongoing to examine questions concerning the salt marsh common yellowthroat's distribution and degree of genetic difference from the upland subspecies *arizela*. Song patterns in breeding yellowthroats are being examined to determine if there are population differences (Rigney 1991). DNA fingerprinting is being carried out by researchers at the Coyote Creek Riparian Station, in cooperation with Dr. Will Gergits and Dr. Scott Terrill, to determine if there are genetic "markers" which indicate a separation of the saltmarsh and upland races (Rigney 1991). These techniques will assist in determining races of yellowthroats in the presumed zones of overlap to better define the exact range and genetic differences among races? Banding studies also are underway to determine the interactions between local populations.

Enhancement of habitat for associated, listed species are is expected to provide benefits to the salt marsh common yellowthroat. For example, habitat restorations aimed at increasing tidal marsh habitat for the California clapper rail and salt marsh harvest mouse will also increase extent of habitat for salt marsh songbirds.

Current Strategy

The principal conservation objective for the salt marsh common yellowthroat is to recover population numbers and distribution through restoration of suitable tidal wetland habitat, so that the species returns to a representative amount of its former range and abundance, and long-term conservation of the species is probable. Protecting, enhancing, and restoring estuarine habitats of the salt marsh common yellowthroat, primarily tidal brackish marsh and riparian ecotones, and limiting impediments to the reproductive success of individual populations, should result in an overall increase in population numbers and distribution. To meet these goals, the strategy for conserving this species will be to: 1) remove or decrease existing threats to salt marsh common yellowthroats and yellowthroat habitat at both breeding and wintering grounds; 2) protect and maintain breeding, wintering, and dispersal habitats at and near known population sites; 3) increase patch size and connectivity where small or isolated populations exist; 4) restore, enhance, and protect currently unoccupied habitat to allow for expansion of the breeding range and increased dispersal opportunities; and 5) conduct research on the ecology, habitat needs, and viability of this species. These measures should protect and enhance numbers of breeding pairs at known sites, and increase population numbers in areas where habitat exists but is not currently utilized by salt marsh common yellowthroats.

Because of the limitations of available census data, population conservation criteria are difficult to quantifydevelop. Attempts to quantify the population size of salt marsh common yellowthroats have resulted in vastly different estimates;, therefore, before conservation criteria are quantifieddeveloped, an accurate baseline population size estimate is critical. This will only be available after survey estimates are expanded to more sites within the species' range. More research is also needed to determine the minimum viable populations for this subspecies, interactions necessary between populations to ensure long term viability, reproductive rates necessary to ensure successful recruitment and population growth, and habitat area necessary to allow for population viability. Adaptive management in recovery plan implementation will allow for development of quantified conservation criteria as these information gaps are filled. These findings should subsequently lead to appropriate refinement of conservation actions and priorities.

9. Cicindela senilis senilis
(Old Man Tiger Beetle)

Description and Taxonomy

Description. Though not abundant, *Cicindela senilis senilis* is today the most frequently found tiger beetle species in the San Francisco Bay Estuary (**Figure C-6**; Maffei 2000*a*). Adults are 10-12 millimeters in length (slightly under 0.5 inch), usually dull brown with yellowish-white irregular markings above, and shiny metallic green to blue-green below. Abundant white hairs on the top of the head are responsible for its common names of old man tiger beetle and senile tiger beetle (Pearson *et al.* 2005); there is no officially recognized common name (Entomological Society of America 2005). Tiger beetles are characterized by large prominent compound eyes and long powerful sickle-shaped mandibles bearing small teeth. The eyes and head together are wider than the thorax. The filiform (thread-like) antennae are 11-segmented and tarsi are 5-segmented. Adults are quick runners and agile flyers. Larvae are S-shaped, yellowish-white grubs found in burrows.

Taxonomy. *Cicindela senilis* was described by G.H. Horn in 1866, and is a member of the tiger beetle family (Cicindelidae, which is sometimes included in the ground beetle family: Carabidae). Two subspecies are now recognized: *Cicindela senilis senilis* and *Cicindela senilis frosti* Varas-Arangua. *Cicindela senilis frosti* is known from Ventura County and south and is distinguished from *Cicindela senilis senilis* on the basis of its greener upper parts.

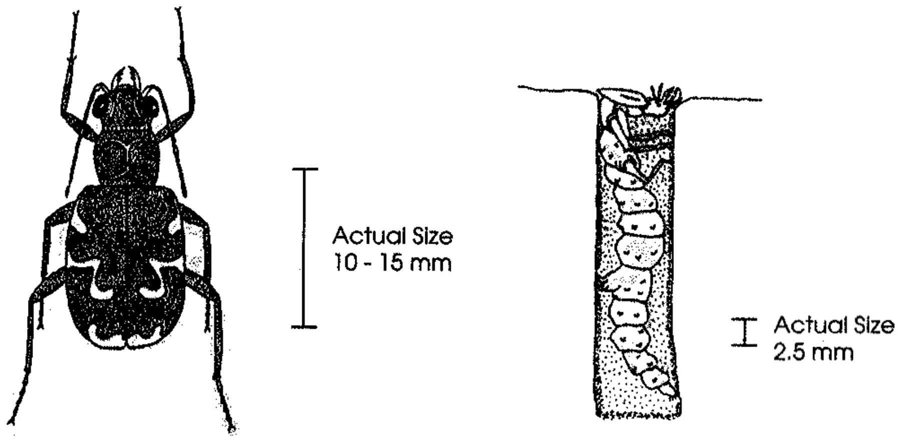

Figure C-6. ***Cicindela senilis senilis* adult and larvae** (with permission from Wes Maffei and U.S. Environmental Protection Agency)**.**

Distribution

Cicindela senilis senilis is endemic to California, and has been recorded from Santa Barbara County north to Sonoma and Lake counties (Pearson *et al.* 2005). While formerly found in salt marshes, tidal mud flats, and interior alkali mud flats, all but a few coastal populations appear to have been extirpated (Pearson *et al.* 2005). *Cicindela senilis senilis* was historically found in the San Francisco Bay Estuary, with populations also reported from San Rafael, Martinez, and Port Costa, although these three localities have not been re-surveyed in over 40 years (Maffei 2000*a*).

Four species of tiger beetles historically were recorded in the San Francisco Bay Estuary: *Cicindela haemorrhagica, Cicindela hirticollis, Cicindela oregona oregona, and Cicindela senilis senilis.* Only *Cicindela senilis senilis* and *Cicindela haemorrhagica* are known to remain. *Cicindela haemorrhagica* is thought to be in decline. The last documented population of *Cicindela oregona oregona* was destroyed in 1996 (Maffei 2000*a*).

Currently, *C. senilis senilis* is found around the south and central portions of San Francisco Bay. In addition, one population was identified at Grizzly Island in 1991 (Maffei 2000*a*), and one small population at American Canyon in 1999 and 2000 (W. Maffei pers. comm.). Less disturbed sites appear to support the largest populations (Maffei 2000*a*).

Life History

Little is known of the specific biology of *Cicindela senilis senilis.* However, tiger beetles are a well-studied group, and much can be extrapolated from general studies (Pearson 1988, Maffei 2000*a*).

Tiger beetles are predators, both as larvae and adults, and feed on a wide variety of arthropods (Pearson 1988). Adults tend to hunt along the muddy margins of their habitat, especially in sunny, warm conditions, while immature stages are found in drier areas (Maffei 2000*a*). Larvae excavate vertical burrows in suitable soil, where they lie in wait to capture passing prey with their sharp mandibles. Prey of tiger beetles around San Francisco Bay is known to include brine flies (*Ephydra cinerea*, *Ephydra millbrae*, *Lipochaeta slossonae*, and *Mosillus tibialis*) and various beetles in the families Carabidae and Tenebrionidae (Maffei 2000*a*), but tiger beetles generally will take almost any prey they can catch and kill, and some will feed on dead organisms. Prey availability appears to affect female survival and fecundity (Pearson 1988).

Female tiger beetles select a site, excavate a hole in the soil, deposit a single egg, and cover the hole. Soil type preference may be extremely specific in some species (Pearson 1988). Eggs, larvae, and pupae all develop underground. Larvae undergo three molts; time for development can last 1 to 4 years, but is not known for *Cicindela senilis senilis.* The last larval *instar* (stage between molts) plugs the tunnel entrance and excavates a pupal cell. Pupation is rapid, usually lasting no more than 30 days.

Cicindela senilis senilis larvae are present throughout the year, suggesting a multi-year life cycle, while adults are active between March and October (Pearson *et al.* 2005). Peak adult activity in the South San Francisco Bay is from late April through June (Maffei unpub. data). Adults overwinter in shallow underground galleries, usually under flat rocks at the edge of salt marshes (Pearson *et al.* 2005). Adults of *Cicindela senilis* that emerge in the fall are known to hibernate (Blaisdell 1912).

Habitat

Cicindela senilis senilis is found along open muddy margins of creeks and streams, and also along the muddy margins of salt pans that are occasionally inundated by high tides (Maffei 2000*a*). They favor the high dry banks of channels and open areas of levees associated with salt ponds and muted tidal marshes. Both adults and larvae prefer habitat that is exposed to full sun, near to permanent or semi-permanent bodies of water, with minimal to moderate vegetation, and with extensive areas of fine silty or sandy soil (Maffei 2000*a*). Larvae generally have more specific microhabitat requirements than adults and may tolerate less variation in physical factors (Pearson 1988).

Threats

Most species covered in this recovery plan are threatened by similar factors because they occupy the same tidal marsh ecosystem. These general threats, faced by all covered species, are discussed in greater detail in the Introduction section of this recovery plan (section **I.D.**). Specific threats to *Cicindela senilis senilis* are described below.

Tiger beetles are sensitive to habitat change and thus can act as indicator species of the health of coastal wetlands (Nagano 1982*a*). They are easily affected by vegetation or soil changes, flooding, and other factors; as wetlands degrade they disappear (W. Maffei pers.

comm.). While *Cicindela senilis senilis* is not particularly rare regionally, it is a central and northern California endemic and appears to live in disjunct populations, which may indicate a population decline. Habitat loss, degradation, and disturbance probably have contributed to the decline of this and other tiger beetles of the San Francisco Bay Estuary. Its disjunct populations are subject to the risks common to isolated populations. Contamination such as by oil spills could reduce or extirpate local populations. Adult beetles, including tiger beetles, are often attracted to artificial lights, especially those producing even small amounts of ultraviolet light (as most do). If true of *Cicindela senilis senilis,* nearby light sources could adversely affect survival and reproduction.

Conservation Strategy

Relatively little is known about the status or conservation needs of *Cicindela senilis senilis*. Habitat needs of the beetles—relatively open areas in the upper intertidal zones—may overlap with those of other species covered by this recovery plan, such as perhaps *Chloropyronmolle* ssp. *molle, Suaeda californica*, salt marsh harvest mouse, or others. Habitat needs and habitat relationships should be investigated and overlaps exploited to identify and develop projects to benefit *Cicindela senilis senilis* as well as other species. Surveys should be conducted in areas where the beetles have been found in the past, and in other appropriate habitat, to provide a baseline population census. Ongoing monitoring will be necessary to determine if populations are stable or declining. Research is needed to understand the biology of all life stages of the species, its ecology, and the threats facing it, in order to determine the level of protection needed. At present, the following conservation strategies are recommended:

1) Conduct surveys to determine distribution and, relative abundance, and to allow avoidance of project effects;
2) Protect habitat that supports the species;
3) Manage and enhance habitat to benefit the species;
4) Incorporate considerations for the species into appropriate restoration projects;
5) Consider reintroducing the species to suitable sites within its range if dispersal is not occurring, and take appropriate action and;
6) Conduct research on the habitat needs, demographyics, and ecology of the species as well as the importance of any threats, and adapt management in accordance with the results.

10. Lathyrus jepsonii var. jepsonii
*(*Delta tule pea)

Description and Taxonomy

Description. *Lathyrus jepsonii* E. Greene is a large climbing perennial herb (**Figure C-7**) in the Fabaceae (pea) family. The species is found in riparian and brackish estuarine wetlands. It has a showy inflorescence of 3 to 8 pink to purplish flowers, and fruits resembling those of garden sweet peas. The thick, somewhat fleshy leaves bear tendrils that allow the plant to climb.

Figure C-7. *Lathyrus jepsonii* var. *jepsonii* (illustration credit: Valerie Layne, USFWS)**.**

Taxonomy. Two varieties overlap geographically in the San Francisco Bay area. The widespread variety *californicus* (S. Watson) Hoover is distinguished by the fine pubescence on its stems and leaves and its terrestrial and wetland habitat. The glabrous (hairless) robust variety *jepsonii* is largely confined to freshwater and brackish wetlands of the Sacramento/San Joaquin River delta and the northern San Francisco Bay Estuary (Munz 1959, Isely 1993).

Population Trends and Distribution

Historical distribution. Most reported occurrences of *Lathyrus jepsonii* var. *jepsonii* are from the Delta (CalFlora 2000), but historical floras and herbarium collections emphasize occurrences in Suisun Marsh (Greene 1894, Jepson 1911, Munz 1959).

Current distribution. *Lathyrus jepsonii* var. *jepsonii* is locally common some years in the northern San Francisco Bay Estuary, where it ranges from tidal marshes of the lower Napa River and its sloughs throughout most of the Suisun Marsh area and Contra Costa shoreline marshes P. Baye unpubl. data 1998; **Figure C-8**). It historically occurred in an unspecified locality of the Tamalpais region, presumably the Marin shoreline of San Francisco Bay in the upper reaches of tidal sloughs. It is no longer reported in Marin or Sonoma counties. Skinner and Pavlik (1994) report it from Santa Clara County, but there are no vouchers or other records. Some outlying occurences may be erroneous because the more widespread var. *californicus* sometimes lacks the key character of *pubescent* foliage and stems (Isely 1993); these outlying occurrences should be verified.

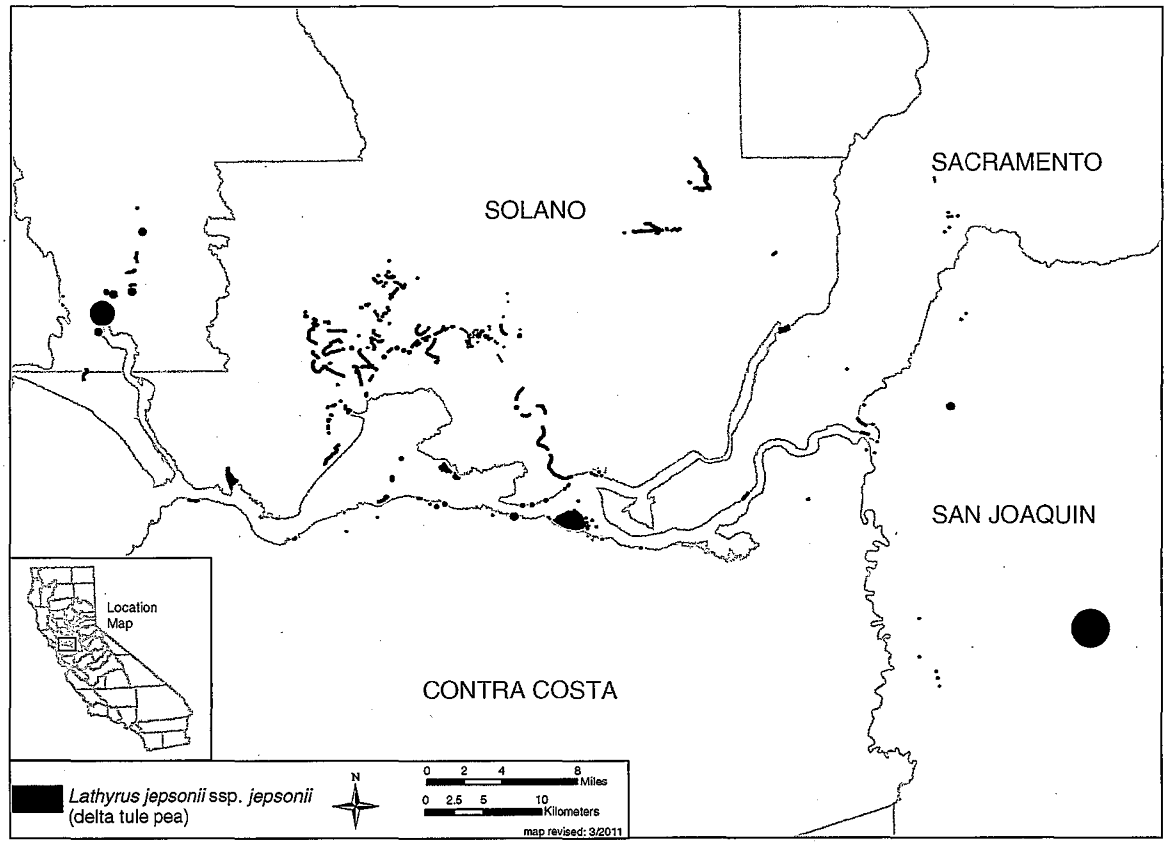

Figure C-8. Distribution of *Lathyrus jepsonii* var. *jepsonii*

Abundance. *Lathyrus jepsonii* var. *jepsonii* abundance appears to vary with salinity. During seasons of relatively high salinity, it may be highly inconspicuous, with reduced vegetative growth, failure to flower, or even failure to emerge from perennating roots. In wet low-salinity years, plants may reappear with robust growth, prolific bloom, and seed production at the same location. This is especially evident at the western end of its range, such as the lower Napa River (P. Baye unpubl. data 1997). It is not known how long the taxon can persist through years of high salinity conditions. *Lathyrus jepsonii* var. *jepsonii* is uncommon in Suisun Marsh, but is not particularly rare in series of high rainfall years.

Habitat

In tidal marshes *Lathyrus jepsonii* var. *jepsonii* typically grows along relatively well-drained creek banks and natural levees (occasionally artificial dikes), where it grows over tall bulrushes and tules as well as other vegetation. It is not found in seasonal wetlands with dry or saline soil in summer.

Threats

Most species covered in this recovery plan are threatened by similar factors because they occupy the same tidal marsh ecosystem. These general threats, faced by all covered species, are discussed in greater detail in the Introduction section of this recovery plan (section I.D.). Specific threats to *Lathyrus jepsonii* var. *jepsonii* are described below.

Lathyrus jepsonii var. *jepsonii* abundance in Suisun Marsh and vicinity has declined because of the elimination of all but the largest tidal creeks due to diking. Locations near the edge of its range in the Napa Marsh area are at higher risk of extirpation because of their relative scarcity and the potential for rapid erosion of fringing tidal marshes when derelict salt ponds and diked baylands are restored to tidal action.

Conservation Strategy

Tidal marsh restoration plans should include measures to protect, salvage, or propagate and reintroduce the Napa Marsh colonies of *Lathyrus jepsonii* ssp. *jepsonii* affected by marsh erosion. Abundance and distribution of *Lathyrus jepsonii* var. *jepsonii* should be monitored throughout its range in the estuary during both drought and high-rainfall years. Conservation actions should be reviewed if significant declines occur in wet-year surveys. Tidal marsh restoration projects within its natural range should evaluate the appropriateness of reintroduction by seeding. Those proposing development in appropriate habitat within the range, including the Delta, should conduct rigorous surveys for the species prior to development and, if the species is found, avoid adverse effects. Conservation considerations for *Lathyrus jepsonii* var. *jepsonii*, including restoration, should extend beyond the nominal geographic scope of this recovery plan to the Delta, which appears to support the majority of occurrences. As sea level rises and salinity pushes further up-estuary, monitoring will be needed to determine any resulting effects on populations of *Lathyrus jepsonii* var. *jepsonii*. Research is needed on threats and on demographyics and ecology of the species.

11. *Spartina foliosa* (Pacific cordgrass, California cord grass)

Description and Taxonomy

Description. *Spartina foliosa* Trin. (Pacific cordgrass) is a member of the Poaceae (grass) family (**Figure C-9**). It grows on tidal mudflats and channel banks in colonies formed by rhizomes. Above-ground stems occur either singly or in clumps of branched leafy yellowish-green shoots about 5 to 15 millimeters (0.2 to 0.6 inch) in width at the base. Most rigid leafy shoots develop into flowering *culms* by mid-summer, and develop seed-heads by late summer or fall. Seed-heads range from 9 to 25 centimeters (3.5 to 10 inches) in length. The height of mature culms seldom, if ever, exceeds 1.5 meters (5 feet), and is usually 1 meter (3.3 feet) or less. The nearly cylindric inflorescence consists of dense overlapping spikes of flowers closely *appressed* to the stem. Leaf blades are flat, flexible, with many fine ribs on the upper surface, and a smooth, waxy lower surface. Leaves normally range from 15 to 45 centimeters (6 to 18 inches) in length, and are 5 to 17 millimeters (0.2 to 0.6 inch) wide at the base (Baird and Thieret 1993).

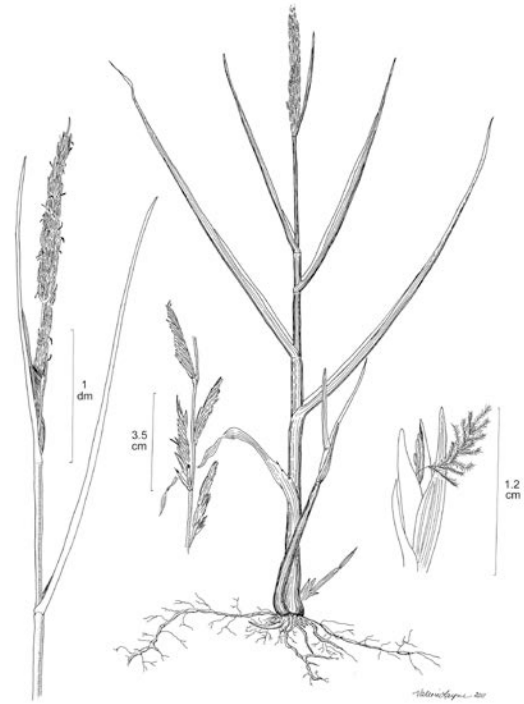

Figure C-9. ***Spartina foliosa*** (illustration credit: Valerie Layne, USFWS)

Taxonomy. *Spartina foliosa* is the only native cordgrass on the North American Pacific coast (Mobberly 1956, Baird and Thieret 1993). It is closely related to the wide-ranging *Spartina alterniflora* Lois. (smooth cordgrass), the dominant salt marsh cordgrass of the Atlantic and Gulf of Mexico coasts (Mobberly 1956, Chapman 1964). *Spartina leiantha* Benth. is a synonym of *Spartina foliosa* often found in older references; the name *Spartina stricta* Roth. was misapplied to this species and also to *Spartina alterniflora* in the earliest floras of California (Brewer *et al.* 1880). *Spartina foliosa* can be confused in the field with non-native cordgrasses in its range. *Spartina densiflora* Brongn. (dense-flowered cordgrass) occurs in Richardson Bay (Marin County) and Humboldt Bay (Humboldt County), and has recently spread to Point Pinole (Contra Costa County). It is distinguished from *Spartina foliosa* by its growth habit (dense clumps or tussocks lacking widely creeping rhizomes), foliage (narrow, less than 8 millimeters [0.32 inch] wide when flat, brittle, erect, inrolled fresh blades with thick ribs), and habitat (upper middle salt marsh zones). *Spartina densiflora* is the dominant cordgrass of Humboldt Bay, and until the 1980s was mistaken for an anomalous ecotype of *Spartina foliosa* (MacDonald and Barbour 1974, MacDonald 1977).

Spartina alterniflora is not always readily distinguished from *Spartina foliosa* in San Francisco Bay because intermediate forms in the hybrid swarm (parents, hybrids, introgressants) are now widespread. One of the diagnostic traits of *Spartina alterniflora* (and many, but not all, of its hybrids) in San Francisco Bay populations is the presence of reddish or purplish pigments in the leaf sheath (base of the leaf near the stem of the plant) and rhizome scales; native *Spartina foliosa* is uniformly yellow-green stemmed (P. Baye pers. comm. 2000). Other vegetative traits that can be useful in distinguishing *Spartina alterniflora* in San Francisco Bay include persistent green foliage on the upper culm well into fall or winter, greater culm height (to 2.5 meter [8.1 feet] or more tall), basal

diameter of culms (to more than 7 centimeters [about 3 inches] wide), and very broad leaf blades (25 millimeters [1 inch] or more wide). Morphological traits of the inflorescence that distinguish *Spartina alterniflora* from *Spartina foliosa* include its more open, loosely overlapping spikes, which are either loosely appressed to the main axis or spread away from it (Baird and Thieret 1993). All these morphological traits are of limited value in identifying hybrid plants, which may be intermediate, have novel characteristics, or closely resemble either parent (Daehler and Strong 1997). Genetic analysis is needed to verify pure *Spartina foliosa* in San Francisco Bay today (Ayres *et al.* 1999, Antilla *et al.* 2000). Pure stands may be limited temporarily to the North Bay and Suisun Marsh area.

Population Trends and Distribution

Historical distribution. The historical range of *Spartina foliosa* had its core in San Francisco Bay, but extended from Point Reyes (Drakes Estero) to Baja California.

Current distribution. *Spartina foliosa* has a disjunct distribution in California. It is limited to fully tidal salt marshes of the north-central coast, and predominantly tidal lagoons of the south coast. The gap in its distribution extends from the south end of San Francisco Bay to Mugu Lagoon, Ventura County. North of San Francisco Bay, *Spartina foliosa* has been long established, but in low abundance and limited distribution, in Bolinas Lagoon, Drakes Estero, and Limantour Estero (Howell 1949). The only large *Spartina* stands in these marshes occur locally in the mouths of drainages of Limantour Estero, and the head of Schooner Bay, Drakes Estero. Major stands in Bolinas Lagoon are limited to areas of past deltaic deposition. Large, rapidly spreading stands of *Spartina foliosa* have (ca. 1990; P. Williams pers. comm. 1999) established spontaneously on deltaic mudflats of southern Tomales Bay, and rapidly increased to hundreds of acres by the end of the 20th century (P. Baye pers. observ. 2000). It is absent in northern Tomales Bay. *Spartina foliosa* was absent in Bodega Bay in the 1960s (Barbour *et al.* 1973), but has gradually established there since the 1980s.

Life History and Ecology

Spartina foliosa is considered a keystone species of California tidal marshes because of its critical role in habitat structure (Zedler 1993) and productivity, and its geomorphic effects on marsh formation (Gabet 1998). It is a dominant species of lower intertidal salt marshes of southern California and San Francisco Bay, occuring from approximately mean sea level to mean high water tidal elevations (Atwater *et al.* 1977). It often grows in dense, single-species stands in low tidal salt marsh and mudflat edges. Until the arrival of *Spartina alterniflora* in San Francisco Bay, *Spartina foliosa* was the only native emergent vascular plant that inhabited the low salt marsh zone of tidal creeks and flats, dominating thousands of acres of salt marsh in San Francisco Bay alone prior to reclamation (Josselyn *et al.* 1993).

In the San Francisco Bay Estuary, the largest stands of *Spartina foliosa* occur in the salt marshes of south San Francisco Bay and northern San Pablo Bay. Very extensive low marsh dominated by this species occurs where marshes prograde over adjacent mudflats; the most significant examples are the strip marshes parallel to Highway 37 in north San Pablo Bay, the Mowry-Dumbarton Marshes, and the Calaveras Point Marshes in south San Francisco Bay. Very large young stands also develop rapidly in restored tidal salt marshes, such as Pond 2A (Napa Marsh) and outer Bair Island. Narrow, sinuous, linear populations occur in extensive networks along the banks of tidal creeks that are either prograding, stable, or eroding slowly.

Spartina foliosa is a common minor component of brackish tidal marshes, and it occurs in nearly fresh brackish tidal marshes on the Petaluma River, Napa River, and in the Suisun Marsh area. It may occur occasionally in small colonies in the eastern portions of the Suisun Marsh/west delta area. Populations appear to be unstable in estuaries that undergo periodic or intermittent non-tidal conditions, such as those of coastal lagoons and stream mouths, where tidal inlets are prone to become closed or partially choked by growth of spits or beach ridges. Abundance and stability of *Spartina foliosa* populations decline abruptly in brackish marshes where it co-occurs in low marsh with *Bolboschoenus* (bulrush) species, often in unstable colonies subject to either erosion or dominance by tules. Its growth is strongly inhibited by deep periodic immersion (Mahall and Park 1976).

Spartina foliosa flowers from June through September in the San Francisco Bay area. Plants reproduce and spread primarily through clonal sprouting from rhizomes. Pollinated flowers may produce seeds, but germination rates are low. Unpopulated areas can be colonized by floating seed; however, seedling establishment is relatively rare. Clones create and trap organic and inorganic sediment and build marsh elevations by accretion, which raises the marsh elevation to form upper marsh plains, a habitat type that is mostly unsuitable for *Spartina foliosa*.

Threats

Most species covered in this recovery plan are threatened by similar factors because they occupy the same tidal marsh ecosystem. These general threats, faced by all covered species, are discussed in greater detail in the Introduction section of this recovery plan (section I.D.). Though invasion of *Spartina alterniflora* and its hybrids is discussed in the Introduction section, below, we discuss in more detail the invasion's specific threat to *Spartina foliosa*.

Today, *Spartina foliosa* is threatened not only by habitat loss, but by genetic disassembly through large-scale hybridization with the invasive non-native *Spartina alterniflora*

(Antilla *et al.* 1998). *Spartina foliosa* and *Spartina alterniflora* are highly interfertile, readily forming hybrids. *Spartina densiflora*, a less closely related species, has not been reported to hybridize with native *Spartina*. *Spartina alterniflora* produces much more abundant and more fertile pollen than *Spartina foliosa*, and where the two occur together seeds of *Spartina foliosa* are likely to contain hybrid embryos (Daehler and Strong 1997, Antilla *et al.* 1998). Hybrid populations flower at times intermediate between the two parent species, so the presence of hybrid plants with a greater overlap in flowering period may accelerate the genetic assimilation of *Spartina foliosa* (Antilla *et al.* 2000). In addition, *Spartina alterniflora* and its hybrids are larger, faster-growing, and superior colonizers of mudflats and unvegetated creeks than *Spartina foliosa*. Because of the apparent competitive and fertilization advantage of the more robust *Spartina alterniflora*, it is likely, in the absence of intervention, that future generations of cordgrass in areas accessible to invading *S. alterniflora* hybrids will be intermediate between parent species. Unless checked, it is likely that future cordgrass marshes will eventually be composed exclusively of hybrid derivatives (hybrids derived from) of *Spartina foliosa* and *Spartina alterniflora*, which will entirely replace the "pure" native species (Daehler and Strong 1997, Antilla *et al.* 1998, Ayres *et al.* 2003).

The Invasive Spartina Project recently surveyed and mapped the distribution of *Spartina* species. Since its introduction to San Francisco Bay around 1976, the San Francisco Bay hybrid *Spartina* complex has spread extensively, and has made large leaps of dispersal, establishing pioneer colonies north of the Bay Bridge and well south of the Dumbarton Bridge (D. Ayres pers. comm. 1998, D. Smith pers. comm. 2000). As populations increase, the export of seed to unoccupied estuarine habitats within and beyond San Francisco Bay is likely to increase. Biological control of *Spartina alterniflora* and its hybrid swarm may be infeasible because of their close similarity to *Spartina foliosa*.

Hybrid *Spartina alterniflora* seed from San Francisco Bay can travel with tidal currents and could transform the remainder of the Pacific coast. Spread of hybrid *Spartina alterniflora* along the coast would eliminate potential refuges for *Spartina foliosa*, such as Drakes Estero and Tomales Bay.

There are precedents for similar *Spartina* invasions. *Spartina anglica*, an invasive hybrid cordgrass also derived from *Spartina alterniflora*, has spread far beyond the ecological niche of its native European cordgrass parent, *Spartina maritima*, and has caused dramatic alteration of European estuaries. Among its impacts are increased sedimentation, loss of mudflat habitat, alteration of habitat structure (Thompson 1990), and transformation of tidal mudflat into dense, monotypic marsh in New Zealand (Partridge 1987). In the Pacific Northwest (Oregon and Washington), an older invasion of *Spartina alterniflora* caused large-scale losses of intertidal mudflat and oyster-farmed tidelands, spurring major eradication efforts (Mumford *et al.* 1990). The vulnerability of Pacific estuaries to invasion by *Spartina alterniflora*, and the impacts of invasion, are summarized by Daehler and Strong (1996). There is ample indirect evidence that irreversible decline in the integrity of the *Spartina foliosa* gene pool could occur soon.

Other threats to *Spartina foliosa* include habitat loss by marsh filling or modification and chronic discharges of fresh wastewater.

Conservation Strategy

Past Conservation

The Invasive Spartina Project has a control program that is actively working with land managers, land owners, environmental groups, and others to arrest and reverse the invasion of non-native *Spartina* in the San Francisco Bay Estuary. The Invasive Spartina Control Plans for the San Francisco Estuary will be implemented at 22 sites throughout the estuary (State Coastal Conservancy 2005).

It is important to remember that the impacts of an invasive *Spartina* plant are not limited to the immediate vicinity of the plant, but extend to the limit where its pollen blows and where all resulting hybrid seeds are carried by the tides and currents. Restoration projects areas should not be restored to tidal action without a realistic contingency plan for what will be done if, against expectation, non-native *Spartina* does invade the site. (One alternative may be to re-dike the site and inundate it long-term to kill invasive *Spartina*.) Conservation of species like *Spartina foliosa* with important populations near invasive *Spartina*-infested tidal marshes will present challenges.

Current Strategy

Conservation of *Spartina foliosa* depends on timely eradication of *Spartina alterniflora* and its hybrids in California. Control (reduction of *Spartina alterniflora* to low levels) is unlikely to provide long-term protection against progressive pollen-swamping and genetic assimilation. This would probably just slow the rate of species assimilation. *Spartina foliosa* cannot be conserved through cultivation of clones. It is infeasible to maintain in long-term cultivation because of its tidal habitat, and cultivation would not provide survival in its the native ecosystem, which is the intent of the Endangered Species Act.

There are substantial challenges to conservation of *Spartina foliosa*. It is popularly perceived to be a common species with minimal need for protection. Its ecological values are also popularly perceived as being merely instrumental, providing habitat for the endangered California clapper rail (*Rallus longirostris obsoletus*). Eradication of *Spartina alterniflora* and its hybrid swarms have caused substantial impacts to many clapper rail populations in San Francisco Bay, particularly in heavily infested areas. Therefore, long-term preventative measures to protect the integrity of a large regional tidal marsh ecosystem, and a species not widely perceived to be at immediate risk of extinction (and without legal protection), must be weighed against the legal prohibitions against harming a listed species at immediate risk of extinction. Moreover, the early stages of *Spartina alterniflora* invasion provide habitat benefits for clapper rails (Daehler and Strong 1996, Josselyn *et al.* 1993).

The essential conservation strategy for *Spartina foliosa* is eradication of the *Spartina alterniflora* hybrid swarm in San Francisco Bay, integrated with a recovery strategy for the California clapper rail. No other species-specific conservation actions are currently needed.

Stage 1. Locate the leading edges of the San Francisco Bay population of *Spartina alterniflora* and visually identifiable hybrids in the field, where widely spaced small colonies occur in a matrix of *Spartina foliosa* marsh or mudflats. Eradicate these colonies as soon as possible while impacts to clapper rails would be relatively low; at least prevent their seed production. Within the zone of extensive, well-established populations of *Spartina alterniflora* hybrid swarms (especially in the East Bay between Oakland and Hayward) postpone tidal restoration projects that would establish predominantly hybrid seedling habitat and provide significant opportunity for expansion of corrupted populations. Vigilantly monitor marshes in the vicinity of the known leading edge of the invasion to detect new pioneer colonies.

Stage 2 (compatible with concurrent implementation of Stage 1). Begin advance compensation for impacts to clapper rails anticipated by mass eradication of *Spartina alterniflora* in the Hayward Shoreline area. Compensation would consist of two elements:

(a) effective sustained control of terrestrial predators of the rail (particularly non-native red fox [*Vulpes fulva*]) in the vicinity of the largest South Bay rail populations, including some partially infested marshes near concurrently targeted eradication areas; and

(b) rapidly establish new salt marsh with complex, sinuous tidal creek networks adjacent to blocks of habitat with substantial populations of clapper rails, but only in areas of the estuary where restored marsh has low likelihood of being colonized by cordgrass hybrids or *Spartina alterniflora*. The diked baylands most physically and biologically conducive and feasible for this purpose are currently in the vicinity of Greco Island, Palo Alto, Mowry Slough, and Calaveras Point.

It would ordinarily be beneficial to conduct habitat restoration as close as possible to the area of clapper rail impact, but this would be counterproductive for both *Spartina foliosa* conservation and clapper rail recovery. Compensatory habitat restoration performed near *Spartina alterniflora*-infested areas would rapidly establish increased corrupted (mixed hybrid/native) cordgrass populations, and defeat eradication. It may be feasible, however, to increase rail breeding success through predator control in hybrid swarm-infested marshes ahead of swaths of cordgrass eradication that move through a subregion. Ultimately, however, there would be a conflict between eliminating hybrid cordgrass reproduction and protecting cordgrass refugia for clapper rails

Stage 3 (compatible with limited concurrent implementation of Stage 2). When Stage 2 measures to stabilize and expand clapper rail populations are confirmed through documentation of rail numbers equal to or greater than the anticipated loss, begin large-scale eradication of infested (hybrid swarm) cordgrass marsh along the Hayward Shoreline and vicinity, including fringing marshes of tidal sloughs and flood control channels. Discrete colonies of hybrid swarm cordgrass may be eradicated by judicious application of effective herbicides approved for use in or adjacent to aquatic habitats. Extensive colonies and diffuse hybrid swarms would require mass removal by methods including:

(a) mechanical maceration of above-ground and shallow below-ground parts by amphibious low ground pressure equipment, where feasible;

(b) mechanical superficial excavation of infested marsh surfaces, using either track-mounted excavators on dike roads within reach, or amphibious/floating dredges;

(c) temporary diking and persistent lethal flooding of thoroughly infested salt marshes, leaving physically intact substrate (and partially decomposed killed vegetation) for subsequent recolonization by native vegetation.

Sediment containing viable hybrid swarm cordgrass must be disposed in diked non-tidal habitats (*e.g.* salt ponds, salt pans, seasonally dry *Sarcocornia pacifica* marsh, or other habitats lethal to cordgrass). Cordgrass removal must be conducted during the non-breeding season for clapper rails, to allow for the maximum amount of successful dispersal to unoccupied suitable marshes or restored marshes farther from eradication zones. During Stage 3, it is important to avoid establishing new cordgrass seedling habitat in tidal marshes and mudflats in the vicinity of the regional eradication zone.

Stage 4. Extend the *Spartina alterniflora* hybrid swarm eradication zone iteratively in blocks or zones along the East Bay shoreline in conjunction with advance compensation for impacts, until it merges with the Stage 1 eradication zone of outlier, pioneer colonies. Conduct tests of residual cordgrass seedling recruitment in eradicated blocks to determine the relative frequency of *Spartina alterniflora*, hybrid/backcross, and native *Spartina foliosa* genotypes, using molecular genetic methods. As soon as seedling recruitment of *Spartina alterniflora* or hybrid swarm cordgrasses is reduced to levels low enough to be controlled successfully by detection and eradication of individual colonies, perform mass-replantings of native *Spartina foliosa* in eradication-denuded marshes, using clonally propagated stock from source marshes with undetectable levels of genetic pollution from *Spartina alterniflora* in the South Bay.

To permit extinction of hybrid swarm cordgrass without local near-extirpation of clapper rails in the vicinity, it would be necessary to postpone eradication of the least infested, large remnant stands of *Spartina foliosa* to the last phases of eradication, leaving them to function as clapper rail refugia. Eradication of hybrid swarms within these stands would need to be accomplished by selective localized herbicide applications. Partially corrupted remnant native cordgrass stands would have to be large enough to accommodate nesting territories of clapper rails for this to be feasible. It is uncertain whether cordgrass stands of sufficient size for clapper rails and sufficiently small *Spartina alterniflora* influence could be stabilized long enough for this tactic to be effective. Supplemental replanting of contiguous devegetated stands with *Spartina foliosa* may help supplement the size of refugia, but replanted areas are likely to become reinfested if hybrid seed reproduction is substantial. Suppression of hybrid seed production in remnant mixed stands may be pursued to inhibit local recruitment of seedlings around remnant mixed stands, applying techniques that reduce successful pollination and seed set (*e.g.*, sublethal dilute herbicide sprays prior to emergence of flowering heads, or sprays of brine/sticker solutions during pollination).

Stage 5. Continue monitoring, detection and spot-eradication of *Spartina alterniflora* hybrid swarm individuals in the region until regional extirpation of the invading species/hybrid swarm is confirmed.

B. Tidal Marsh -Associated Listed Species to Consider

1. Western snowy plover, Pacific coast population (*Charadrius alexandrinus nivosus*)

Description. The western snowy plover, *Charadrius alexandrinus nivosus,* is a small, pale sand-colored (white and gray-brown) shorebird in the family Charadriidae (plovers and lapwings; **Figure C-10**). It weighs from 34 to 58 grams (1.2 to 2 ounces), and ranges in length from 15 to 17 centimeters (5.9 to 6.6. inches; U.S. Fish and Wildlife Service 2007*a*). In breeding plumage the males usually have a rufous crown and black markings on the head and breast while one or more of these markings are dark brown in females. The sexes cannot be distinguished in nonbreeding plumage. Fledged juveniles have white edges on their wing coverts and scapulars. The Pacific Coast Population is currently designated as threatened in the U.S (CA, OR, WA) and Mexico (within 50 miles of Pacific coast; U.S. Fish and Wildlife Service 1993*a*). In response to receiving a petition to delist the species, the U.S. Fish and Wildlife Servie published a 12 month finding in the Federal Register on April 21, 2006, announcing that delisting of the species at that time was not warranted (71 FR 20607; U.S. Fish and Wildlife Service 2006*a*). Three critical habitat units have been designated in the San Francisco Bay area: Point Reyes Beach, Limantour Spit, and Half-Moon Bay (U.S. Fish and Wildlife Service 2005*a*).

Distribution. Historical records indicate that nesting western snowy plovers were once more widely distributed and abundant along the coast than they are currently (U.S. Fish and Wildlife Service 2007*a*). There are no historical records to establish the presence or absence of nesting western snowy plovers on San Francisco Bay sand spits and salt flats prior to the urbanization of the mid-19th century.

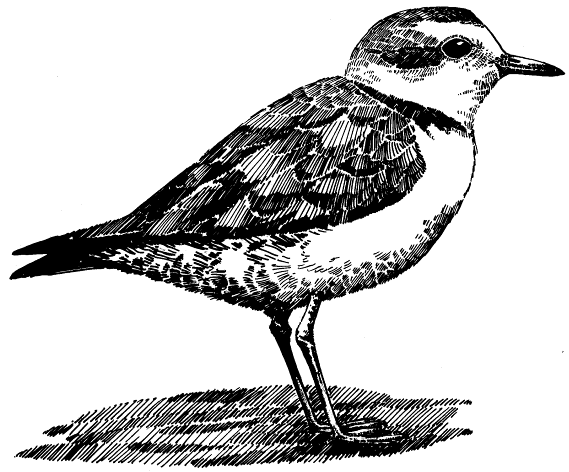

Figure C-10. Western snowy plover (© Larry Eifert)

The western snowy plover ranges along the Pacific coast from southern Washington state to southern Baja California, Mexico (**Figure C-11**). The Pacific coast population is defined as those individuals that nest on the mainland coast, peninsulas, offshore islands, bays, estuaries, or rivers of the United States Pacific coast and Baja California, Mexico (U.S. Fish and Wildlife Service 1993*a*). This population breeds, forages, and roosts primarily on maritime beaches, especially sand spits, and creek or river mouths and also inhabits flat, relatively barren, whitish-substrate habitats near shorelines on sandy lagoon and estuarine edges, salt pans, dredge disposal sites, and coastal dikes.

Western snowy plover habitats are often adjacent to tidal marshes, such as Humboldt Bay, Drakes and Limantour Esteros, Elkhorn Slough, and Morro Bay. The artificially expanded salt pond system of the South Bay (and to a relatively minor extent San Pablo and Suisun bays), in recent decades has supported one of the largest breeding populations on the west coast, comprising approximately 16 to 22 percent of the entire California coastal population. The San Francisco Bay population declined significantly between the initial survey in 1978 and follow-up surveys in 1989 and 1991 (U.S. Fish and Wildlife Service 2007*a*).

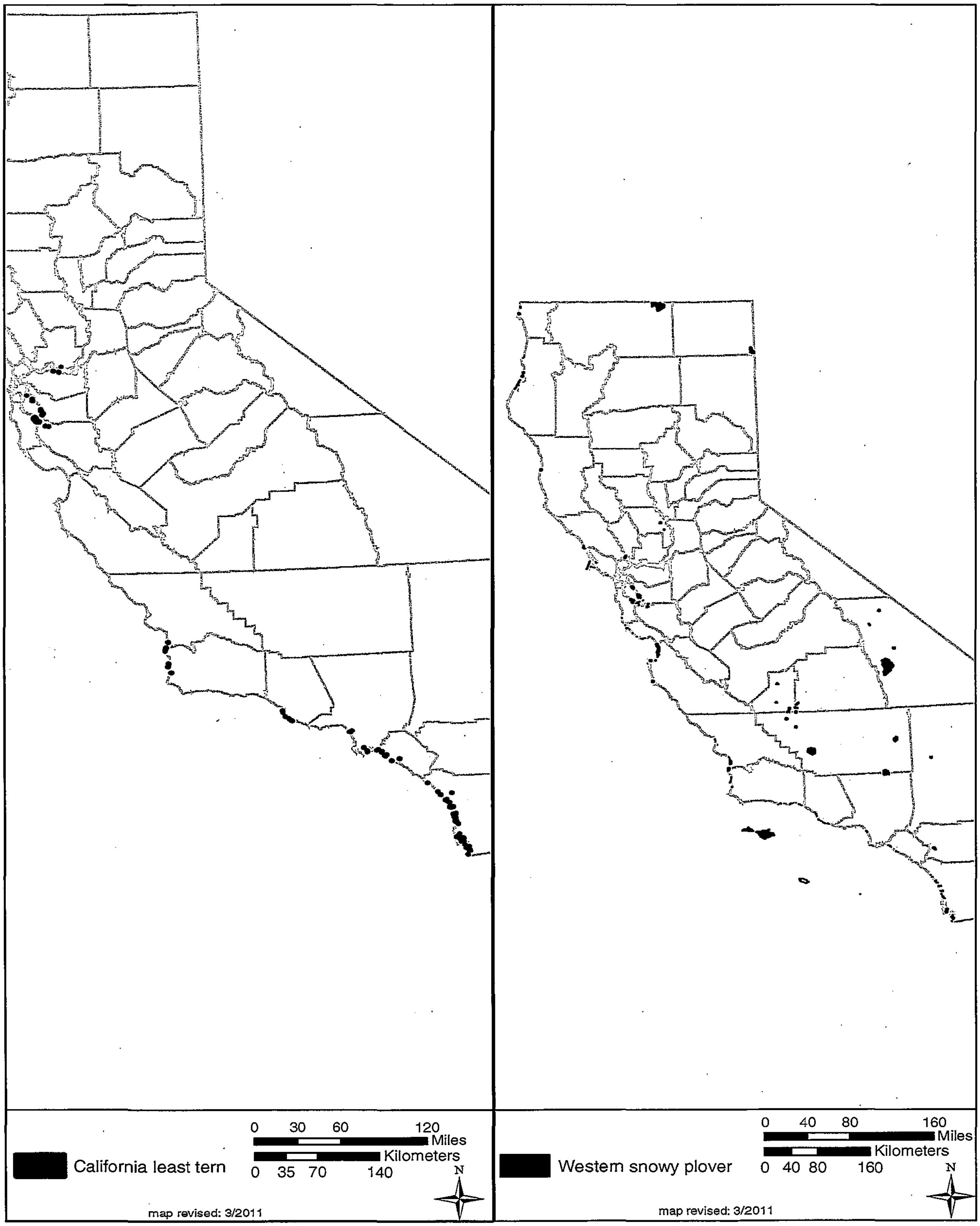

Figure C-11. Distribution of Western snowy plover and California least tern

Life History and Ecology. Western snowy plovers nest in scrapes (small depressions laced with pebbles or debris) on flat open habitats with minimal vegetation and some debris on pale bright substrate, such as beaches, salt pans, or flats. Nesting occurs mostly between March and July, but re-nesting may occur through August. Birds are gregarious in the winter non-breeding period. Individual birds are usually quite site-faithful, returning annually to the same nesting locations; however, some birds disperse to new sites within and between years. Nest sites are usually within a hundred meters of water. Birds may renest and produce subsequent clutches if eggs are lost. Chicks fledge approximately one month after hatching. Adults do not feed chicks, but lead them to food. Snowy plovers are visual foragers, employing a "run-stop" foraging pattern. In shoreline habitats they consume kelp flies, brine flies, amphipods, or other available insects and invertebrates, often associated with high-tide debris deposits or intertidal flats (U.S. Fish and Wildlife Service 2007*a*).

Threats. Threats include nest site disturbance, or destruction by dogs, beach vehicles, and pedestrians; increased predation rates by raptors, rats, ravens, gulls, foxes, skunks, raccoons, and domestic and feral pets; oil spills; and in some cases dredge spoil disposal. In San Francisco Bay salt ponds, threats also include incompatible timing of salt pond brine flooding and draining. Important sandy to muddy intertidal flats that function as foraging habitat are threatened by invasion of *Spartina alterniflora* (smooth cordgrass; P. Baye pers. observ. 1992, 2000).

The greatest potential threat to conservation of western snowy plovers in San Francisco Bay is habitat conversion associated with tidal restoration essential to recovery of salt marsh species. Antagonism between habitat requirements of federally listed snowy plovers and salt marsh species must be avoided by a systematic long-term regional conservation strategy.

Conservation Strategy. A detailed recovery strategy can be found in the Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*) (U.S. Fish and Wildlife Service 2007*a*). In that document a recovery criterion of 500 breeding birds is described for the San Francisco Bay Recovery Unit. The U.S. Fish and Wildlife Service believes that reaching this criterion is compatible with tidal marsh restoration. Tidal marsh restoration in occupied western snowy habitat, particularly at densely populated sites, should be phased in after intensive adaptive management of other compensating salt pond habitat has demonstrated success in increasing plovers.

Three areas in the San Francisco Bay Estuary have been identified as critical habitat in the administrative draft proposed critical habitat rule for the Pacific Coast population of the western snowy plover. These areas are: 1) the southwestern third of pond SF2 in the Ravenswood complex, 2) the eastern tips of ponds A22 and A23 in the Warm Springs area and, 3) ponds E11, E14, E6A and E6B in the Eden Landing area.

Restoration of estuarine sand spits with marsh ecotones, an important element of *Suaeda californica* (California sea-blite) recovery in San Francisco Bay, should be planned to accommodate habitat preferences of snowy plovers. Estuarine sand spits adjacent to shallow subtidal areas would also provide potential nesting habitat for federally endangered California least terns.

This recovery plan does not recommend tidal marsh restoration of salt ponds in Elkhorn Slough. At Morro Bay, Drakes Estero, Tomales Bay, and Humboldt Bay, no tidal marsh recovery actions are expected to conflict with western snowy plover recovery needs.

2. California Least Tern (*Sterna antillarum browni*)

Description. The California least tern (*Sterna antillarum browni*) is the smallest member of the subfamily Sterninae, measuring about 23 centimeters (9 inches) bill to tail (**Figure C-12**). The wing is approximately 17 cm (7 inches; Massey 1976). Plumage during the breeding season is characterized by a glossy black cap, sharply defined white triangular forehead, pale gray upper parts, pale gray wings with black outer primaries, yellow bill with a variable amount of black at the tip, and reddish-orange legs and feet (Massey and Atwood 1978). Chicks are covered with down of mottled beige and brown tones that provide camouflage in beach sand (Massey 1972). Recently fledged birds (juveniles) have brown and buff coloration; however, within a few weeks they undergo their first molt, which culminates in loss of all brown feathers and becomes the first basic, winter plumage (Massey and Atwoood 1978). The California least tern was listed as endangered on June 2, 1970 (U.S. Fish and Wildlife Service 1970) with a recovery plan completed in 1985 (U.S. Fish and Wildlife Service 1985*b*). The recovery plan is currently undergoing revision. It is listed as endangered and fully protected by the State of California (California Department of Fish and Game 2005). The U.S. Fish and Wildlife Service completed a 5-year review in 2006 which recommended the downlisting of the species to threatened status (U.S. Fish and Wildlife Service 2006*b*).

Distribution. The historical breeding range of this subspecies has usually been described as extending along the Pacific Coast from Moss Landing, Monterey County, California, to San Jose del Cabo, Baja California Sur, Mexico (American Ornithologists' Union Committee 1957, Grinnell and Miller 1944*a*). However, least terns have been documented in several locations north of this range (Pray 1954, Chandik and Baldridge 1967, **Figure C-11**). San Francisco Bay sightings of least terns date back to 1927 (Grinnell and Wythe 1927), and nesting was confirmed in 1963 at the Oakland Airport (Feeney 2000). Large estuarine sand spits and barrier beaches in San Francisco Bay, potentially suitable nesting habitat for California least terns and western snowy plovers, have been reduced from approximately 37 kilometers (23 miles) to less than 3.2 kilometers (2 miles; P. Baye and R. Grossinger pers. comm. 2000).

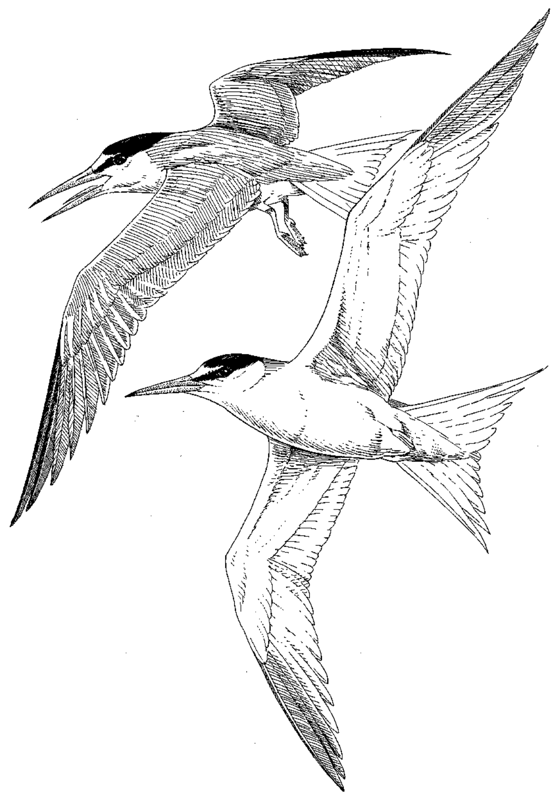

Figure C-12. California least tern (Kendal Morris/USFWS)

Since 1970, breeding has been documented from San Francisco Bay south to the Tijuana River at the Mexican border. The breeding range in California is discontinuous, with large colonies spread out along beaches at the mouths of estuaries. The current range is concentrated in three southern California counties: Los Angeles, Orange, and San Diego. Between Ventura County and San Francisco only Purisma Point and Mussel Rock Dunes (formerly called Guadalupe Dunes) and Vandenberg have been used regularly (Marschalek 2006). San Francisco Bay appears to be the usual northern limit of the least tern range. Currently, the five most populous nest sites (Camp Pendleton, Los Angeles Harbor, Naval Base Coronado, Batiquitos Lagoon, and Point Magu) host 71 percent of the entire population (Marschalek 2006). Since the first census in 1976, not more than 19 percent of the breeding pairs have ever been located north of Los Angeles County.

The U.S. population is grouped in five discrete clusters: San Francisco, San Luis Obispo/Santa Barbara County, Ventura County, Los Angeles/Orange County, and San Diego (Massey and Fancher 1989). Each cluster contains multiple breeding sites. The San Francisco Bay cluster includes eight known locations that have been in use for varying lengths of time from 1969 to the present: Suisun Marsh near Collinsville, Solano County; P.G.E. Pittsburgh, Contra Costa County; Port Chicago, Contra Costa County; Alameda Naval Air Station, Alameda County; Bay Farm Island, Alameda County; Oakland Airport, Bay Farm Island, Alameda County; Alvarado Salt Ponds, Alameda County; Bair Island, San Mateo County (U.S. Fish and Wildlife Service *in litt.* 1996). Seemingly in response to East Bay Regional Park District's recently completed least tern habitat enhancement on an island within the Hayward Regional Shoreline, the species began appearing in significant numbers in 2006. In 2007, a total of 35 nests were observed, resulting in 49 fledglings (Riensche *in litt*. 2007). In addition, a new population was observed in 2005 near Montezuma, Solano County, and more than 20 least tern chicks were observed at the site in July 2006 (Pilotte *in litt.* 2006).

Approximately 6.5% of the U.S. nesting population is in the San Francisco Bay area. Although most of the San Francisco Bay area colonies are small, that at Alameda Naval Air Station (Alameda National Wildlife Refuge) is one of the larger individual colonies (Hazard *in litt*. 2009). Since 1990, the size of the population and fledgling success at that site has been among the highest in the state, with the contribution to the statewide fledgling populations among the four highest in 12 of the last 15 years, totaling at least 2500 fledglings (Caffrey 2005). In a study of the population at the Alameda Naval Air Station, conducted by PRBO Conservation Science from 2002 to 2005, the estimated number of breeding least tern pairs increased from 287 to 424, with estimated breeding success (fledglings per male) averaging roughly 69 percent (Elliot *et al.* 2007). As determined in a 2006 review of the species' status, although the number of least terns has increased within the San Francisco Bay colonies, there has not been an increase in the number of colonies in the bay area (Marschelek 2006, U.S. Fish and Wildlife Service 2006*b*). Several of the nest sites in the Bay Area are relatively new, indicating that the species is expanding geographically in the area (Hazard *in litt.* 2009). It also appears the species is expanding into the Bay-Delta region and even into the Central Valley proper, though the truly interior nestings consist of just a few pairs overall and are sporadic (Hazard *in litt.* 2009).

Life History and Ecology. The breeding season of the California least tern extends from April to October. Adults arrive in their nesting areas from mid-April to early May. Some pair bonds are already established on arrival, others form soon thereafter. Active courtship may be observed within the first few days after arrival (Massey 1974). Selection of a mate lies with the female.

Nesting habitat preferences of California least terns are similar to those of western snowy plovers, and both species may nest at the same site. Breeding habitats include beaches, sand spits, sandy river mouths, unvegetated sandy flats, *playas* and saline lake shorelines, extensive salt pans, and some artificial habitats that act as surrogates for these. Least terns usually choose nest locations on open expanses of light-colored sand, dirt, or dried mud close to a lagoon or estuary with a dependable food supply (Massey 1974). Increased human activity on beaches has made many areas unsuitable, and forced terns to nest on mud and sand flats at a farther distance from the ocean or on man-made habitat such as airports and landfills.

The least tern nest is a small depression in which the eggs are laid. Breeding birds aged three years or older typically lay eggs in May. After the eggs are laid, the nest is often lined with shell fragments, small pebbles, or small twigs. One pair member incubates while the other stays close by. Egg loss is often due to predation or unfavorable weather conditions. In either case, parental abandonment may occur. Hatching begins in early June, and young fledge by mid to late June. Chick mortality is primarily due to predation, or occasionally starvation. A smaller second wave of nesting often occurs from June to late July, and consists of renests after initial failures, as well as two year old birds breeding for the first time (Massey and Atwood 1981).

There is a strong tendency for first-time nesters to breed where they hatched or at a site in the same cluster. Parents and fledglings remain close to the breeding sites for a variable period before migration; fledglings require enough time to mature and become partially independent at procuring food. Adults train fledged young to forage. Post-breeding dispersal areas used for foraging and roosting are characterized by quiet (low turbidity) waters, suitable food sources, and protection from disturbance. These areas include Oakland Airport, Roberts Landing, Baumberg salt ponds, and Alvarado salt ponds in Alameda County; and Alviso/Sunnyvale salt ponds and Mountain View/Charleston Slough ponds in Santa Clara County. California least terns generally forage in nearshore ocean waters and in shallow estuaries and lagoons within 3.2 km (2 miles) of the breeding area. Fledglings accompanied by adults are often observed at shallow water, freshwater, and estuarine marshes of south San Francisco Bay prior to migrating south (Atwood and Minsky 1983). Migration usually begins in July and may continue through September.

California least terns have only been observed to eat fish (Massey 1974). Most fish taken are younger than one year, and typically include northern anchovy (*Engraulis mordax*) and topsmelt (*Atherinops affinis*), plus several other species (Atwood and Kelly 1984).

Predation affects the survival of California least tern eggs, young, and adults. Predators on eggs include spotted skunk (*Spilogale putorius),* American crow (*Corvus brachyrhynchos*), common raven (*Corvus corax*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), rat (*Rattus* sp.), Beechey ground squirrel (*Spermophilus beecheyi*), and feral cat (*Felis catus*). Predators on chicks include American kestrel (*Falco sparverius*), northern harrier (*Circus cyaneus*), loggerhead shrike (*Lanius ludovicianus*), red fox, and feral cat. Fledglings and adults have been preyed upon by American kestrel, peregrine falcon (*Falco peregrinus*), great horned owl (*Bubo virginianus*), burrowing owl (*Athene cunicularia*), and feral cats (U. S. Fish and Wildlife Service 2006*b*).

Threats. While the number of terns has increased at the San Francisco Bay colonies, there has not been an increase in the number of colonies in the Bay area, as required by the California Least Tern (*Sterna antillarum browni*) Recovery Plan. The level of production (fledged chicks per pair) has declined and continues on a downward trend (Marschalek 2006). However, new information suggests even at these production levels, the tern populations are continuing to increase.

Threats to the species' habitat have been ameliorated, but not eliminated. Habitat for the species is degraded throughout its range, and competing human activities continue to threaten the species. The remaining populations are located on small sites within wildlife refuges, military installations, and other public lands requiring intensive management. Within these managed sites, the species remains vulnerable to predation, invasive non-native plants, and human-related disturbance. Without continued intensive management of these sites, the Service anticipates that the threats of habitat loss and predation would reverse the population recovery that has occurred wince the species was federally listed (U.S. Fish and Wildlife Service 2006*b*).

In San Francisco Bay some of the most significant threats to least terns are related to degradation of habitat or reduction in habitat availability. Predation has been problematic at the Alameda Naval Air Station. Salt pond dredging and dike maintenance operations can cause short-term or multi-year loss of habitat availability. In the future, conversion of some salt ponds to restored tidal marshes could permanently eliminate unvegetated salt flats and dike roads used for nesting. Post-fledging foraging and rearing sites could also be affected by tidal restoration performed for recovery of rare or endangered salt marsh species.

In addition, limited prey availability associated with warm surface water temperatures may decrease fledging success in El Niño years (Caffrey 2005). These temperature patterns may be enhanced by warmer global sea temperatures and become more persistent in the future, leading to a possible northward range shift for California least terns in response to the availability of prey species. The limited availability of nesting areas in the San Francisco Bay could result in reduced nesting success which, if there is a substantial northward range shift, could threaten the existence of the subspecies throughout its range.

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The numerous bay area dikes allow feral cats easy access to California least tern, as well as other rare species like California black rail, clapper rail, western snowy plover, and salt marsh harvest mouse (American Bird Conservancy 2006). Five general areas within the scope of this recovery plan were identified as sites where cat predation is considered a threat to sensitive bird species: Don Edwards San Francisco Bay National Wildlife Refuge, San Pablo Bay wetlands, Benicia State Recreation Area, Eastshore wetlands (Alameda County), and Elkhorn Slough (Monterey County; American Bird Conservancy 2006).

Conservation Strategy. Enhancement and preservation of sites with the most successful recent use by least terns should be protected at least until successful long-term breeding habitats are restored elsewhere in San Francisco Bay. The Alameda least tern colony is the highest priority for continuing protection and management in the area covered by this plan. The Alameda National Wildlife Refuge has been managed to enhance fledgling production and success. Current management activities include monitoring, fencing, vegetation control, predator management, and enlargement of the nesting enclosure (Caffrey 2005). Other sites for protection and management include the PG&E Pittsburgh site, Oakland Airport, and Bair Island.

A potential conflict exists between tidal marsh ecosystem recovery goals and maintenance of post-fledge foraging and roosting in diked habitats in the South Bay. In the near term salt ponds and salt pond dikes used by California least terns should be preserved, and should be managed to be compatible with the needs of least terns. Where industrial salt pond operations discontinue and lands are available for restoration, it will be necessary to provide a mix of sustainable replacement habitat for least terns and sufficient restored tidal marsh for other listed species. Salt intake pond habitats may be replaced by autonomous sustainable shallow microtidal lagoons by modifying salt pond dikes and water intake structures.

Increases in potential nesting habitat could be achieved by converting extensive industrial salt crystallizer beds to wide, playa-like salt pan habitats, where willing landowners are amenable. This would also benefit recovery of snowy plovers and contribute to high tide shorebird habitat. Re-establishment of sand spits near the Hayward shoreline for recovery of *Suaeda californica* (California sea-blite) may also be modified to encourage expansion of least tern nesting colonies.

3. Tidewater goby (*Eucyclogobius newberryi*)

Description. The tidewater goby (*Eucyclogobius newberryi*) is the only species in a unique genus of gobies (Gobiidae). It is an elongate, grey-brown fish, approximately 5 centimeters (2 inches) in length (**Figure C-13**). Male tidewater gobies are nearly transparent; females develop darker colors on the body and dorsal and anal fins (U.S. Fish and Wildlife Service 2005*b*). The tidewater goby was federally listed as endangered on March 7, 1994 (U.S. Fish and Wildlife Service 1994). It is a California Fish Species of Special Concern (California Department of Fish

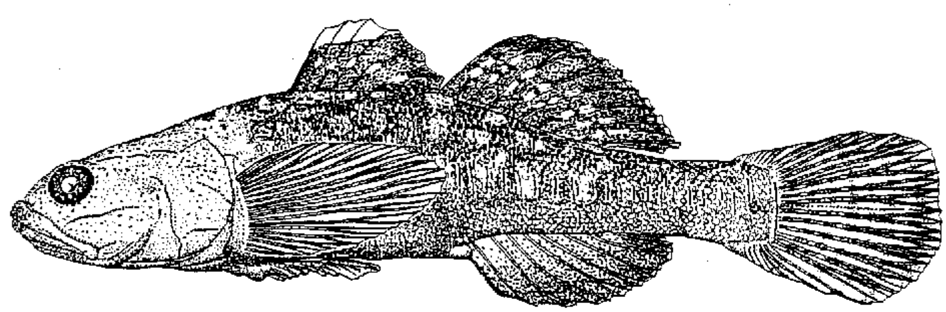

Figure C-13. Tidewater goby (with permission from Camm Swift)

and Game 2009). A recovery plan was released on December 7, 2005 (U.S. Fish and Wildlife Service 2005*b*). In 2007 the Service completed a 5-year status review throughout the species' range (U.S. Fish and Wildlife Service 2007*b*), and in 2008 the U.S. Fish and Wildlife Service published a final rule re-designating critical habitat to include additional sites in Del Norte, Humboldt, Mendocino, Sonoma, Marin, San Mateo, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, Ventura, and Los Angeles counties, CA (U.S. Fish and Wildlife Service 2008).

Distribution. The tidewater goby is endemic to California. Historically, it ranged from the mouth of the Smith River, Del Norte County, to Agua Hedionda Lagoon, San Diego County, in 87 known localities. Today, tidewater goby are found entirely within the known historical range at approximately 105 currently known extant localities (U.S. Fish and Wildlife Service 2005*b*).

Because the tidewater goby occurs in small unstable populations, its modern range is dynamic, but remains between Del Norte County (Lake Earl Lagoon) to San Diego with many large and variable gaps in distribution (**Figure C-14**). The species has become extirpated in the largest estuaries of the California coast (San Francisco Bay and Morro Bay). Today, the only fully tidal bay known to support the tidewater goby is Humboldt Bay. When the species was listed in 1994, it was known from 87 locations; however, additional locations have been identified since that time. Also, the species has been extirpated from some locations. Currently, of the 134 total possible locations, the species has been extirpated from 29 (21 percent); therefore 105 locations are presumed to be currently occupied (Smith *in litt*. 2007).

Life history. Tidewater gobies are a benthic species found in lagoons, estuaries, and stream mouths. They are generalist feeders, feeding mainly on small animals. They are preyed upon by a number of native and non-native species of fish, as well as piscivorous birds and garter snakes (*Thamnophis* spp.; U.S. Fish and Wildlife Service 2005*b*).

Spawning occurs in coarse sand where eggs are deposited in burrows from spring to mid-summer. Females aggressively compete for access to males with burrows. Female tidewater gobies can lay from 300 to 500 eggs per clutch (Swift *et al*. 1989), with 6 to 12 clutches per year (Swenson 1999). Tidewater gobies generally live for only 1 year (Moyle 2002).

The annual lifecycle of the tidewater goby, and the extreme climate-driven changes in their stream mouth habitat, makes the species prone to local extinction and recolonization. It is possible that some populations are naturally intermittent, and depend on dispersal from other populations to persist (U.S. Fish and Wildlife Service 2005*b*). The *metapopulation* structure of the species is not known.

Habitat. Tidewater goby habitat today includes various coastal brackish and marine waters, upper edges of shallow bays, and intermittently non-tidal lagoons. Within shallow embayments the tidewater goby usually occurs in brackish water less than 1 meter (3.3 feet) deep, but tolerates hypersaline conditions and is capable of marine dispersal. This wide salinity tolerance allows the tidewater goby to exploit the highly fluctuating salinity conditions that occur in California stream mouths (U.S. Fish and Wildlife Service 2005*b*). The stream mouth habitat of tidewater gobies contrasts with most listed or other special-status fish species that occur in the more upstream, freshwater-influenced reaches of estuaries. At Pescadero Creek Estuary (San Mateo County) it occurs near another species of concern, *Astragalus pycnostachyus* var. *pycnostachyus* (marsh locoweed).

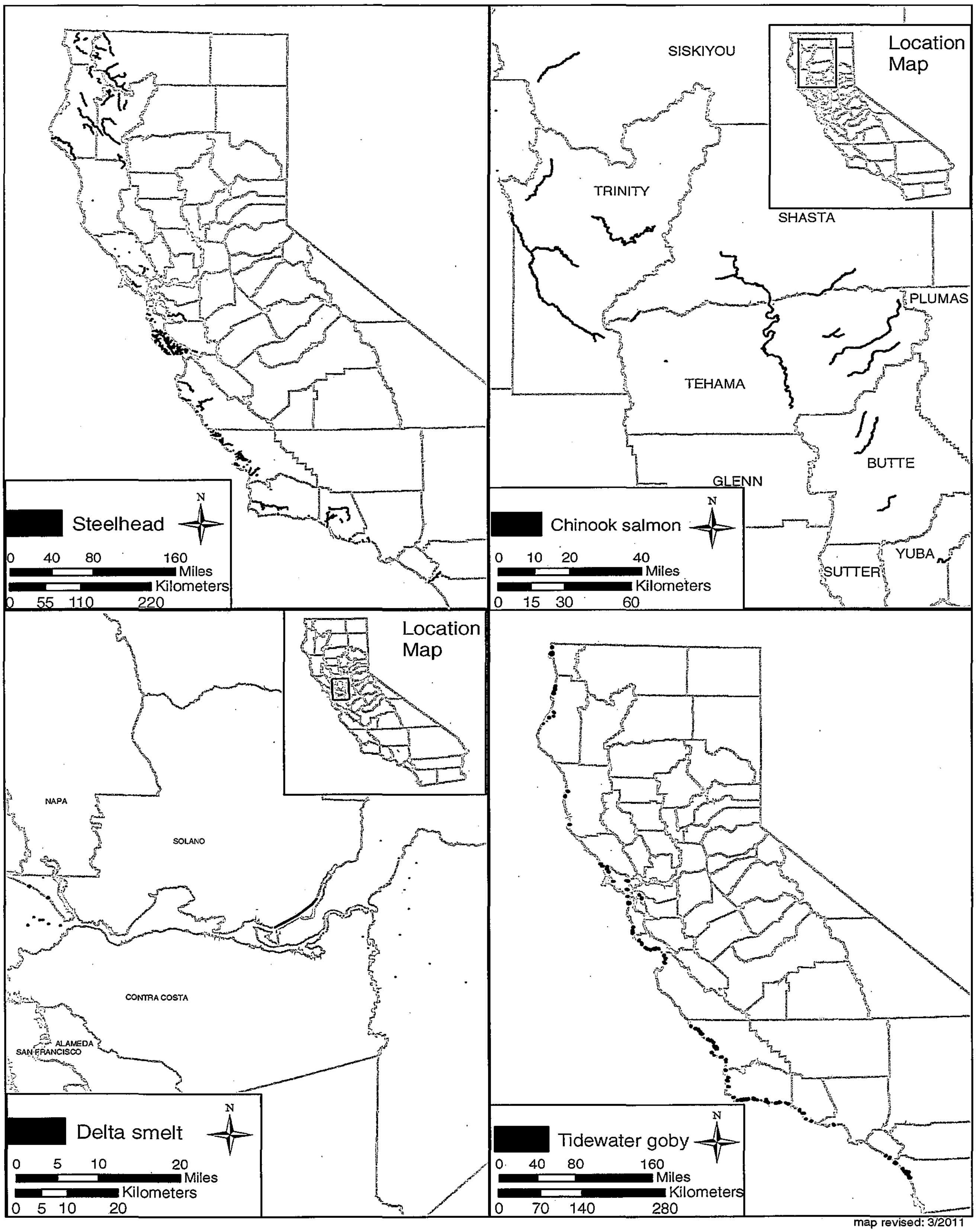

Figure C-14. Distribution of tidewater goby, Delta smelt, chinook salmon, and steelhead

Threats. The tidewater goby is threatened by habitat loss and alteration from development, flood control, anthropomorphic breaching of coastal lagoons, and freshwater withdrawal. Also, predation by and competition with native and non-native species continue to be a concern (U.S. Fish and Wildlife Service 2007*b*). Population extirpation or decline from these factors can result in decreased gene flow and ability to recolonize.

Conservation Strategy. Recovery actions for the species include four primary tasks: 1) monitor, protect, and enhance current habitat conditions for extant populations; 2) conduct research to acquire additional information needed for management; 3) restore degraded habitats to suitable conditions, and reintroduce or introduce tidewater gobies to those habitats; and 4) develop and implement an information and education program (U.S. Fish and Wildlife Service 2005*b*).

Tidal marsh recovery actions for listed species and conservation actions for other species of concern are not expected to have adverse impacts on tidewater goby populations or habitat. Protection of tidal (and intermittently tidal) marshes at creek mouths of San Mateo County, and restoration of tidal marsh and creek habitat in Humboldt Bay, would probably benefit tidewater gobies indirectly.

4. Delta smelt
(*Hypomesus transpacificus*)

Description. The delta smelt (*Hypomesus transpacificus*) is a small slender-bodied fish about 7.0 centimeters (2.8 inches) long (**Figure C-15**) in the family Osmeridae. It is found only in the Sacramento-San Joaquin Estuary. Live fish are nearly translucent with a steely-blue sheen on their sides; eyes are relatively large. The delta smelt is listed as threatened by both Federal (U.S. Fish and Wildlife Service 1993*b*) and State (California Department of Fish and Game 2009). A *Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes* was signed and approved on November 26, 1996 (U.S. Fish and Wildlife Service 1996).

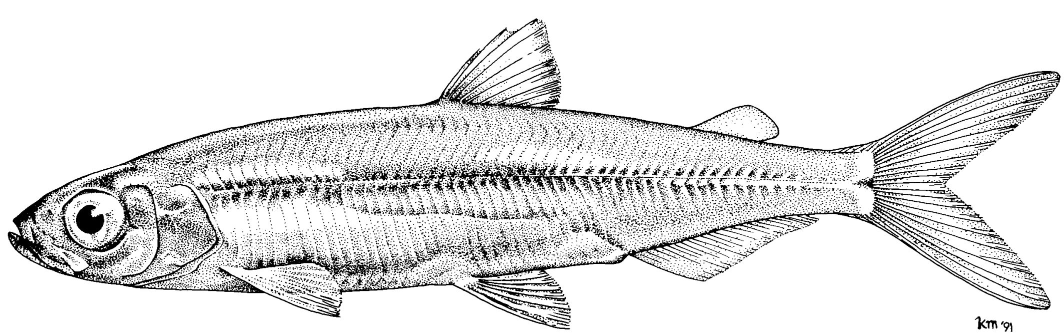

Figure C-15. Delta smelt (Kendal Morris/USFWS)

Distribution and Abundance. Delta smelt were one of the most abundant *pelagic* fishes in the delta in the early 1970s. After 1981, they experienced a steep decline in population that has continued over the last 20 years (Moyle *et al*. 1992, Sweetnam 1992) with no significant signs of recovery (U.S. Fish and Wildlife Service *in litt.* 2004). The current population size is unknown due to sampling uncertainties.

Distribution of delta smelt ranges from Suisun Bay at the downstream end to the upper Sacramento (mostly below Isleton) and lower San Joaquin (below Mossdale) rivers (Moyle *et al*. 1992; **Figure C-14**). In years of very high delta discharges adults can be found further downstream in the estuary, and newly emerged larvae have been detected as far west as the Napa River. The fish spawn in freshwater from January to July, and can occur in the Sacramento River to Sacramento, the Mokelumne River system, the Cache Slough region, the delta, and the Montezuma Slough area (U.S. Fish and Wildlife Service 1996).

Delta smelt distribution is influenced by salinity and food supply. Adults tolerate a range of salinity, but seldom occur in water with more than 10-12 parts per thousand salinity (about 1/3 sea water). In most years, fall abundance is highest when salinity in Suisun Bay the preceding spring is less than 2 parts per thousand.

Life history. Spawning appears to take place from January through July (Wang 1986, Sweetnam and Stevens 1993), or late March through mid-May in low outflow years. Smelt broadcast their eggs, which sink to the bottom and stick to hard substrates (Moyle 1976). Spawning success depends on bottom roughness (low-intertidal and subtidal vegetation, snags, rocks) for adhesive eggs, and escape habitat. Hatching takes about 9 to 14 days and feeding begins 4 to 5 days later (U.S. Fish and Wildlife Service 1996). Growth is rapid.

Delta smelt have nearly an annual life cycle. Most adults die after they spawn; however, 3-8 percent live for 2 years (Bennett 2003). These 2-year-old fish have 3 to 5 times the fecundity of 1-year-old fish, and may be significant in carrying the population over years of low abundance. The species has relatively low fecundity, and populations and habitats fluctuate strongly among years (U.S. Fish and Wildlife Service 1996, Sommer and Herbold 2000).

Zooplankton are the main food of delta smelt. The most important food prey is the euryhalinecopepod, *Eurytemora affinis*. *Pseudodiaptomus forbesi*, an exotic species, has become a major part of the diet (Moyle *et al*. 1992). Delta smelt are eaten by young striped bass (*Morone saxatilis*), white catfish (*Ameiurus catus*), and black crappie (*Pomoxis nigromaculatus*; U.S. Fish and Wildlife Service 1996). Inland silversides may be an important predator on larval delta smelt and competitor for copepod prey (U.S. Fish and Wildlife Service *in litt.* 2004).

Habitat. Delta smelt are found in the open, surface waters of the delta and Suisun Bay. Except when spawning, delta smelt tend to concentrate in the mixing zone, the area where incoming salt water and outflowing freshwater come together and zooplankton prey is most abundant. Most spawning occurs in sloughs and shallow edge waters of channels in the upper delta. Important spawning habitat occurs in Montezuma Slough, and may occur in Suisun Marsh and tributaries of northern Suisun Bay. Egg survival and spawning may be limited by high salinity in years of low river discharge, and spawning may be constrained to upper portions of the watershed in dry years.

Threats. The species decline is due to multiple factors. These include (in order of importance): 1) reduction in delta outflows caused by diversions and dams; 2) entrainment losses to water diversion; 3) high outflows; 4) changes in food organisms; 5) toxic subtances; 6) disease, competition, and predation; and 7) loss of genetic integrity (U.S. Fish and Wildlife Service 1996). Highly significant entrainment losses occur in delta diversion pumps, at downstream habitats (such as diked Suisun Marsh waterfowl wetlands), and at coolant water intakes of the power generation plant at Pittsburg. Larvae and juveniles are vulnerable to entrainment impacts because screens are not effective for these life stages (Sommer and Herbold 2000). Although diversions and droughts can harm the species by increasing downstream salinity impacts, extremely high outflows may flush smelt to the Central Bay or Golden Gate. Other long-term impacts may be caused by changes in plankton composition and trophic structure associated with non-native invasive invertebrate species (U.S. Fish and Wildlife Service 1996). Prey types and densities in the San Francisco Bay Estuary may potentially limit delta smelt (Sommer and Herbold 2000). The *pelagic* lifestyle, short lifespan, spawning habits, and low fecundity are characteristics that are greatly affected by changes in the reproductive habitat. A substantial population is probably necessary to keep the species from going extinct (U.S. Fish and Wildlife Service 1996).

Since about 2002, delta smelt is one of four *pelagic* fish species subject to what has been termed Pelagic Organism Decline (POD) (Sommer *et al.* 2007). The POD denotes the sudden, overlapping declines of San Francisco Estuary *pelagic* fishes first recognized in data collected from 2002 to 2004. The cause of POD is not fully understood, but appears to be layered and multifactorial (Baxter *et al.* 2008).

Conservation strategy. Large populations, predictable and ample food supply, and abundant diverse, extensive breeding habitats are needed to avoid high risks of extinction. The recovery of delta smelt is highly compatible with regional recovery objectives for tidal marshes around Suisun Bay, particularly from the mouth of the Sacramento River (near Collinsville and Browns Island) to western Montezuma Slough, including the baylands around Potrero Hills and Denverton. Recovery actions for tidal marsh species in the Suisun Marsh area are not expected to have any adverse impacts on delta smelt. Two types of recovery actions in this recovery plan are likely to benefit delta smelt:

(1) *Restoration of tidal marsh, channels, and mudflats near the null zone (entrapment zone) of the estuary*. In early stages of tidal marsh restoration this will provide expansion of extensive shallow subtidal habitat for foraging in one of the most potentially productive reaches of the estuary. In late stages, high densities of small dead-end sloughs would provide significant increases in spawning and rearing habitat.

(2) *Restoration of brackish tidal marsh, channels, and mudflats in Suisun Marsh*. Brackish marsh systems in this freshwater-influenced portion of the estuary are likely to provide significant new habitat and food production for delta smelt. Connections between freshwater drainages or creeks and brackish tidal marsh are likely to provide important refugia for the species during years of low river outflow or high diversion.

This recovery plan recommends converting some (and if successful, most) waterfowl-priority managed marshes from non-tidal seasonal wetlands with artificial flood and drain hydrologic regimes to shallow low-salinity microtidal lagoons with substantial (but limited) tidal circulation, gentle bottom gradients, and vegetated edges. This will provide productive habitat, which is ecologically and hydrologically beneficial to estuarine fish and wildlife, including for dabbling ducks (as well as other non-game waterbirds). This would probably provide substantial foraging habitat, and possibly spawning and rearing habitat in wet years, for delta smelt. It would also reduce the proportion of the Suisun baylands from which delta smelt are excluded, or which act as population sinks during managed marsh water intake periods.

On December 15, 2008, the U.S. Fish and Wildlife Service issued its Biological Opinion to the U.S. Bureau of Reclamation on the effects of the continued operation of the Federal Central Valley Project and the California State Water Project on the delta smelt and its designated critical habitat. The U.S. Fish and Wildlife Service determined that the continued operation of these two water projects, as described in their current project description, is likely to jeopardize the continued existence of the delta smelt and adversely modify its critical habitat. The Biological Opinion is accompanied by a Reasonable and Prudent Alternative intended to protect each life-stage and critical habitat of this species.

5. Chinook salmon (*Onchorhynchus tshawytscha*)

Description. Chinook salmon (*Onchorhynchus tshawytscha*) are anadromous salmonids (family Salmonidae; trout and salmon relatives) that migrate from the ocean as adults to gravel-bedded freshwater streams for spawning, and return to the ocean as first year juveniles (**Figure C-16**). The juvenile fry to smolt life stages pass through estuaries where significant growth may occur in interaction with tidal marsh ecosystems. Chinook salmon occur as biologically distinct populations or races distinguished by geographic isolation and timing of distinct breeding periods, or runs, in fall, late fall, winter, and spring. The Sacramento River winter-run chinook salmon was listed as threatened in 1989 by the National Marine Fisheries Service, and was reclassified as endangered in 1994. This race is also listed as endangered by the State of California (Moyle 1976, Maragni 2000). **Figure C-14** shows the known distribution of Chinook salmon.

Life History. Chinook salmon juveniles and adults are opportunistic carnivores, consuming a wide range of aquatic invertebrates and fish. In estuarine habitats, including mudflats, eelgrass beds, and channels of tidal marshes, they prey on insects, crabs, amphipods, copepods, chironomid midge larvae, and small fish (Maragni 2000). Juvenile salmon may use submerged portions of marsh vegetation as refuges from predators, as well as foraging areas during high tides. Tidal marsh ecosystems are considered to be of great importance to the survival and growth of juvenile salmonids (Healy 1982, MacDonald *et al.* 1988). The tidal marsh is exploited as foraging habitat by Chinook salmon fry, particularly at high tide, when they retreat to channels as the tide ebbs. Smolts tend to utilize tidal marsh channel habitats (Healy 1991).

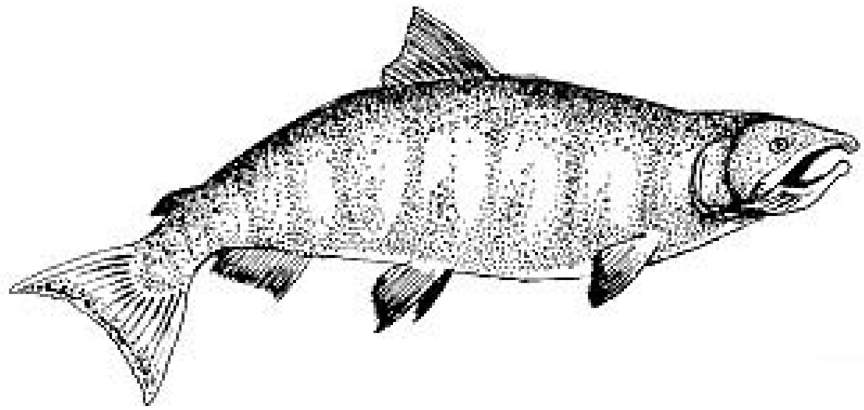

Figure C-16. Chinook salmon Bob Savannah/USFWS)

Threats. Threats to Chinook salmon are extensive and numerous, however are outside the breadth and scope of this recovery plan.

Conservation Strategy. Fall-run Chinook salmon, are expected to benefit directly from extensive restoration of tidal marsh ecosystems in the San Francisco Bay Estuary during all successional stages. Alteration of tidal regimen of any of the salt ponds should not confuse anadromous salmon from accessing appropriate river systems of origin, either Guadalupe River or Coyote Creek, by creating attraction flows that divert them to ponds when entering or exiting their spawning grounds. Please consult the National Marine Fisheries Service for further information as to salmonid recovery planning.

6. Steelhead
(*Onchorhynchus mykiss irideus*)

***Description*.** Steelhead (*Onchorhynchus mykiss irideus*) are fish of the family Salmonidae (trout and salmon; **Figure C-17**). They are anadromous, migrating to the ocean to mature and returning to freshwater streams to spawn. The inland, nonmigratory subspecies, *Onchorhynchus mykiss gairderi,* is known as rainbow trout (Behnke 1992). Steelhead are considered to be a coastal, anadromous subspecies of rainbow trout. Like Chinook salmon, distinct population segments are differentiated on the basis of the timing of migration and geographic distribution. Mixed populations of resident (nonmigratory) and anadromous steelhead may possibly interbreed, causing some ambiguity in taxonomic classification. The San Francisco Bay Estuary supports winter-run steelhead, which mature in the Pacific Ocean (Leidy 2000). Central coast stream mouth estuaries also support steelhead populations and habitats. The National Marine Fisheries Service listed the Central California Coast populations of steelhead as threatened in 1997 (National Marine Fisheries Service 1997).

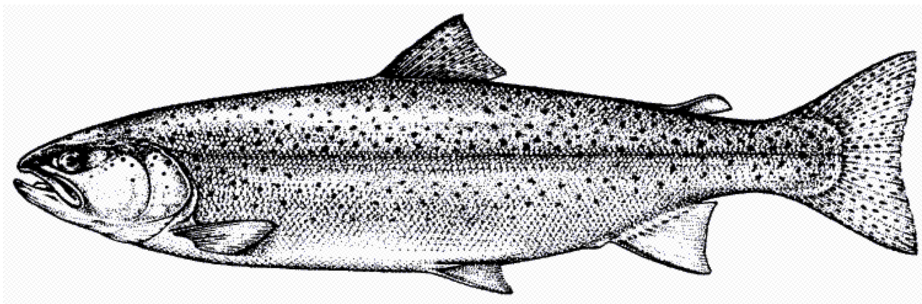

Figure C-17. Steelhead (Government of Canada Fisheries and Oceans)

Steelhead, unlike Chinook salmon, do not die after reproducing, and may return annually to natal streams to spawn. They remain in nontidal freshwater habitats for 1 to 4 years, then migrate to sea as smolts. Steelhead begin upstream migration in fall or winter after 1 to 4 years at sea, passing through estuaries during their migration. In the San Francisco Bay Estuary, the timing of upstream migration may be affected by releases of cold water from reservoirs tributary to the Sacramento River, inducing them to arrive in the estuary as early as August or September where they may be found through March. Steehead spawn only in gravel-bedded freshwater streams, not tidal habitats (Moyle 1976, Leidy 2000).

Distribution. Because of the difficulty of distinguishing resident and migratory forms of *Onchorhynchus mykiss* in coastal streams, precise distributions of listed steelhead populations are difficult to determine. Potentially, all large coastal stream mouth estuaries of the central California coast are steelhead habitat (**Figure C-14**). The total size of the San Francisco Bay Estuary steelhead population has been estimated to be less than 10,000 (Leidy 2000).

Life History. Tidal marsh ecosystems are most important to juveniles during their downstream migration, as upstream migrating steelhead rarely eat (Pauley and Bortz 1986). Juvenile steelhead are opportunistic drift feeders, consuming insects and their larvae, snails, amphipods, opossum shrimp, and small fish (Moyle 1976). The importance of tidal marsh habitats for growth and survival of steelhead is not as well documented as for Chinook salmon.

Threats. Threats to steelhead are extensive and numerous, however are outside the breadth and scope of this recovery plan.

Conservation Strategy. Tidal marsh restoration in the San Francisco Bay Estuary is unlikely to cause adverse impacts to steelhead, and may provide benefits as a result of increased estuarine prey production. The conversion of seasonally flooded and drained non-tidal waterfowl marshes in Suisun Marsh to microtidal lagoons may potentially reduce entrainment and mortality of juvenile steelhead. Alteration of tidal regimen of any of the salt ponds should not confuse anadromous steelhead from accessing appropriate river systems of origin, either Guadalupe River or Coyote Creek, by creating attraction flows that divert them to ponds when entering or exiting their spawning grounds. Please consult the National Marine Fisheries Service for further information as to salmonid recovery planning.

C. Other Species to Consider

California tidal marshes are inhabited by a diverse web of interacting species. In addition to the species discussed in the previous sections, which are covered by other plans or are covered by this recovery plan and addressed from a detailed recovery or conservation perspective, there are many other species that deserve consideration when projects affecting tidal marshes are contemplated. **Table C-2** provides a list of some of the notable species associated with tidal marshes in the recovery plan area, although the list is not exhaustive. Species have been included in the table for a variety of reasons, such as they:

- are declining or at-risk
- may be adversely affected by tidal marsh restoration or other projects
- have important functions in the tidal marsh ecosystem
- are special-status or sensitive species that occur at the edges of tidal marshes
- are sensitive species which formerly occurred and may still occur, so should be the subject of focused surveys
- may have unique ecotypes in local tidal marshes
- are very poorly known, and require further study

Table C-2. Other species to consider

Common Name	**Scientific Name**
ANIMALS	
shorebirds and waterfowl (see list next page)	
green sturgeon	*Acipenser medirostris*
California tiger salamander	*Ambystoma californiense*
brine shrimp	*Artemia franciscana*
sandy beach tiger beetle	*Cicindela hirticolis gravida*
mudflat tiger beetle	*Cicindela trifasciata sigmoidea*
western pond turtle	*Clemmys marmorata*
Jamieson’s wasp	*Compsocryptus jamiesoni*
southern sea otter	*Enhydra lutris nereis*

brine flies	*Ephydra cinerea, Ephydra millbrae, Lipochaeta slossonae*
California vernal pool tadpole shrimp	*Lepidurus packardi*
Bryant's savannah sparrow	*Passerculus sandwichensis alaudinus*
Pacific harbor seal	*Phoca vitulina richardsi*
Sacramento splittail	*Pogonichthys macrolepidotus*
California red-legged frog	*Rana aurora draytonii*
longfin smelt	*Spirinchus thaleichthys*
western tanarthrus beetle	*Tanarthrus occidentali*
California brackish water snail, mimic tryonia snail	*Tryonia imitator*
California sea lion	*Zalophus californianus*
PLANTS	
marsh bentgrass	*Agrostis exarata*
California sea-pink	*Armeria maritima* ssp. *californica*
Suisun marsh aster	*Symphyotrichum lentum* (and *intergrades* with *A. chilensis*)
Chilean aster	*Aster chilensis*
slim aster	*Symphyotrichum subulatum* var. *ligulatus*
marsh locoweed, coastal marsh milk-vetch, brine milk-vetch	*Astragalus pycnostachyus* var. *pycnostachyus*
alkali milk-vetch	*Astragalus tener* ssp. *tener*
California saltbush (salt marsh ecotypes)	*Atriplex californica*
Douglass' or salt marsh baccharis	*Baccharis douglasii*
black-head water sedge	*Carex aquatilis* var. *dives*
dense sedge	*Carex densa*
clustered field sedge	*Carex praegracilis*
Johnny-nip (salt marsh ecotypes)	*Castilleja ambigua* ssp. *ambigua,*
Humboldt Bay owl's-clover	*Castilleja ambigua* ssp. *humboldtiensis*
alkali centaury	*Centaurium trichanthum*
Bolander's spotted water-hemlock	*Cicuta maculata* var. *bolanderi*
northern salt marsh bird's-beak	*Chloropyron maritimum ssp. palustre*
least spikerush	*Eleocharis parvula*
sea-milkwort	*Glaux maritima*
seaside heliotrope	*Heliotropium curassavicum*
Congdon's spikeweed	*Hemizonia parryi* ssp. *congdonii*
Parry's spikeweed	*Hemizonia parryi* ssp. *parryi*
maritime spikeweed	*Centromadia pungens* ssp. *maritima*
prostrate hutchinsia	*Hutchinsia procumbens*
southwestern spiny rush	*Juncus acutus* L. ssp. *leopoldii*
saltmarsh toad-rush	*Juncus ambiguus*
wire-rush, Baltic rush	*Juncus balticus*
brown bog rush	*Juncus effusus* var. *brunneus*
salt rush	*Juncus lesueurii*

brown-headed rush	*Juncus phaeocephalus*
iris-leaved rush	*Juncus xiphioides*
Contra Costa goldfields	*Lasthenia conjugens*
Coulter's goldfields	*Lasthenia glabrata* ssp. *coulteri*
smooth goldfields	*Lasthenia glabrata* ssp. *glabrata*
rayless smooth goldfields	*Lasthenia glaberrima*
alkali goldfields	*Lasthenia platycarpha*
smooth layia	*Layia chrysanthemoides*, halophytic ecotypes
alkali peppergrass	*Lepidium dictyotum*
dwarf peppergrass	*Lepidium latipes*
sharp-fruit peppergrass	*Lepidium oxycarpum*
creeping wildrye, halophytic ecotypes	*Leymus triticoides*
Mason's lilaeopsis	*Lilaeopsis masonii*
smooth popcornflower	*Plagiobothrys glaber*
Petaluma popcornflower	*Plagiobothrys mollis* ssp. *vestitus*
annual coast plantain	*Plantago elongata*
seaside plantain	*Plantago maritima*
marsh fleabane	*Pluchea odorata*
Pacific alkali goosegrass	*Puccinellia nutkanensis*
clustered goldenweed	*Pyrrocoma racemosa*
ruppia, widgeon-grass	*Ruppia maritima*
Parish's glasswort	*Sarcocornia subterminalis*
adobe or marsh sanicle	*Sanicula maritima*
Parish's glasswort	*Senecio hydrophilus*
hemlock water parsnip	*Sium suave*
southern goldenrod	*Solidago confinis*
alkali-blite	*Suaeda moquinii*
salt marsh bladder clover	*Trifolium depauperatum* var. *hydrophilum*
eelgrass	*Zostera marina*

Shorebirds and waterfowl of San Francisco and San Pablo bays (U.S. Fish and Wildlife Service 1987)

WATERFOWL	**Abundance in each season**			
	Sp	**S**	**F**	**W**
___ tundra swan	r	-	r	r
___ greater white-fronted goose	-	-	o	o
___ snow goose	-	-	r	o
___ Ross' goose	-	-	-	r
___ brant	r	r	r	r
___ Canada goose*	u	r	r	u
___ wood duck	r	r	o	o
___ green-winged teal	u	o	u	c
___ mallard*	c	c	c	c
___ northern pintail*	c	c	a	a

___ blue-winged teal*	o	r	o	o
___ cinnamon teal*	c	u	c	c
___ northern shoveler*	c	u	a	a
___ gadwall*	u	c	c	c
___ Eurasian wigeon	-	-	r	r
___ American wigeon	c	u	r	a
___ canvasback	c	o	c	a
___ redhead	r	-	o	o
___ ring-necked duck	r	-	r	r
___ greater scaup	u	r	o	c
___ lesser scaup*	a	o	a	a
___ oldsquaw	r	r	r	r
___ black scoter	r	-	o	r
___ surf scoter	u	r	a	a
___ white-winged scoter	o	-	u	u
___ common goldeneye	u	r	u	c
___ Barrow's goldeneye	r	-	o	o
___ bufflehead	c	o	c	a
___ hooded merganser	-	-	o	r
___ common merganser	r	-	o	r
___ red-breasted merganser	u	-	u	u
___ ruddy duck*	c	c	a	a

SHOREBIRDS	**Sp**	**S**	**F**	**W**
___ greater yellowlegs	c	u	c	c
___ lesser yellowlegs	o	o	u	r
___ willet	a	c	a	a
___ wandering tattler	r	r	o	r
___ spotted sandpiper	r	r	r	r
___ whimbrel	u	o	u	o
___ long-billed curlew	c	u	c	c
___ marbled godwit	a	c	a	a
___ ruddy turnstone	u	u	u	u
___ black turnstone	u	u	u	u
___ red knot	c	u	c	c
___ sanderling	u	u	u	u
___ semipalmated sandpiper	-	r	o	-
___ western sandpiper	a	c	a	a
___ least sandpiper	c	c	a	a
___ Baird's sandpiper	r	r	r	-
___ pectoral sandpiper	r	r	r	-
___ dunlin	c	o	a	a
___ short-billed dowitcher	c	u	c	c
___ long-billed dowitcher	c	o	c	c

Season Symbols:

Sp - Spring - March to May
S - Summer - June to August
F - Fall - September to November
W - Winter - December to February

Abundance Symbols:

a - abundant: a common species which is very numerous
c - common: certain to be seen in suitable habitat
u - uncommon: present, but not certain to be seen
o - occasional: seen only a few times during a season
r - rare: known to be present, but not every year
* - birds known to nest locally
# - threatened or endangered

Accounts for Other Species to Consider

More information on most of the animal species in **Table C-2** is available elsewhere. Information on many of the plant species is less available, so brief accounts of these species are provided below.

In addition to non-listed rare plant species of concern, other California tidal marsh plant taxa (including species, subspecies, varieties, and geographically distinct ecotypes) may be at risk. One of the purposes of this recovery plan is to preclude the need to list such species in the future by addressing their conservation needs through ecosystem-level actions. Another purpose is to ensure the continued survival of listed species by conserving their natural communities. Little is known about the interactions among endangered plant species and their associated species in tidal marshes of the central California coast, but ecologically important interactions have been confirmed in similar taxa in southern California tidal marshes (Pennings and Callaway 1992, Callaway and Sabraw 1994, Callaway 1994), and in northeastern North American tidal marshes (Bertness 1992; Bertness and Yeh 1994; Hacker and Bertness 1995, 1999). To maintain necessary community interactions, it is prudent to protect tidal marsh plants associated with listed species.

Much of the important biological diversity in plants is difficult to conserve under existing circumstances. Plants often have significant variation among populations, and intergradation (due to hybridization and introgression) occurs more freely than in animals (Stebbins 1974). Genetic variability within species, particularly that which is related to ecological adaptation (such as salt tolerance, a trait relevant to tidal marsh ecotypes), has much evolutionary and ecological value for biological diversity and for population viability of rare species (Wolf and Sinclair 1997, Lesica and Allendorf 1995).

Many plants that are neither rare nor endangered over their geographic range as a whole have undergone significant regional declines in abundance, or have suffered specific losses of populations specially adapted to saline marsh soils. Some widespread species, such as creeping *Leymus triticoides* (creeping wildrye), have declined from former abundance or dominance in salt marsh edges, but are still common in other habitats. Similarly, *Atriplex californica* (California saltbush), which is widespread but not abundant, has become extirpated over significant portions of its historical tidal marsh range. There are also many examples of species found mainly in other communities that occur marginally in tidal marsh communities and add substantial floristic diversity. Some may form distinct salt-tolerant tidal marsh edge ecotypes, such as *Solidago confinis* (southern goldenrod), *Lepidium oxycarpum* (sharp-fruited peppercress), and *Pyrrocoma racemosa* (clustered goldenweed). Other typical tidal marsh species, including *Glaux maritima* (sea-milkwort) and *Senecio hydrophilum* (salt-marsh butterweed), have apparently undergone significant contractions of range in coastal California, becoming extirpated in estuaries. The conservation significance of declines is great; it represents both a significant potential loss of adaptive genetic diversity and may be an early symptom of rarity and endangerment, an early warning to intercede before the species or its ecosystem require more costly conservation measures (Lomolino and Channell 1998, Wilcove *et al.* 1993).

The U.S. Fish and Wildlife Service has reviewed many legally unprotected California tidal marsh plants that historically occurred in tidal marshes, but are declining, scarce, or rare today. Based on available data, species with ecologically significant conservation status have been classified in two categories and assessed individually. “Species of concern” are those taxa for which there is currently ample evidence for concern about the future viability of their populations. This evidence includes substantial decline in abundance, geographical distribution, loss of population variability or distinct populations, or increased threats. Species reasonably presumed to be distinct taxonomic units are included in this category, even if some taxonomic uncertainty exists. “Species of Regional Conservation Significance” is a broader category that includes some species that otherwise may qualify as “species of concern,” but which suffer from more basic taxonomic uncertainty, or data gaps about current or past distribution and abundance. In most cases this category applies to species that are wide-ranging, but have declined significantly in abundance, range, or variability in contemporary tidal marshes of the central California coast. Even though some of these species may not be rare globally, they contribute much of the floristic diversity of California tidal marshes. This floristic richness of the California tidal marsh plant community is a crucial matter for its ecological functions.

Some of the species discussed below have either acute conservation needs or substantial new information regarding their status. These species are given full accounts. Other species are given briefer summary accounts, either because less information is available, or because the severity of their threats is lower and justifies less rigorous evaluation.

Conservation of species will require general tasks that conform to overall recovery strategies for endangered tidal marsh species as well as species-specific tasks. General actions are aimed at the conservation of species threatened primarily by loss or degradation of habitat and significant declines in range. These actions may not apply to species threatened primarily by unique species-specific threats, such as hybridization with non-native congeners or local environmental degradation. General actions include:

(1) Within subregional floristic surveys of coastal marshes, determine approximate distribution and abundance of species. For annual species or those with affinity for lower-salinity brackish marshes, surveys should include at least two years of above-average rainfall, when they are most likely to be detected. Survey areas should include at least historical localities and suitable habitat in the vicinity of historical and contemporary localities. Survey areas should also include likely habitat within or adjacent to historical range in areas with no collection records or reported occurrences.

(2) Reports or maps identifying the location, abundance, and significance of these species should be distributed to State, Federal, and local regulatory, land use planning, and natural resource agencies. Reports should include species checklists and status summaries to assist in preparation of environmental assessment or impact reports. In addition, reports should be made available to the interested public, adjacent landowners, conservation organizations, and land-use organizations. Reports should include recommendations for protection and conservation of populations within agency jurisdiction.

(3) Where populations are on private lands, reports should also be distributed to private landowners with recommendations for voluntary cooperative protections. If feasible, develop and implement incentives for private landowners to cooperate with, or adopt independently, species and wetland habitat conservation measures.

(4) Resource, regulatory, and planning agencies should use their discretion to protect existing populations of these species through protection of suitable habitat and opportunities to restore additional habitat around them.

(5) Populations should be occasionally revisited to reconfirm their status. Verified populations should be protected against destruction or habitat degradation.

(6) Where coastal marsh restoration projects include reintroduction, these species should be assessed for feasibility and appropriateness of active reintroduction from proximate populations. Where appropriate, reintroduction of founder populations should be attempted. Direct transplantation of stock from natural populations should be avoided. Founders should be scientifically sampled and propagated from wild stock with minimum interference with the structure and abundance of wild populations. Where resources are sufficient, long-term monitoring of artificial founder populations and daughter populations is preferable, and documentation of founder populations (with reports to the California Department of Fish and Game) is essential.

(7) Where taxonomic questions arise concerning the distinctiveness of infraspecific taxa or the possibility of unrecognized infraspecific taxa, new research on variation within and

among populations of species of concern should be conducted. The research should address whether previously unidentified taxa may require additional protection or legal status.

SPECIAL STATUS PLANT SPECIES

Astragalus pycnostachyus A. Gray var. *pycnostachyus* (Marsh locoweed (Abrams 1951), brine milk-vetch (Barneby 1964), coastal marsh milk-vetch)

Description and Taxonomy

Description. *Astragalus pyncnostachyus* A. Gray var. *pycnostachyus* (marsh locoweed) is a stout, tall (40 to 90 centimeters [1.3 to 3 feet tall]) erect perennial herb in the Fabaceae (pea) family. Its growth habit is characterized by clumps of thick hollow shoots emerging from a central rootstock. The main shoots are reddish-purple, often covered with whitish woolly hairs when young, but becoming nearly smooth with maturity. Leaves are compoundly pinnate, with 23 to 41 narrow leaflets covered with fine, dense, silvery-white hairs. On well-developed specimens, leaves reach about 15 centimeters (about 6 inches) long at full size. The inflorescence is a raceme (elongate cluster of flowers) with a long stalk (peduncle), 4 to 10 centimeters (1.5 to 4 inches; Barneby 1964, Spellenberg 1993). Flowers are numerous, commonly 40 to 90 or more per raceme on Point Reyes specimens, crowded and overlapping, with greenish white to yellowish-cream colored petals. Fruits are an inflated dry legume up to about one centimeter (less than 0.5 inch) long, with a beak 5 to 8 millimeters long (up to 0.3 inch) containing two to five hard-coated seeds (Barneby 1964, Spellenberg 1993). Biochemical traits of *Astragalus pycnostachyus* have not been characterized, but the genus is well known for the variation in pharmacologically active or toxic substances among its many species (Rios and Waterman 1997).

Taxonomy. The type specimen of *Astragalus pycnostachyus* var. *pycnostachyus* was collected at Bolinas Lagoon, Marin County by Henry Bolander in 1863. *Astragalus pycnostachyus* var. *pycnostachyus* (coastal marsh milk-vetch) was distinguished from its southern coastal Californian variety, *Astragalus pycnostachyus* var. *lanosissimus* (Ventura marsh milk-vetch), by Rydberg in 1929, who placed it in the now-abandoned genus *Phaca*, as *Phaca lanosissima* Rydb. Munz and McBurney transferred the southern variety to *Astragalus pycnostachyus* in 1932 (Abrams 1951). The diagnostic characters that separate the varieties were formerly treated as discontinuous (Barneby 1964), but they overlap or vary continuously in the most recent taxonomic treatment (Spellenberg 1993). The distribution of *Astragalus pycnostachyus* var. *lanosissimus* is disjunct from the southern range of var. *pycnostachyus* in San Mateo County, historically occurring in southern California only (Ventura and Los Angeles counties). The southern variety (*i.e., Astragalus pycnostachyus* var. *lanosissimus*) was rediscovered in 1997 at a proposed development site where it was inadvertantly resurrected from a buried seed bank. It was listed as endangered on May 21, 2001 (U.S. Fish and Wildlife Service 2001*a*).

Astragalus pycnostachyus is a distinctive taxon within the highly diversified genus. The only other robust perennial coastal milk-vetch species that occurs on the immediate coast within the geographic range of *Astragalus pycnostachyus* is *Astragalus nuttallii,* which it resembles (Barneby 1964). *Astragalus nuttallii* (two highly similar varieties: var. *nuttalii* from Santa Cruz to the south and var. *virgatus* north of Santa Cruz; Munz 1959) is prostrate to erect, green with sparse hairiness (or none) on its vegetative parts, and typically grows in matted or tangled clumps on dry coastal dunes and bluffs. In contrast, *Astragalus pycnostachyus* in coastal bluffs is restricted to seeps or areas with high groundwater.

Population Trends and Distribution

Historical distribution. The historical range of *Astragalus pycnostachyus* var. *pycnostachyus* extended from coastal Humboldt County (Humboldt Bay) to coastal San Mateo County. It appears to be principally a maritime species; there are no records of *Astragalus pycnostachyus* from the San Francisco Bay Estuary tidal marshes. The species is apparently extirpated in its type locality at Bolinas Lagoon where it was last reported in 1945 (Howell 1949). *Astragalus pycnostachyus* var. *pycnostachyus* has not been recorded in Mendocino County (Smith and Wheeler 1992) or Sonoma County (Best *et al.* 1996), and was not reported from Humboldt County since collections were made by Tracy between 1918 and 1930 south of Cape Mendocino, and W.S. Cooper in 1925 at Samoa. The majority of historical collections were made at Point Reyes, Marin County. Other historical populations occurred at two inland localities, Crystal Springs Reservoir (San Mateo County) and an unknown site similar to subsaline grassland at Bolinas Lagoon (Greene 1891). Remaining historical localities were associated with coastal stream mouths of San Mateo County (Tunitas, San Gregorio, Pomponio, Pescadero, Arroyo de los Frijoles, and Bean Hollow creeks), and one coastal site (Pillar Point).

Current distribution. Surveys revealed large new occurrences in San Mateo County (Niederer *in litt.* 2004), which now appears to be the core population of *Astragalus pycnostachyus*. A new population was also discovered in 2003 along the mouth of the Mattole River in Humboldt County, with 108 individual plants confined to 30 square meters (323 square feet; Imper *in litt.* 2004). The Humboldt population is currently the northern limit of the species range.

Surveys for *Astragalus pycnostachyus* in 1997-1999 along the Marin County coastline found populations only at Drakes Estero and Limantour Estero, near historical collection localities at Point Reyes, Marin County. Colonies of *Astragalus pycnostachyus* var. *pycnostachyus* occur near Schooner Landing and Sunset Beach (Drakes Estero), and Whitegate Trail Marsh at the head of Limantour Estero. Smaller colonies are found mostly along the eastern shore of Drakes Estero and at Drakes Head. In 1999, the total Marin County population was approximately 600 to 650 mature plants, distributed within 9 colonies (P. Baye unpubl. data 1997-1999). As of 2003, Point Reyes supported a total of approximately 950 individual plants in 13 colonies (Coppoletta *in litt.* 2004). The majority of these plants were found in the narrow habitat zone between the salt marsh and upland coastal scrub, and dominated by *Baccharis pilularis* (coyote brush).

In 1999, populations of *Astragalus pycnostachyus* in coastal San Mateo County were small and sparse, with a total of fewer than 180 plants distributed in three colonies (P. Baye unpubl. data 1997-1999). However, surveys in 2004 found hundreds of new plants at Pescadero Marsh, Pomponio, San Gregorio, and a new population at Tunitas Creek (Niederer *in litt.* 2004). The largest populations were on bluffs in breaks in the coastal scrub in disturbed areas such as old road cuts, gullies, landslides, cliffs, and trails. *Astragalus pycnostachyus* was also found about a half mile inland at Pomponio, in the middle of a rarely used dirt road.

Life History and Ecology

Reproduction and Ecology. *Astragalus pycnostachyus* appears to be a potentially long-lived perennial species. It grows in discrete erect or ascending individual clumps and lacks spreading clonal growth. Flowering typically begins in June, and may continue as seed ripens through late summer or fall (P. Baye pers. observ. 1997-1999). Reproduction appears to depend exclusively on seedling establishment. Seedlings were locally frequent in and among adult plants, both in disturbed and completely vegetated sites. Dispersal of seeds appears to occur mostly across short distances, but the presence of relatively isolated small colonies hundreds of meters (over a thousand feet) from main colonies in Drakes Estero suggests occasional long-distance seed dispersal. In some cases, seeds may be dispersed within the inflated dried pods, which are light and buoyant enough for transport by currents and waves. However, the inland sites, such as the colonies approximately 800 meters (a half mile) inland at Pomponio and colonies on bluffs, suggest another mechanism. Fruits may be lightweight enough when dry to become windblown. Seeds germinate rapidly after *scarification*, even at low temperatures. Unscarified seeds germinate more erratically (P. Baye pers. observ. 1999). The rediscovery of the variety *lanosissimus* after 30 years suggests that the species is capable of forming a long-lived dormant seed bank. It is possible that the new variety *pychnostachyus* populations in San Mateo County in 2004 came from seed released by erosion.

Bees (honeybees and bumblebees) are common visitors to flowers of *Astragalus pycnostachyus* at Schooner Bay (P. Baye pers. observ. 1998). Bees are also typical pollinators of other large-flowered *Astragalus* species (Karron 1987). Nothing is known of the breeding system of *Astragalus pycnostachyus*. Karron (1989) found that some rare, geographically restricted perennial species of *Astragalus* were self-compatible. The capacity for seed production of individual mature plants is very high. Preliminary data from the Schooner Landing colony in 1998 indicate that individual plants commonly produce over a thousand to several thousand seeds per year. Seed set observed at Drakes Estero was very high in 1998, with a very high proportion of mature fruits by mid-summer, with continuing flowering.

Astragalus pycnostachyus roots, like those of almost all species in the Fabaceae family, generally support root nodules with symbiotic nitrogen-fixing bacteria, a potentially important source of nitrogen in sandy soils. Other possible sources of plant nutrients for the species include decomposing organic tidal litter in driftlines, nutrients from flood-deposited sediments or seawater overwash, and plant litter from adjacent nitrogen-fixing species such as *Myrica californica* (wax myrtle; P. Baye pers. observ. 1997-1998).

Shoreline erosion and seawater flooding during high tides in the growing season appear to cause mortality of adult and juvenile plants alike. Populations occur mostly in wave-sheltered environments, where direct exposure to strong salt spray is minimal. Intensive cattle trampling appears to affect seedling survival in some Drakes Estero sites (P. Baye unpubl. data 1998). Grazing impacts on *Astragalus pycnostachyus* is relatively minor even where general grazing pressure is strong, probably because of toxic and unpalatable substances that deter herbivory in many *Astragalus* species (Molyneaux and Ralphs 1992).

Habitat Characteristics/Ecosystem

The description of historic localities of *Astragalus pycnostachyus* generally includes reference to moist coastal habitats, particularly margins of salt marshes (Greene 1891, Greene 1894, Jepson 1911, Howell 1949, Thomas 1961, Munz 1959). Habitat descriptions from herbarium collections also include sandy or grassy flats within ocean-facing coastal slopes 3 to 150 meters (10 to 500 feet) above sea level and drier margins of salt marsh just above the high tide line.

The habitats of most modern *Astragalus pycnostachyus* colonies are often associated with the uppermost tidal flooding zone of sheltered estuaries, tidal marshes, and coastal stream mouths. Many populations occur in the driftline zone, the band of tidal debris left by extreme tides. Substrates typically are sandy or gravelly (spits and beaches), coarse alluvium (floodplain deposits of stream mouths), or clayey to silty sands. The one known colony on a flat bluff top above sea level (Pomponio Creek) is associated with the wet ground of a local seep.

Astragalus pycnostachyus appears to have an affinity for the upper margins of flooded saline habitats or subsaline soil, but has very limited tolerance to substrate salinity. Acute injury, dieback, and death can result from even brief seawater inundation during the growing season. Associated species indicate habitat with subsaline or brackish, rather than full haline conditions of salt marsh. Habitats of most colonies are transitional between brackish or salt marsh and adjacent upland communities (beach, foredune, coastal scrub, coastal grassland). Many colonies are associated with low narrow vegetated sand or gravel beach ridges subject to storm overwash. Seawater inundation during winter dormancy, however, may cause little or no injury to perennial coastal plant species that are otherwise intolerant during growth (Baye 1990). No salt spray injury has been observed on *Astragalus pycnostachyus* even in highly spray-exposed sites (*e.g.,* Pomponio Beach bluff crest). Tolerance to salt spray is probably related to the dense woolly hairs of the leaf surface, especially on young expanding leaves.

Plant associations that include *Astragalus pycnostachyus* are variable, but typically include a mix of halophytes (plants that tolerate saline soil) and glycophytes (plants relatively intolerant of salinity) in ecotones between periodically flooded saline habitats and unflooded non-saline soils. Halophytes commonly associated with *Astragalus pycnostachyus* include *Distichlis spicata* (saltgrass), *Frankenia salina* (alkali-heath), *Spergularia macrotheca* (large-flowered sand-spurrey), and *Atriplex californica* (California saltbush). Wetland halophytes tolerant of strongly waterlogged, frequently inundated soils (*e.g., Spartina foliosa* [Pacific cordgrass], *Bolboschoenus maritimus* [alkali-bulrush]) are never associated with *Astragalus pycnostachyus*, but it does occur in association with wetland species characteristic of riparian fresh-brackish marsh vegetation (*e.g., Carex obnupta* [slough sedge], *Scirpus pungens* [threesquare bulrush]) at coastal bluffs seeps and riparian vegetation of stream mouths. The upper boundaries of colonies occur at the edges of coastal scrub or dune communities. Ruderal (weedy) and pioneer species (*e.g., Carpobrotus chilense* [sea fig], *Cirsium arvense* [Canada thistle], *Anagallis arvensis* [scarlet pimpernel]) are also common in some shoreline vegetation with *Astragalus pycnostachyus*. Peak local abundance of *Astragalus pycnostachyus* is usually centered along the upper edges of high tide lines, the approximate boundary between adjacent habitat types. *Astragalus pycnostachyus* is a locally dominant to abundant component of the vegetation at Schooner Landing, Limantour Estero head, and Sunset Beach sites, forming tall stands with high density and cover. At other sites it is usually gregarious and locally abundant, but sometimes occurs in sparse colonies of scattered individuals (*e.g.*, western Schooner Bay, western Drakes Head Marsh)

One habitat type cited by Munz (1959) that is no longer well represented in modern colonies is "moist depressions behind dunes," or dune slacks (Ranwell 1972). Dune slack habitat may occur at several historical localities, including Samoa and Bolinas. The beach colony at Pomponio Creek approximates dune slack habitat. Many of the plant species associated with salt marsh edges and *Astragalus pycnostachyus* colonies are also common to dominant elements of dune slacks of the central California coast (*e.g., Juncus lesueurii* [rush], *Potentilla anserina* [silverweed], *Scirpus pungens*). At a former colony in a foredune slack (vegetated beach depression) north of the mouth of Pescadero Creek, *Astragalus pycnostachyus* occurred within an assemblage composed of *Ammophila arenaria* (European beachgrass), *Leymus mollis* (American dunegrass), *Distichlis spicata*, *Grindelia stricta* (gumplant), *Potentilla anserina*, *Heliotropium curassavicum* (seaside heliotrope), and *Gnaphalium stramineum* (cudweed). This population was eliminated by storm erosion following severe winter floods in 1998. A small colony of *Astragalus pycnostachyus* persisted in a similar ecotone between low dune, beach, and brackish marsh near the mouth of Pomponio Creek, in driftlines dominated by *Ammophila arenaria* and woody flood debris, but including *Distichlis spicata* and *Scirpus pungens*.

Other plant assemblages that support colonies of *Astragalus pycnostachyus* include upper brackish or salt marsh, variations of coastal scrub associations, and fresh-brackish riparian vegetation. The largest stands of the species at Point Reyes are co-dominated by *Grindelia stricta* and *Distichlis spicata*. The brackish non-tidal marsh assemblage at Pescadero Creek with *Astragalus pycnostachyus* is dominated by *Sarcocornia pacifica* (pickleweed), *Distichlis spicata*, *Juncus lesueurii*, *Potentilla anserina*, and *Frankenia salina*. The largest colony of *Astragalus pycnostachyus* at Pescadero is distributed on a levee top adjacent to the brackish marsh. It occurs in an assemblage dominated by *Eriophyllum staechadifolium* (seaside coast sunflower), *Scrophularia californica* (bee-plant), and including *Juncus patens* (rush), *Achillea millefolium* (yarrow), and *Leymus triticoides* (creeping wildrye). A small marsh edge population at Pomponio Creek occurred in a diked brackish marsh association with *Scirpus pungens*, *Carex obnupta* (slough sedge), *Leymus triticoides*, *Frankenia salina*, *Aster chilensis* (chilean aster), *Jaumea carnosa* (fleshy jaumea), and other species of the upper zones of brackish marsh. In the tidal riparian flood zone at San Gregorio Creek, *Astragalus pycnostachyus* occurred in disturbed alluvium with an anomalous assemblage of riparian, brackish marsh, and coastal scrub elements: *Grindelia stricta*, *Achillea millefolium*, *Eriophyllum staechadifolium* (lizard-tail), *Baccharis pilularis* (coyote-brush), *Rubus ursinus* (California blackberry) *Juncus bufonius* (toad rush), *Anagallis arvensis*, *Parapholis incurva* (sicklegrass), and *Melilotus alba* (white sweet-clover). A similar anomalous and predominantly non-halophytic assemblage at Pomponio Creek occurred on a low bluff seep dominated by *Juncus lesueurii*, and *Toxicondendron quercifolium* (poison-oak), and included *Scrophularia californica* (bee-plant), *Stachys ajugoides* (hedge-nettle), *Iris douglasii* (Douglas' iris), *Carpobrotus edulis* (iceplant), and *Carex obnupta*.

Threats Assessment

Historical threats to *Astragalus pycnostachyus* var. *pycnostachyus* include habitat loss due to residential shoreline development, bridge and highway construction, and decline in habitat quality caused by cattle trampling and invasion by non-native vegetation. These influences have caused sufficient cumulative decline so that the impacts of natural disturbances may be artificially magnified and catastrophic. Natural disturbances that cause decline include extreme high tidal flooding during the growing season and storm erosion of habitat.

Residential development at Stinson Beach that eliminated nearly all suitable habitat apparently caused extirpation of *Astragalus pycnostachyus* var. *pycnostachyus* at the type locality at the mouth of Bolinas Lagoon. Bridge construction and shoreline stabilization at coastal stream mouths appear to have substantially reduced the fluctuating, disturbed ecotonal habitats at San Mateo County stream mouths. Current threats at Drakes Estero include intensive trampling by cattle, which congregate in loafing areas along bayside beaches at high marsh edges where *Astragalus pycnostachyus* plants and seedlings occur. There is little evidence for direct grazing or browsing of stems by cattle or deer, but intensive trampling by cattle can destroy seedlings and juvenile plants, and cause injury to brittle mature flowering stems. Trampling impacts are probably minor for larger populations, but may be highly significant for small populations, such as founder (pioneer) colonies. Locally intensive cattle trampling may also magnify natural disturbance by shoreline erosion by reducing vegetative cover excessively, such that otherwise beneficial storm erosion events may lead to excessive erosion followed by trampling-impaired seedling regeneration. This may explain in part the extensive unoccupied suitable habitat in Creamery Bay, Drakes Estero, which is adjacent to source populations (P. Baye pers. observ. 1997-1999).

On State Park lands, maintenance activities have caused local impacts to *Astragalus pycnostachyus* populations. Trail maintenance on riverside levees at Pescadero Creek (brush cutting and weed-whacking along the trail edge) in 1998 and 1999 destroyed most of the maturing fruiting stems along the linear population there, and similar mowing activities at the south end of the parking lot at Pomponio Beach eliminated almost all the above-ground parts of the population there. Depending on the time of year cutting is performed and the initial condition of the plants the populations appear to regenerate, but long-term effects of annual brush removal may have severe impacts on regeneration and reproduction.

Non-native vegetation may inhibit the regeneration of seedlings of *Astragalus pycnostachyus*. Dense stands of iceplant at Pomponio Beach headlands appear to coexist with mature *Astragalus pycnostachyus,* but seedlings and juveniles are notably absent within iceplant stands, though present in adjacent areas with a high proportion of sparse vegetation cover. Seedlings are generally found only in sparse, disturbed sites along high tide lines, so it is reasonable to presume that dense cover by any invasive species in high tide lines would reduce the chances of successful seedling establishment of *Astragalus pycnostachyus*. Studies are needed to investigate the impact of non-native invasive vegetation and other factors on seedling establishment.

Natural sources of mortality for *Astragalus pycnostachyus* may become threats where populations have suffered cumulative declines from artificial threats. These natural disturbances include mass dieback caused by extreme high summer tides, which flood the root zone of *Astragalus pycnostachyus* with tidewater of marine salinity. Following the extreme high July tides of 1999 (accompanied by southerly winds which may increase peak tidal elevations; B. Moritsch pers. comm. 1999), approximately two thirds of the colony at northwestern Schooner Bay exhibited rapid dieback of stems, leaves, and fruits below the elevation of the summer tidal surge. Adjacent plants above the tidal surge elevation were apparently unaffected. This phenomenon also suggests that accelerated sea level rise, which is expected to occur with global climate warming, may impose another cumulative impact that threatens the species.

Conservation Efforts

There are currently no known conservation efforts directed towards *Astragalus pycnostachyus* var. *pycnostachyus* other than periodic surveys. As an indirect result of the Federal listing for the similar southern var. *lanossissimus,* staff and management at the California Department of Fish and Game, Point Reyes National Seashore, and the California Native Plant Society, in coordination with the U.S. Fish and Wildlife Service, have increased the priority of var. *pycnostachyus* in their management and planning. This variety benefits from having its largest populations included within the Point Reyes National Seashore, where it is protected against residential development or public works projects. Most populations in San Mateo County occur at stream mouths at beaches owned and managed by the California Department of State Parks. However, no monitoring or management activities are currently directed towards it there or anywhere else in its range. The new Humboldt County population is on Bureau of Land Management (BLM) land.

Conservation Strategy

The highest priority for conservation of this species is protection of existing populations against further artificial losses or habitat degradation. The next highest priority is to manage existing habitat to promote increases in the size and number of colonies, and to promote resilience of populations (their ability to recover naturally following disturbances or catastrophes). Management to augment populations should include facilitation of seed dispersal into suitable unoccupied habitat in the vicinity of existing populations. To complete the long-term conservation of the species, colonies should be re-established at or near those historical localities where populations have become extirpated, where unoccupied suitable habitat or restorable habitat exists. Where reintroduction is foreclosed by habitat loss, new populations should be established in receptive habitat as close as possible.

Management of existing populations should aim at minimizing artificial threats such as cattle trampling, mowing and weeding of trails, and invasion of non-native vegetation, which should improve degraded habitat quality. Management should also include ongoing annual monitoring and reporting programs for all known populations. Existing populations should be monitored for numbers of adult plants, seedlings, local distribution, and reproductive output. Surveys for additional populations should be performed repeatedly in Humboldt County near historic localities and other locations with suitable habitat in their vicinities. Surveys should be repeated periodically at all stream mouths in San Mateo County, because episodic recruitment of seedlings from dormant seed banks may enable populations to re-emerge where past surveys have been negative. All populations should be monitored to determine long-term population trends, and surveys should be performed to detect either new populations or relocate populations from historic collection sites. Rediscovered or newly detected populations should also be monitored and protected.

In suitable habitat at Point Reyes, upper tidal marsh margins with suitable habitat along western and northern Drakes Estero should be protected against cattle trampling and loafing. Monitoring here should focus on seedling establishment and comparison between the frequency of seedling colonies per unit length shoreline in areas with cattle exclosures and areas with no exclosures. Existing high marsh habitat in the vicinity of colonies at Drakes Head Marsh, Sunset Beach, and upper Limantour Estero (Whitegate Trail spit and marsh) should also be protected by cattle exclosures. Cattle entry to intertidal areas should be restricted to steeper erosional shorelines lacking marsh.

The type locality, Bolinas Lagoon, still supports ideal habitat for *Astragalus pycnostachyus* at Kent Island, despite the elimination of nearly all habitat along Stinson Beach's backbarrier shoreline. Seed from Point Reyes colonies should be translocated to suitable habitat at Kent Island, and a few nursery-raised plants translocated as well to establish a new founder population.

As a hedge against catastrophic extinction of the species or complete loss of germplasm from major populations, seed from all known populations should be collected during years of high reproductive output and stored according to guidelines for genetic sampling of conservation collections (Guerrant *et al*. 2004).

Reintroduction of *Astragalus pycnostachyus* in remaining suitable habitat within or proximate to its historical range should be attempted, particularly at sites of historic collection, or well-protected sites with relatively abundant, secure potential habitat. In addition to Bolinas Lagoon, outstanding candidate localities for reintroduction include marsh-beach ecotone areas at the following localities:

• the geomorphically young Limantour Spit (unoccupied habitat adjacent to extant populations)

• the small barrier beach and brackish marsh/lagoon behind Pillar Point, Halfmoon Bay (extirpated historic population)

• the mouth of Tunitas Creek (extirpated historic population)

• near the mouth of Pilarcitos Creek, Halmoon Bay (suitable habitat in historic range, no historic record)

• the mouth of Gazos Creek (nearest suitable habitat to the extirpated Arroyo de Frijoles population).

Source populations for founders of new colonies should be derived from the nearest populations along the coast. For Limantour and Bolinas reintroduction, mixed seed donors from adjacent Drakes and Limantour Esteros would be appropriate. For Halfmoon Bay and Tunitas Creek founders, a composite seed sample from San Gregorio, Pomponio, and Pescadero populations (which support heterogeneous habitats, like the Halfmoon Bay and Tunitas receptor sites) should be utilized. Sites of reintroduction should be managed to minimize degradation due to invasion by exotic species, trampling, or impacts of construction activities near the shoreline.

Castilleja ambigua (Hook. and Arn.) Chuang and Heckard
salt marsh owl's-clover, Johnny-nip, *Castilleja ambigua* Hook. & Arn. ssp. *ambigua*), Humboldt Bay owl's-clover, *Castilleja ambigua* ssp. *humboldtiensis* (Keck) Chuang & Heckard

Description and Taxonomy

Description. *Castilleja ambigua* is an annual hemiparasitic herb traditionally placed in the Scrophulariaceae (snapdragon or figwort) family, but recently realigned with the parasitic Orobanchaceae (broom-rape) family. One of the subspecies (*humboldtiensis*) occurs exclusively in tidal salt marsh habitats. Salt marsh ecotypes were historically widespread in the subspecies *ambigua*. The species as a whole ranges more widely over wet or mesic grassland soils along the Pacific coast, central California to British Columbia. The variability among populations is considerable.

Castilleja ambigua subspecies *ambigua* (type locality: California, probably San Francisco or Monterey; Keck 1951) has variable forms ranging from erect and unbranched to highly branched and ascending, and low and nearly prostrate spreading forms. Its size ranges from only a few centimeters tall (less than 2 inches) to 30 centimeters (1 foot) tall, and at least as wide. The stems and leaves of subspecies *ambigua* are generally pubescent, particularly on upland grasslands. Its leaves are *lanceolate* to oblong in shape, either simple or lobed (up to three lobes, rarely five), and up to 5 centimeters (nearly 2 inches) in length. The inflorescence is a dense, cylindrical spike of flowers with bracts up to 12 centimeters (4.5 inches). The bracts are variously tipped white, greenish-white, or yellowish-white in typical populations, but some salt marsh populations of subspecies *ambigua* have white-tipped bracts maturing to dull purplish during fruit maturation. The flowers are tubular with three wider pouch-like lips, colored yellowish or whitish (maturing to dull purplish in some salt marsh populations) with small purple pollinator guides near the tip of the pouch. The pointed beak (galea) of the flower is straight, acute, whitish, yellow, or yellowish green (sometimes pale purplish in some salt marsh populations), and either nearly smooth or with very fine pubescence. Four stamens are included in the corolla. Capsules are 8 to 12 millimeters (less than 0.5 inch) long, and release mature seeds by splitting open along sutures (Chuang and Heckard 1991, P. Baye unpubl. data). Capsules of subspecies *ambigua* from southeastern Tomales Bay produced from 26 to 32 seeds per capsule (P. Baye unpubl. data 1998). Seeds are 1 to 2 millimeters (0.06 inch) long, pale brown, with a net-like pattern of ridges on the loose-fitting seed coat (Chuang and Heckard 1991).

Castilleja ambigua ssp. *insalutatus* (type locality: Pacific Grove, Monterey County; Keck 1951) is distinguished from ssp. *ambigua* only by its purplish pigmentation in the mature corollas and bracts, and by its geographic restriction to the Monterey/San Luis Obispo coast. It is otherwise not readily distinguishable from ssp. *ambigua* in this portion of its range (Matthews 1997).

Castilleja ambigua subspecies *humboldtiensis* (type locality: Humboldt Bay; Keck 1927, 1951) is distinguished from the other subspecies in California by its broad (sometimes broadly ovate), crisp, fleshy, leaves, larger seeds, and purplish pigmentation of the mature corollas and bract tips. The plants from the type locality have very showy bracts tipped bright rose-fuchsia, are sparsely branched, and can develop long, cylindrical spikes of whitish-pink to light purple flowers. A local "white" form has been identified at one locality in Humboldt Bay (Jacoby Creek; Eicher 1987). Populations from Mendocino (Big River Estuary) are similar, but tend to be less richly pigmented. The disjunct southern populations in Tomales Bay (Marin County) have short spikes of white-tipped bracts before and during flowering, maturing to pale rose-lavender during maturation of seed capsules (G. Fletcher unpubl. data, P. Baye unpubl. data 1998-2000). Subspecies *humboldtiensis* tends to be no taller than 15 centimeters (6 inches), with few branches that spread among adjacent vegetation. It is currently restricted to very few salt marsh localities between Humboldt Bay and Tomales Bay (G. Fletcher pers. comm. 1997, B. Grewell pers. comm. 1998-1999, P. Baye unpubl. data 1997-2000). Although it strongly contrasts vegetatively with salt marsh populations of ssp. *ambigua* in San Francisco Bay and the Marin coast, it is similar to ssp. *ambigua* along the northern California coast and Oregon with relatively fleshy, broad leaves and white-tipped bracts.

Taxonomy. Bentham originally placed *Castilleja ambigua* in the related genus *Orthocarpus*, and published it under the name *Orthocarpus castillejoides* Benth. in 1835. The type of *Castilleja ambigua* was probably from the San Francisco area (Chuang and Heckard 1991), or possibly Monterey Bay (Pennell 1951). The species was re-placed in the genus *Castilleja* by Chuang and Heckard (1991), restoring the name combination used by Hooker and Arnold in 1833. Chuang and Heckard (1991) now place *Castilleja ambigua* in the subgenus *Colacus* (Jepson) Chuang and Heckard, Section *Oncorhynchus* (Lehm.) Chuang and Heckard. Pennell (1951) placed *Castilleja ambigua* in the section *Castillejoides*, along with the annual owl's-clovers *Orthocarpus purpurascens* (= *Castilleja exserta*, purple owl's-clover) and *Orthocarpus densiflora* (= *Castilleja densiflora*, common owl's-clover).

Castilleja ambigua is a wide-ranging and highly variable species that requires further taxonomic study (Pennell 1951, Chuang and Heckard 1991). Greene (1894) and others erroneously placed *Castilleja ambigua* within *Orthocarpus densiflorus*, a very similar (perhaps intergrading) and wide-ranging inland species. The early lack of discrimination between these two taxa obscured information about its regional distribution in late 19th century floras. Other published taxa that have been placed in synonymy within *Castilleja ambigua* include *Orthocarpus maculatus* Eastw., *Orthocarpus longispicatus* Elmer, and *Orthocarpus sonomensis* Eastw (Pennell 1951, Chuang and Heckard 1991).

Castilleja ambigua has been variously interpreted as either a single variable species (Keck 1927, Pennell 1951, Munz 1959), or as multiple species now reduced to synonyms (Chuang and Heckard 1991). Jepson (1925) first distinguished the regionally restricted variety *insalutatus* within *Orthocarpus castillejoides*. Keck (1927) distinguished a regionally restricted variety from salt marshes of Humboldt Bay, var. *humboldtiensis*, based on its purple-tipped bracts. Keck, in collaboration with Pennell, also named, but did not publish, a purple-pigmented form from San Francisco Bay (Burlingame, San Francisco peninsula), *Orthocarpus castillejoides* "var. *purpureotinctus*" in contrast with "var. *typicus*." This pigmented variant is intermediate with ssp. *insalutatus* and ssp. *ambigua*.

Castilleja ambigua as interpreted by Chuang and Heckard (1993) consists of three subspecies: ssp. *ambigua* (widespread), ssp. *insalutata* (rare), and ssp. *humboltiensis* (rare).

Differences among the widely disjunct populations of *Castilleja ambigua* ssp. *humboldtiensis* have not been analyzed quantitatively. In Tomales Bay, ssp. *humboldtiensis* is highly distinct from ssp. *ambigua* even where the two occur in adjacent zones of the upper salt marsh (P. Baye unpubl. data 1997). In the revised key (Chuang and Heckard 1991), ssp. *humboldtiensis* is distinguished by discontinuous quantitative variation in seed size and branching patterns, and other unique characters. Unlike the other subspecies, ssp. *humboldtiensis* occurs exclusively in tidal marshes and within regularly flooded parts of the upper intertidal zone (Eicher 1987).

Population Trends and Distribution

Historical distribution. *Castilleja ambigua* ssp. *ambigua* ranges from Vancouver Island, British Columbia, to Monterey County, California (Abrams 1951, Matthews 1997). The southern portion of its range overlaps with ssp. *insalutatus*, which was collected historically from the Monterey Peninsula to northern San Luis Obispo County (Matthews 1997, Hoover 1970). The current population status of ssp. *insalutatus* in San Luis Obispo County is uncertain. *Castilleja ambigua* ssp. *humboldtiensis* occurs in two sets of populations: rose-purple bracted populations prevail in numerous local populations in Humboldt Bay and a disjunct North Coast population at the Big River Estuary, Mendocino County, and a number of local white-bracted populations occur around Tomales Bay, Marin County. *Castilleja ambigua* ssp. *ambigua* was formerly collected from the San Francisco Bay region (Greene 1894, Munz 1959). Nearly all of the historical collection localities of ssp. *ambigua* in the San Francisco Bay Estuary include sites of past or present tidal marshes.

Current distribution. All historical populations of *Castilleja ambigua* ssp. *ambigua* in the San Francisco Bay Estuary are apparently extirpated in their reported localities. Only one large modern population is known today in the San Francisco Bay Estuary, the natural salt marsh population at Whittell Marsh, Point Pinole (East Bay Regional Parks), Contra Costa County. A nearby population has been reported from subsaline diked bayland sites near Giant Highway (Breuner site; K. Miller pers. comm. 1997). In 1999, the Whittell Marsh population was distributed in extensive, nearly linear colonies of the high salt marsh, abundant in a narrow zone above the *Sarcocornia pacifica* (pickleweed)-dominated marsh. The population in 1999 was estimated at over 300,000 plants, but it declined to the tens of thousands in 2000 (P. Baye unpubl. data). Virtually all suitable habitat has been eliminated from historical localities of *Castilleja ambigua* in San Francisco Bay tidal marshes, but surveys are needed to determine the status of possible remnant colonies near Richmond, Martinez, and Oakland. Unlike those onthe immediate coast, non-halophytic populations of *Castilleja ambigua* ssp. *ambigua* are reportedly rare in herbaceous plant communities of the East Bay area (2 or fewer populations known; Ertter 1997), and are not reported today from wetlands and upland grasslands adjacent to tidal marshes elsewhere in the San Francisco Bay Estuary.

There are a few, usually small, salt-tolerant populations of *Castilleja ambigua* ssp. *ambigua* along central California coast marshes outside of San Francisco Bay. Other confirmed coastal marsh populations of ssp. *ambigua* occur very locally at the fringing sandy brackish non-tidal marsh at Rodeo Lagoon, Marin Headlands, and at brackish seasonal wetland peripheral to tidal marsh at northwestern Bolinas Lagoon (Pine Gulch Creek), Marin County. Zoned adjacent mixed populations of ssp. *ambigua* occur with ssp. *humboldtiensis* in salt marshes of Tomales Bay (*e.g.,* Toms Point Marsh, Tomales Bay Trailhead). The largest salt marsh population of ssp. *ambigua* occurs at the extreme east end of Limantour Estero. From Point Reyes northward, maritime grasslands of the coast also support sparse populations of ssp. *ambigua* (Best *et al.* 1996, Smith and Wheeler 1991), but these tend to differ from nearby salt marsh populations (P. Baye unpubl. data 1997-1999).

Abundance. Population numbers of *Castilleja ambigua* ssp. *ambigua* in salt marshes fluctate annually, sometimes to extreme abundance or scarcity. At Rodeo Lagoon no plants emerged in the spring of 1998 because the habitat was submerged. Unusually late germination and flowering occurred in August and September, with flowering through December (P. Baye pers. observ. 1998). Abundance of ssp. *ambigua* at Limantour Estero also fluctuated from scarcity in drought years of the early 1990s to local abundance in the late 1990s (P. Baye pers. observ. 1992-1999). No salt marsh populations of ssp. *ambigua* have been found in surveys south of San Francisco Bay (Pescadero Creek, Elkhorn Slough, Morro Bay; P. Baye unpubl. data 1997-1999). The significant population decline between 1999 and 2000 at Whittell Marsh occurred between two years of above-normal and late rainfall, despite high rates of viable seed production prior to both years (P. Baye unpubl. data 1999-2000).

In Humboldt Bay multiple small populations are known from the Eel River mouth estuary, the fringing marshes of Eureka, Samoa, Table Bluff, Elk River Spit, Indian Island, the remnant salt marsh islands of Mad River Slough, and other localities in the South Bay and Arcata Bay (CalFlora 2000, Bivin *et al.* 1991, P. Baye pers. observ. 2000). In 1988, 24 populations were identified in Mad River Slough, (Humboldt Bay), of which four were ranked in size from 10,000 to 100,000, and eight were ranked 1000 to 10,000. Density of *Castilleja ambigua* ssp. *humboldtiensis* at the marsh island population at Mad River Slough declined to 0 in 1992 after two drought years, rebounded to a high density of 64.4 plants per 0.25 square meter (2.7 square feet) after two years of above-average rainfall, then declined again to approximately 21.7-30.4 plants per 0.25 square meter until 1998, when it declined abruptly to 5.2/ 0.25 square meter after a year of extremely high rainfall. In 1999 the population increased again to 52.6/0.25 square meter after another year of above-normal rainfall (Pickart 1999). In a 1998 study of North, Central and South Humboldt Bays, and Mad River Slough, estimates of approximate density of

Castilleja ambigua ssp. *humboldtiensis* were determined. Mad River Slough and North Humboldt Bay were found to support densities of the subspecies around 6,800 to 7,500 per acre, whereas Central and South Humboldt Bays supported densities around 400 to 3,200 per acre (U.S. Fish and Wildlife Service 2001*b*).

Life History and Ecology

Reproduction. *Castilleja ambigua* is an annual herb. In tidal marshes of Point Reyes, emerging seedlings of ssp. *ambigua* have been observed in late winter and early spring. Along lagoon shorelines, such as Rodeo Lagoon, germination is associated with drawdown and exposure of the non-tidal shoreline, which may be delayed to the summer by high water levels some years (P. Baye pers. observ. 1998). Flowering and seed ripening times of salt marsh populations of *Castilleja ambigua* vary annually and among localities and subspecies. The flowering period of the Point Pinole salt marsh population of ssp. *ambigua* usually begins in mid to late March and ends before May; ripe seed are abundant by mid to late May. Coastal Marin tidal marsh populations (Point Reyes area) flower slightly later, April to May or early June, and set seed by or before early summer. In contrast, upland coastal grassland populations of ssp. *ambigua* from Point Reyes to Mendocino flower later, from May to August (rarely September). This pattern suggests potential seasonal reproductive isolation between nearby populations in salt marshes and terrestrial habitats (P. Baye unpubl. data 1997-2000).

Flowering of *Castilleja ambigua* ssp. *humboldtiensis* in Tomales Bay begins in April and may extend into June, overlapping with early ripe seed that begins in late May. The small population of ssp. *humboldtiensis* at the Big River Estuary (Mendocino) has a similar seasonal pattern of flowering and seed ripening, with a few flowering individuals in late June (P. Baye unpubl. data 1997-2000). In Humboldt Bay, most seed set is complete by early July (Bivin *et al.* 1991), but conspicuous flowering spikes are still common some years in late June (P. Baye unpubl. data 2000). In Humboldt Bay, the mean number of seeds per fruit of ssp. *humboldtiensis* was 21, and the mean number of fruits per plant was 2.0 (Bivin *et al.* 1991). Up to 32 seeds per capsule were observed in Tomales Bay (P. Baye pers. observ. 1998, 2000).

Virtually no pollinators have been observed in Humboldt Bay populations of ssp. *humboldtiensis*, which nonetheless have high seed set (Bivin *et al.* 1991). This is suggestive of self-pollination at least in northern populations, and perhaps in salt marshes throughout its range.

Habitat and Community Associations

Salt marsh populations of *Castilleja ambigua* ssp. *ambigua* typically occur in high salt marsh at or above the level of mean higher high water. In salt marshes of west Marin County (Point Reyes area) and at Point Pinole, ssp. *ambigua* is typically found in sparse or low-density vegetation of the high marsh zone to the upland ecotone, but ranges above to the limit of tidal influence. It occurs abundantly in linear colonies along the edges of silty salt pans, on sediment composed of coarse silt, fine sand, and some coarser particles.

The high marsh habitat preferences of *Castilleja ambigua* ssp. *humboldtiensis* in the north coast appear to differ from those of Tomales Bay, and are more similar to those of salt marsh populations of ssp. *ambigua*. In mixed populations of ssp. *ambigua* and *humboldtiensis* at Tomales Bay trailhead, Marin County, ssp. *humboldtiensis* occupies the saturated daily-flooded upper middle intertidal to high marsh zone (co-occurring with *Chloropyron maritimum*), while ssp. *ambigua* is confined to the high marsh and ecotone with upland grassland (P. Baye unpubl. data 1998). At other localities in Tomales Bay (Toms Point, Shields Marsh), ssp. *ambigua* also occupies saturated upper intertidal marsh soils just below the high marsh and upland ecotone, with ssp. *humboldtiensis* on the wetter marsh plain. The Shields Marsh population of ssp. *humboldtiensis* in Tomales Bay also occurs in poorly drained tidal brackish marsh. In contrast, at Humboldt Bay, ssp. *humboldtiensis* occurs at higher elevations than *Chloropyron maritimum ssp. palustre*, although both species overlap considerably (Eicher 1987, Pickart and Miller 1988). *Castilleja ambigua* ssp. *humboldtiensis* in northern Humboldt Bay ranges from about 2.1 meters (6.9 feet) to over 2.6 meters (8.5 feet; mean lower low water datum), with greatest abundance between about 2.26 meters (7.4 feet) and 2.6 meters (8.5 feet; Eicher 1987). High salt marsh soils at Humboldt Bay are relatively well-drained, ranging from peaty silts to silty sands (P. Baye pers. observ. 1992, 2000). Similarly, at the Big River Estuary, ssp. *humboldtiensis* occurs on high, silty natural high salt marsh levees along eroding banks (P. Baye unpubl. data 2000).

Salt marsh populations of *Castilleja ambigua* are rarer than those of *Chloropyron maritimus*, but are often associated with them. Populations of ssp. *humboldtiensis* are often associated with high salt marsh plants *Grindelia stricta* ssp. *stricta* (salt marsh gumplant) and *Distichlis spicata* (saltgrass) in Humboldt Bay and the Big River Estuary (Pickart and Miller 1988, P. Baye unpubl. data 2000), but in Tomales Bay it is associated with middle marsh zone dominants such as *Jaumea carnosa* (flesh jaumea) and *Triglochin maritima* (sea-arrow grass), typical of wetter brackish marshes, as well as *Distichlis spicata* (P. Baye unpubl. data 1998, 2000). In contrast, frequent associates of ssp. *ambigua* are typical of the well-drained high marsh and upland ecotone of Tomales Bay, including *Armeria maritima* (California sea-pink), *Distichlis spicata*, *Frankenia salina* (alkali-heath), *Limonium californicum* (sea-lavender), *Lotus corniculatus* (birdsfoot trefoil), *Sarcocornia pacifica, Spergularia macrotheca* (sand-spurrey), and *Triglochin concinna* (arrow-grass). Peak abundance of ssp. *ambigua* in Point Reyes area marshes is below the highest salt marsh zone characterized by *Grindelia stricta, Festuca rubra* (red fescue), *Frankenia salina*, and *Juncus lesueurii* (P. Baye unpubl. data 1997-1998). Other high salt marsh species infrequently or occasionally associated with ssp. *ambigua* in the Point Reyes area marshes include *Atriplex californica* (California saltbush), *Cuscuta salina* (dodder), *Grindelia stricta, Juncus lesueurii, Juncus ambiguus* (saltmarsh toad-rush), *Lasthenia glabrata* (goldfields), and *Scirpus cernuus* (fiber optic grass). A similar zonation pattern occurs at the Point Pinole and Bolinas Lagoon salt marsh populations of ssp. *ambigua*, where high marsh associates include *Parapholis incurva* (sickle grass), *Lolium multiflorum* (ryegrass), *Lasthenia glabrata, Juncus bufonius* (toad rush), *Frankenia salina, Distichlis spicata, Spergularia* spp., *Polypogon monspeliensis* (beard grass), and stunted forms of *Cotula coronopifolia* (brass buttons).

In the fringing non-tidal brackish marsh along the southwest shoreline of Rodeo Lagoon, *Castilleja ambigua* ssp. *ambigua* is associated with *Festuca rubra, Atriplex triangularis, Chenopodium macrospermum* (coast goosefoot), *Plantago coronopus* (buckshorn plantain), *Juncus bufonius, Juncus lesueurii, Scirpus cernuus,* and *Eryngium armatum* (coast eryngo), all in sandy to silty brackish marsh soil (P. Baye pers. observ. 1998).

Threats Assessment

Like *Chloropyron maritimus*, the decline of salt marsh ecotypes of *Castilleja ambigua* is most directly attributable to loss of salt marsh habitat as a result of historic diking and filling for agriculture and urbanization, particularly the high marsh edge and transition to supratidal uplands and lowlands. *Castilleja ambigua* has been extirpated almost completely in the San Francisco Bay Estuary salt marshes, which was arguably the largest population of the salt marsh ecotypes of the species. Today, the greatest obstacles to long-term conservation of *Castilleja ambigua* ssp. *ambigua* are the lack of suitable high salt marsh and emergent salt pan edge habitat around the estuary and limitations of seed dispersal from the isolated remnant population in Point Pinole.

At least one of the populations of the distinct Tomales Bay variant of ssp. *humboldtiensis* is locally threatened by unmanaged cattle trampling near Tomales Bay trailhead. Other Tomales Bay populations occur in preserves, and are subject only to natural threats. Similarly, the Big River population is relatively free from artificial threats.

The principal threat to ssp. *humboldtiensis* at its type locality (and core population) in the Humboldt Bay area was historic diking and filling of tidal marshes, which has largely abated in recent years. Its survival there depends chiefly on the preservation of old remnant or recently accreted salt marshes, old salt marsh islands, and numerous marginal populations around the bay. A few of these locations are now well protected against trampling, illegal dumping, and vandalism by fencing. Some populations occur on unmanaged or unprotected private lands subject to unknown potential land use changes.

Persistence of existing salt marshes in Humboldt Bay, and their habitat quality, face risks from shoreline development, fill or development of diked baylands, increased abundance of non-native invasive *Spartina densiflora*, and catastrophic seismic uplift (earthquake-induced rise in marsh surface elevations) associated with the Cascadia fault. Cattle grazing and trampling in some portions of Tomales Bay adversely affect reproductive success of *Castilleja ambigua* in some years, but impacts have not been quantitatively assessed.

Conservation Strategy

The conservation of salt marsh subspecies, populations, or ecotypes of *Castilleja ambigua* must rely on (1) identification and protection of existing populations, (2) protection of genetic (possibly unrecognized taxonomic) variability among populations, and (3) expansion of populations in additional new (restored or spontaneous) salt marshes within their historic range. The only confirmed salt marsh populations in San Francisco Bay around Point Pinole should be preserved and monitored annually. Populations on private property at risk of development or adverse land use changes should be acquired and managed. Seed from the Point Pinole population should be collected and stored. The Point Pinole population should be used as a source for new founder populations in suitable existing unoccupied salt marsh habitat in historic range within the San Franicsco Bay Estuary. It should also be used to found populations in newly restored salt marshes that are designed to supply ample high marsh edge habitat, including gentle terrestrial ecotone slopes and relatively coarse-grained sediments. Salt marsh remnants in the vicinity of historic collection localities should be re-surveyed to detect additional relict populations.

Salt marshes of Humboldt Bay, Tomales Bay, Limantour Estero, Drakes Estero, and Bolinas Lagoon should be systematically surveyed throughout at least one precipitation cycle to detect and record the size, distribution, and infraspecific taxonomic identity of all *Castilleja ambigua* populations there. Significant variation in morphological or ecological attributes of populations should be identified. All populations that occur on lands not already in permanent protection should be either acquired and included in public wildland management, or protected under conservation easements and cooperative management. Where populations in Tomales Bay are affected by cattle trampling and grazing, experimental exclosures should be constructed and monitored to estimate impacts of cattle grazing on population size, resilience, and persistence. Based on experimental/monitoring results, cattle access should be managed accordingly. Salt marsh populations in the Point Reyes area should be periodically monitored to track changes in at least approximate population size and distribution. Salt marsh restoration of diked baylands at the south end of Tomales Bay should be designed to include suitable habitat for *Castilleja ambigua*, and should be implemented. The small population at Rodeo Lagoon should be monitored and protected against detrimental vegetation changes such as encroachment by iceplant. Seed samples from most Point Reyes area populations should be stored as a hedge against precipitous population decline or extirpation.

In Humboldt Bay, selected diked historic baylands should be restored to tidal salt marshes with upper edges, including gentle slopes and some coarse-grained sediments, preferably in the close vicinity of existing populations of *Castilleja ambigua* ssp. *humboldtiensis*. These restored marshes should have densities of invasive *Spartina densiflora* suppressed, and ssp. *humboldtiensis* should be reintroduced to appropriately restored habitat.

In fact, populations of *Castilleja ambigua* ssp. *humboldtiensis* responded in a dramatic and positive manner to an initial *Spartina densiflora* removal effort conducted in 2006-2007 in a portion of the Lanphere Dunes Unit of Humboldt Bay National Wildlife Refuge, (U.S. Fish and Wildlife Service 2009*a*). The response is likely due to both the reduction of competition and the availability of bare sites for establishment. Monitoring programs for ssp. *humboldtiensis* such as are conducted by the Humboldt Bay National Wildlife Refuge should be expanded to include all of Humboldt Bay and the Eel River Estuary by local stewardship groups. Selected natural and reintroduced populations should be intensively monitored quantitatively for demographic variables (reproductive output, survivorship, long-term local population trends, etc.). Seed from larger Humboldt Bay populations should be collected and stored as a hedge against precipitous population decline or extirpation, or for scientifically designed reintroduction experiments.

More comprehensive sampling of *Castilleja ambigua* populations should be the basis of taxonomic re-evaluation and analysis. The species should be re-examined to determine the degree of differentiation or relationship among terrestrial and marsh populations within a region, and among populations within salt marshes. In addition, common-garden comparisons of populations and progeny tests of artificial hybrids should be conducted to re-assess geographic patterns of genetic variation within the species and related species such as *Castilleja densiflora*. Improved understanding of patterns of population variation should be applied to conservation priorities, and may possibly be needed to include protection of gene flow with some terrestrial populations. This research should also determine which evolutionary or ecological units are of greatest conservation significance, and may be needed for potential future determinations for listing redefined taxa in the complex as threatened or endangered. Applied research on the reproductive ecology of salt marsh ecotypes of *Castilleja ambigua* is also needed to establish scientifically sound protocols for population reintroduction as a conservation tool.

Salt marsh bird's-beaks

Northern salt marsh bird's beak, Point Reyes bird's-beak (*Chloropyron maritimum* ssp. *palustre)*

Description and Taxonomy

Description. *Chloropyron maritimum* ssp. *palustre* (previously known as *Cordylanthus maritimus* ssp. *palustris)* is an annual hemiparasitic herb in the Orobanchaceae (broom-rape) family. It has an erect to ascending growth habit with plants ranging from small and unbranched to robust with many ascending branches. Plant height varies from 10 to 20 centimeters tall, rarely to 30 centimeters (4 to 8 inches, rarely 12 inches). There is much geographic and local variation in morphology and pigmentation among populations of *Chloropyron maritimum ssp. palustre*. Leaves are typically oblong to oblong-*lanceolate*, less than 2.5 centimeters (1 inch) long, entire, and range in color from pale gray-green or dark purple-green. Leaves often have patchy salt crusts associated with short glandular hairs of the leaf surface. The inflorescence is a spike of leafy gray-green or purple-green bracts that partially encloses the flowers. Corolla color ranges from white to cream with dark purple or purplish or purplish-brown lips (*e.g.,* Tomales Bay, Drakes Estero, and Humboldt Bay), or white tinged rose-violet with violet-purple lips (northern San Francisco Bay, San Pablo Bay, Bodega Bay; Munz 1959, Chuang and Heckard 1993, P. Baye unpubl. data 1997-2000). The fruit capsule contains 10 to nearly 40 (usually 20 to 30) dark brown seeds. Seeds are 2 to 3 millimeters (0.08 to 0.11 inch) long, with a net-like pattern of fine polygonal ridges (Munz 1959, Chuang and Heckard 1993).

Chloropyron maritimum ssp. *maritimum* a highly similar subspecies, is distinguished from ssp. *palustris* mainly by geographic distribution, branching patterns, growth habit, narrower and more acute leaves, and variations in seed size and floral traits (Chuang and Heckard 1973, 1993). Subspecies *maritimus* was federally listed as endangered in 1978 (U.S. Fish and Wildlife Service 1978), and a final recovery plan prepared in 1985 (U.S. Fish and Wildlife Service 1985*a*). At that time, populations of *Cordylanthus maritimus* at Morro Bay, San Luis Obispo County, were classified as ssp. *palustris*. Accordingly, the Morro Bay population was not covered in the recovery plan. Since then, this population has been reclassified (Chuang and Heckard 1986), placing it within the geographic coverage of this recovery plan.

Taxonomy. *Cordylanthus maritimus* ssp. *palustris* was originally placed in the Scrophulariaceae (figwort family). However, based on molecular systematic studies using DNA sequences of three *plastid* genes, Olmstead *et al.* (2001) transferred the hemiparasitic group Castillejiinae, including *Cordylanthus*, to the Orobanchaceae, thereby placing it in the genus *Chloropyron* (Tank and Olmstead 2008). This systematic treatment will be followed in the upcoming revision of the Jepson Manual.

Chloropyron maritimum consists of three closely related geographic entities in the subgenus *Hemistegia*, a morphologically and ecologically distinctive group associated with saline wetlands. The subgenus *Hemistegia* was distinguished from the rest of the genus *Cordylanthus* by Asa Gray in 1867, originally giving it the rank of section. Chuang and Heckard (1991) retained the circumscription of *Cordylanthus*, but elevated section *Hemistegia* to the rank of subgenus. This group was also previously distinguished as a separate genus (*Chloropyron*) by H. Behr, based on early San Francisco Bay collections of *Cordylanthus maritimus* ssp. *palustris*, which he published as *Chloropyron palustre* Behr. Heller revived Behr's genus, and published the name *Chloropyron maritimum* (Nutt.) Heller in 1907. Synonomy was further complicated when Greene reassigned the taxon to the genus *Adenostegia, as A. maritima* (Chuang and Heckard 1973).

The prevailing modern taxonomic treatment of *Chloropyron maritimus* recognizes three partially intergrading subspecies:

(1) the wide-ranging *Chloropyron maritimum* ssp. *canescens* (= *C. canescens* A. Gray), which inhabits the margins of alkaline or saline wetlands and flats or mineral springs of interior valleys from southeastern Oregon, the Great Basin of Nevada and Utah, south to Owens Valley, California;

(2) *Chloropyron maritimum* ssp. *maritimum*, a taxon narrowly and discontinuously distributed in very few coastal salt marshes of the south-central and southern California coast, and coastal Baja California, Mexico;

(3) *Chloropyron maritimum* ssp. *palustre*, which is restricted to few coastal salt marshes from San Francisco Bay to southern Oregon.

Population Trends and Distribution

Historical distribution. *Chloropyron maritimum* ssp. *palustre* historically occurred in widely separated tidal salt marshes from Coos Bay, Oregon, to south San Francisco Bay (Alviso, Santa Clara County). The largest number of historical collection localities was in San Francisco Bay, which was probably the former core population of the subspecies. Historical localities in San Francisco Bay include Redwood City, Cooley's Landing, Palo Alto, sites near Alviso, Milpitas, Alameda Marsh, Oakland, south San Francisco, Tiburon, and Greenbrae. It is now extirpated in most of the type locality, reduced to a series of mostly small isolated populations in Richardson Bay (Almonte/Mill Valley, Marin City/Sausalito), Greenbrae, and in the Petaluma Marsh. Based on its sub-habitat specificity (salt marsh edges along uplands, salt pans, and tidal creeks), and the proportionally greater loss of old high-elevation tidal marsh in the Central and South Bay (93.5 to 98.2 percent area reduction; San Francisco Estuary Institute 1998), it is likely that population decline in San Francisco Bay has exceeded 98 percent.

Current distribution. Today, *Chloropyron maritimum ssp. palustre* is restricted to tidal salt marshes in only four geographic population clusters: (1) estuaries of the Oregon coast, mostly Coos Bay, southwestern Oregon; (2) Humboldt Bay area, Humboldt County; (3) Marin-Sonoma coast, mostly in the vicinity of Point Reyes (Bodega Bay, Tomales Bay, Drakes-Limantour Estero, and Bolinas Lagoon); and (4) northwestern San Francisco Bay Estuary (Petaluma Marsh to Richardson Bay). Since the elimination of historical populations in the San Francisco Bay Estuary, the relative abundance of the subspecies has shifted northward. The largest modern populations (over 100,000 plants in peak years) occur at a site next to Empire, Coos Bay (Kaye 1992), the Walker Creek delta in Tomales Bay, and marshes behind Limantour Spit (Sunset Beach and Limantour Marsh) in Point Reyes. The only remaining large populations left in San Francisco Bay (over 10,000 plants in peak years) occur at one old collection locality (Greenbrae; Heerdt Marsh) and one expanded population (Pohono Street, near Sausalito, which increased from one plant in 1990 (Kaye *et al*. 1991) to over 10,000 in 1999 (P. Baye unpubl. data 1999).

Chloropyron maritimum ssp. palustre is widespread in Humboldt Bay tidal marshes, where it is a co-dominant component of the vegetation in years of peak abundance (Pickart and Miller 1988). Based on historical estimates of tidal marsh area loss (from 2,800 hectares [7,000 acres] reduced to 400 hectares [1000 acres]; Shapiro and Associates 1980), the Humboldt Bay population today may represent as little as 15 percent of the pre-historical size. In years of peak abundance, populations in Humboldt Bay may reach hundreds of thousands of individual plants. Most other populations of moderate to small size occur in recently formed habitat or unstable salt marsh habitat. Many localities represent small colonies (few tens to few thousand plants) of low or doubtful stability (Pickart and Miller 1988).

Half the populations of *Chloropyron maritimum ssp. palustre* in Tomales Bay from 1991 to 1993 consisted of single narrow colonies near the upper edges of salt marshes. The median population size was 1198 plants (range: 9 to 75,000; Kelly and Fletcher 1994). The stability of colonies increased with size and density, but was relatively unaffected by proximity of nearby populations (Kelly and Fletcher 1994).

Annual populations of *Chloropyron maritimus* typically fluctuate by orders of magnitude among years (Parsons and Zedler 1997). Population fluctuations in *Chloropyron maritimum ssp. palustre* may relate to rainfall and vegetation structure, but the relationship is neither simple nor well understood. High rainfall does not necessarily correspond with large population size of ssp. *palustris* as it does for ssp. *maritimus* in more arid southern California (Parsons and Zedler 1997, Pickart 1997, B. Grewell pers. comm. 1998). For example, population size of ssp. *palustris* at Heerdt Marsh (Greenbrae, Marin County) increased to tens of thousands in 1997 in a year of high early winter rainfall and a dry late winter/spring, but declined abruptly to just over 400 plants in 1998 in a year of record high rainfall throughout the spring (P. Baye unpubl. data 1997-1998).

It is evident that *Chloropyron maritimus* persists through unfavorable years as a persistent dormant seed bank (Parsons and Zedler 1997) because high densities and abundance may follow years of extremely low seed production. The longevity of the marsh soil seed bank of this species is not known, but artificially stored seed of ssp. *maritimus* have remained viable for over 11 years (Parsons and Zedler 1997).

Life History/Ecology

Reproduction. All *Chloropyron* species were once thought to be self-incompatible (Chuang and Heckard 1973), but northern populations of *Chloropyron maritimum ssp. palustre* that produce abundant seed are seldom, if ever, visited by day-flying insects, even when adjacent species are visited (Bivin *et al.* 1991, Kaye *et al.* 1991).

Flowering of *Chloropyron maritimum ssp. palustre* in San Francisco Bay and the Point Reyes area begins in late May or June, peaks in early to mid-summer, and extends through fall at low frequencies. Ripe seed is produced from mid-summer through fall (P. Baye pers. observ. 1992-1999). In Humboldt Bay most plants were observed to flower between June 3 and August 20, and to fruit and die before September in 1991, a dry year (Bivin *et al.* 1991). The mean number of fruits per plant in Humboldt Bay populations ranges from 5.7 to 25.7 with 10 to 17 seeds per capsule. The mean number of seeds per plant ranges from 59 to 359.8 (Bivin *et al.* 1991). Seed germination occurs in winter or early spring, and appears to correspond with rainfall. In Humboldt Bay, seedlings were detected in mid-February (Bivin *et al.* 1991), and probably emerged earlier. Fungal pathogens have been identified as a cause of mortality in summer following storm tides, and significant declines in density occur in many colonies during March or April (Bivin *et al.* 1991).

Pre-dispersal seed predation, indicated by capsules full of larval frass instead of seeds, can be very high in some populations of *Chloropyron maritimum ssp. palustre* in some years (B. Grewell pers. comm. 1997, P. Baye pers. observ. 1997), but the long-term impact of this predation is unknown. Pre-dispersal seed predation in ssp. *maritimus* is caused by the salt marsh snout moth, *Liphographus fenestrella* (Pyralidae; Parsons and Zedler 1997). Nothing is known of post-dispersal seed predation in *Chloropyron maritimus*.

Evidence for long-distance seed dispersal of *Chloropyron maritimum ssp. palustre* is suggested by (1) seed size, form, and buoyancy conducive to floating and dispersal; and (2) new colonies commonly establishing spontaneously in newly stabilized marsh habitat (*e.g.*, distal end of Limantour spit, south end of Tomales Bay, eroded artificial fill in Richardson Bay, the former dredge disposal sites in Coos Bay, and the west side of Bodega Harbor [Barbour *et al.* 1973]). However, Kelly and Fletcher (1994) suggest that low probability of successful dispersal may limit colonization and persistence. Dispersal to restored tidal marshes does not always occur. The 25 year-old Muzzi Marsh in Corte Madera, adjacent to the large Greenbrae population of ssp. *palustris*, remains uncolonized.

Habitat Characteristics/Ecosystem

Chloropyron maritimum ssp. palustre occurs only in tidal salt marshes, usually near or in the high marsh zone (Eicher 1987). It rarely occurs in microtidal conditions (P. Baye pers. observ. 1997). *Chloropyron maritimum ssp. palustre* is usually most abundant in marsh sites of relatively improved drainage along tidal creek banks and natural levees, cliffed banks of salt pans, alluvial fans at the edges of salt marshes, and stabilized sand deposits in the upper intertidal zone. It is found on sandy marsh substrates with relatively sparse, short salt marsh vegetation, and is usually absent or declining in dense, tall salt marsh vegetation (Kelly and Fletcher 1994, Parsons and Zedler 1997). In Tomales Bay, abundance decreases with vegetation height; *Jaumea carnosa* (flesh jaumea), *Sarcocornia pacifica* (pickleweed), and *Districhlis spicata* (saltgrass) abundance; and with the robust annual *Atriplex triangularis* (spearscale). Abundance is positively associated with *Triglochin concinna* (creeping sea arrow-grass) and *Limonium californicum* (sea-lavender; Kelly and Fletcher 1994). *Castilleja ambigua* ssp. *humboldtiensis* (Humboldt Bay owl's clover) co-occurs with *Chloropyron maritimum ssp. palustre* in Humboldt Bay, Limantour Estero, and Tomales Bay, although it is usually slightly lower in tidal elevation (Eicher 1987, Bivin et al. 1991, P. Baye pers. observ. 1997).

Chloropyron maritimum ssp. palustre can be found in mature salt marshes of pre-historical origin (Petaluma Marsh, Heerdt Marsh), but often occurs in greatest abundance in recently formed marsh substrates, including sandy dredge spoils (Empire site, Coos Bay), rapidly aggraded deltaic marshes (Walker Creek, Tomales Bay), old stabilized sandy washover fans of spits (Limantour Spit), and heterogeneous artificial fill (Pohono Street, Richardson Bay). Most populations in the Point Reyes/Tomales area occur in small salt marshes near creek deltas and sand spits (Kelly and Fletcher 1994, Niemi and Hall 1996, P. Baye unpubl. data 1997-1999).

Disturbances can benefit *Chloropyron maritimus*, as well as other annual salt marsh species (Bertness *et al* 1992, Callaway *et al.* 1990, Callaway and Sabraw 1994). *Chloropyron maritimus* ssp. *maritimus* increases in abundance in response to disturbances that reduce vegetation cover (Vanderweir and Newman 1984, Parsons and Zedler 1997). This also appears to apply to ssp. *palustris*. Large high-density colonies of ssp. *palustris* occur at Sunset Beach, Drakes Bay, where large driftlines and wave erosion maintain partially scoured, turfy salt marsh with large gaps. Parasitic *Cuscuta salina* (salt marsh dodder) is another potentially significant gap-forming agent (B. Grewell pers. comm. 1998).

Salt marsh structure and microtopography also influence *Chloropyron maritimum ssp. palustre.* Populations are sometimes locally concentrated along, or restricted to, the low berm-like cliffed edges of salt pans (*e.g.*, Creamery Bay and Schooner Bay, Drakes Estero [P. Baye unpubl. data 1998]; Petaluma Marsh), edges of natural low levees of tidal creeks (*e.g.*, Muddy Hollow delta, Limantour Estero; Walker Creek, Tomales Bay), microdeltas (Pine Gulch Creek, Bolinas Lagoon), or upper intertidal sand bars, washover fans, and ecotones between bayside sand spits and salt marshes (Drakes Bay; P. Baye unpubl. data 1997-1999). Salt marsh plains with dense vegetation also support colonies at some localities (Humboldt Bay [Pickart and Miller 1988] and Bothin Marsh in Mill Valley, Marin County [P. Baye pers. observ. 1993]).

Chloropyron maritimum ssp. palustre grows vigorously and abundantly both in marshes with exposure to full marine salinity (Sunset Beach, Drakes Estero) and in the vicinity of deltas with some brackish influence from creek discharge (Walker Creek, Limantour Spit Marsh, Petaluma Marsh). Most tidal marsh plants, even those that are highly salt-tolerant when mature, require a strong depression of salinity for germination and seedling establishment (Woodell 1985).

The largest populations of ssp. *palustris* are on sandy marsh substrates (Russell 1973) with sparse and low vegetation cover, suggesting that unproductive environments, rather than productive nitrogen-rich environments, favor abundance.

Chloropyron maritimum ssp. palustre has apparently little or no parasite-host specificity (Chuang and Heckard 1971), but is most frequently associated with the potential host *Distichlis spicata* (Chuang and Heckard 1973). *Chloropyron maritimus* can grow without host plants (Chuang and Heckard 1971), but ssp. *palustris* may become stunted in the absence of host plants (P. Baye pers. observ. 1997).

Threats Assessment

Early historical records suggest that the largest and most extensive populations and blocks of habitat of *Chloropyron maritimum ssp. palustre* were in San Francisco Bay. Early California floras did not even recognize populations north of San Francisco Bay

(Brewer *et al.* 1880, Greene 1894, Jepson 1911). The reduction of the putative core San Francisco Bay population of this subspecies to a marginal one has resulted in substantial range collapse. The principal historical cause of decline in ssp. *palustris* in San Francisco Bay has been destruction of habitat by conversion of marsh to other land uses such as agriculture, urban landfill, and salt ponds. The disproportionate urbanization of former sandy salt marsh habitats in San Francisco Bay (San Francisco peninsula, Oakland, Alameda), which probably contained proportionally larger populations, was probably particularly destructive to this species. The loss of pre-historical San Francisco Bay salt marshes with well-developed microtopography (particularly natural tidal creek levees) and their replacement with recently formed smaller, planar, fringing marshes, probably reduced habitat quality and limited the ability of the species to colonize more recently formed marshes. Marsh subsidence due to groundwater extraction, and freshening of tidal marshes to brackish conditions in the extreme South Bay, probably eliminated all substantial potential there for natural habitat of this species after the mid-20th century.

Proposals for large-scale reclamation of tidal salt marshes for urbanization or agriculture in central and northern California have been extremely infrequent since the Clean Water Act Section 404 regulations on wetland fill went into effect. Large-scale bay fills associated with airport expansions have been proposed for areas where *Chloropyron maritimus* has been long extirpated, and where marsh restoration would be impractical for the forseeable future. However, local small-scale “piecemeal” wetland fills can have significant impacts when located near populations of ssp. *palustris*. The largest remaining populations in San Francisco Bay, Pohono Street Marsh and Heerdt Marsh (Greenbrae Boardwalk), have been partially infilled by commercial and residential development. Filling of diked baylands with limited wetland jurisdiction continues to occur in the historical range of ssp. *palustris* in San Francisco Bay, eliminating opportunities to re-expand or re-introduce historic populations.

The survival of *Chloropyron maritimum ssp. palustre* currently depends on the viability of populations in the Point Reyes, Humboldt Bay, and Coos Bay areas. Humboldt Bay, like San Francisco Bay, suffered a significant decline in tidal marsh area because of diking for agricultural and urban land reclamation, with reduction in salt marsh habitat to only 15 percent of historic area (Shapiro and Associates 1980). Population decline of ssp. *palustris* was probably commensurate with loss of tidal marsh acreage in Humboldt Bay. Although it persists in abundance at many salt marshes of Humboldt Bay, its survival is threatened by several factors, including: (1) displacement of suitable habitat by invasive non-native *Spartina densiflora* (Pickart 1999); (2) marsh bank erosion, sea level rise, and low modern inputs of fine sediments to Humboldt Bay; (3) apparent low habitat suitability of recently accreted or restored salt marsh dominated by *Sarcocornia pacifica* and non-native *Spartina*; and (4) habitat degradation caused by ditching, shoreline stabilization, oil spills, and other factors. Humboldt Bay tidal marshes are subject to catastrophic episodes of seismic uplift—marsh emergence and conversion to upland caused by fault movements of periodic (ca. 300 year frequency) extreme earthquakes associated with the Cascadia fault (Carver 1992). In the absence of a relatively stable (seismically and biologically) core population in San Francisco Bay, it is uncertain whether northern populations would be able to survive predictable but infrequent catastrophic seismic marsh failures. Most of the salt marshes in Point Reyes and Tomales Bay are recent in origin, and may actually be greater in extent than pre-historical conditions because of watershed erosion and artificially exaggerated deltaic deposition (Niemi and Hall 1996). However, salt marshes there are located along the San Andreas fault where they are subject to natural seismic cycles of catastrophic subsidence (marsh "drowning") and rebound sedimentation, as observed in the 1906 San Francisco earthquake (Lawson 1908, Rowntree 1973).

Non-native *Spartina densiflora* continues to spread in Humboldt Bay and Richardson Bay. It is most abundant in the upper middle marsh to high marsh where ssp. *palustris* is narrowly distributed. *Spartina patens* (salt meadow cordgrass), a creeping, turf-forming species native to the Atlantic and Gulf coasts of North America, has been introduced to San Francisco Bay and Oregon. Although another potential dominant plant in the upper middle and high salt marsh zones, its populations have not yet spread from a few points of establishment. If this species is able to initiate efficient seed reproduction (which could be triggered by arrival of a new mating strain), its spread could cause signficant loss of habitat quality for *Chloropyron maritimum ssp. palustre*.

Indirect grazing impacts (primarily trampling) along salt marsh edges with *Chloropyron maritimum ssp. palustre* are probably important factors in the establishment of colonies, the exclusion of seedling establishment, and the local extirpation of colonies in the Point Reyes area. Kelly and Fletcher (1994) found that all colonies of *Chloropyron maritimum ssp. palustre* were near ungrazed upland vegetation. Some historic localities, such as White Gulch in Tomales Bay (Kelly and Fletcher 1994), have been subjected to locally intensive grazing and trampling (by managed herds of reintroduced tule elk), and lacked *Chloropyron maritimum ssp. palustre* (P. Baye pers. observ. 1998). Surveys indicate that large stretches of otherwise suitable habitat along Creamery Bay and Home Bay in Drakes Estero are unoccupied by ssp. *palustris* in areas of cattle loafing and trampling (P. Baye unpubl. data 1997-1999). Many immature fruiting plants were found broken by cattle trampling in brackish marsh edges at the Tomales Bay trailhead at the south end of the bay (P. Baye pers. observ. 1997).

Oil spills and oil spill clean-up operations are a potential threat to *Chloropyron maritimus*. Oil tends to deposit mostly above the mean higher high water line where most *Chloropyron maritimus* populations are congested in a narrow elevational zone. Oil spill impacts could be greatest during flowering and fruiting in summer, but fall-winter spills and clean-up may have significant impacts on soil (and surface) seed banks. No actual oil spill impacts on this species have been documented.

Off-road vehicle impacts threaten numerous populations of *Chloropyron maritimum ssp. palustre* on Coos Bay North Spit in Oregon, even where vehicle restrictions are posted (Kaye *et al.* 1991). Shoreline erosion of soft unconsolidated sand substrates causes destruction of some colonies in Oregon, but dynamic shoreline erosion and accretion also establish new habitat, which may become colonized, as in Drakes Estero.

Conservation Strategy

The large, well-preserved salt marshes of Point Reyes and Tomales Bay now support the largest, and probably most resilient, core populations of *Chloropyron maritimum ssp. palustre*. Most of these marshes occur within the Point Reyes National Seashore, Golden Gate National Recreation Area (National Park Service), Tomales Bay State Park, or Audubon Canyon Ranch (a private non-profit conservation and research organization), where they are permanently protected against marsh conversion to other land uses. Ownership of parcels containing known populations (including adjacent uplands) should be determined, and any privately owned marsh sites of occurrence should be protected either by conservation easements or fee-title purchase from willing sellers. In Tomales Bay and Drakes Bay, tidal marsh edges should be protected against intensive trampling by cattle or tule elk. This may be achieved by limiting stocking rates (cattle density), or by restricting cattle/elk access to the shoreline with fencing. Tidal marsh at the south end of Tomales Bay that was eliminated by diking should be restored to tidal influence. Restoration plans for diked Tomales baylands should emphasize suitable substrate and slopes along the upper marsh edge as habitat for *Chloropyron maritimus*. Population size and distribution should be monitored annually.

Protection of the Point Reyes area marshes may not be sufficient, however, to act as a core population to conserve ssp. *palustris* because (1) marshes there are more subject to catastrophic seismic subsidence, and less capable of rebound, than those of San Franicsco Bay; and (2) much geographic variability (and possibly genetic diversity) within the taxon occurs outside of the Point Reyes area. This indicates a need to protect existing major populations in Coos Bay, Humboldt Bay, and Bodega Harbor, and to protect and re-expand (reintroduce to restored habitat) remnant populations in San Francisco Bay.

Remnant populations of *Chloropyron maritimum ssp. palustre* in San Francisco Bay, San Pablo Bay, and Humboldt Bay will need to be protected against degradation caused by wetland filling, shoreline stabilization and flood control, levee maintenance, ditching, and invasion by exotic species (particularly *Spartina densiflora* in Humboldt Bay and Richardson Bay). Measures to protect mature, floristically diverse tidal marsh remnants in Humboldt Bay include fencing (*e.g.,* Indian Island roadsides) that should be continued and expanded. Title of private lands supporting major remnant populations in Humboldt Bay should be verified. Private landowners of these tidal marshes should be provided options for public acquisition or conservation easements to ensure protection and appropriate land management. Tidal marshes within the historic range of ssp. *palustris*, particularly in central San Francisco Bay where remnant populations occur, should be re-surveyed annually where suitable habitat persists to detect previously unrecorded or re-emergent extirpated colonies, and to monitor changes in the size and distribution of populations. Permanent plots within selected populations should be monitored for annual changes in population density and to detect long-term recruitment from seed banks after temporary disappearances.

Chloropyron maritimum ssp. palustre can colonize extensively and rapidly on both naturally or artificially deposited sediment that is relatively coarse-grained (dredge spoil fans, flood tidal deltas, sandflat margins, and eroded fill). This suggests a high potential for successful reintroduction to restored habitat within its historic range with suitable tidal elevations, substrate, and vegetation. Tidal marsh restoration designs should therefore give high priority to placement of coarse-grained sediments in selected local areas to form high marsh along landward edges of tidally restored sites.

There exists much potential for habitat restoration and reintroduction of *Chloropyron maritimum ssp. palustre* in concert with recovery actions in San Francisco Bay for federally listed species. Many extirpated historical populations occurred in areas of undeveloped diked baylands suitable for tidal marsh restoration, and some areas of existing salt marsh with unoccupied suitable subhabitat are potentially available for re-introduction experiments. Pilot projects to reintroduce ssp. *palustris* to existing suitable unoccupied habitat near historical collection localities (*e.g.*, near Deepwater Slough, Bair Island; near the Pond 3 salt marsh restoration site in Alameda; near Pier 94 North, San Francisco; Roberts Landing, San Leandro) should be planned and implemented.

Restoration and reintroduction projects in diked baylands of San Francisco Bay should emphasize available parcels with low existing habitat values and high restoration potential. Pilot studies should be modelled in part on successful precedents from southern California with ssp. *maritimus* (Parsons and Zedler 1997). In general, tidal marsh restoration planning within San Francisco Bay should incorporate design features that support reintroduction of ssp. *palustris*, such as gradually sloped sandy or coarse silty high marsh transitions instead of steep-sided clay levees. Experimental use of sandy or sandy silt dredge materials to create gently sloped high marsh edges as habitat should be attempted in San Francisco Bay. Where tidal marsh restoration projects have already established sandy or silty upper intertidal terraces (*e.g.*, Sonoma Baylands), ssp. *palustris* should be reintroduced. Previously constructed tidal marsh restoration projects that did not provide adequate potential habitat for *Chloropyron maritimus* should be “retrofitted” to accommodate reintroduction of ssp. *palustris*. This would involve regrading the upper middle and high marsh zones with appropriate soils, management to control invasions of non-native species, and reintroduction of seed. “Retrofitting” would be particularly appropriate for Muzzi Marsh, Corte Madera, which is adjacent to the Greenbrae population. Where feasible, restoration sites that can incorporate seasonal creek outflows, alluvial sediment deposition (but not perennial wastewater discharges) to marsh designs should be given high priority as reintroduction sites. Seed donor populations in San Francisco Bay for reintroductions should be sampled during years of peak abundance from the two largest remaining populations in Richardson Bay and Greenbrae.

In Humboldt Bay, most tidal marsh has been eliminated by diking. Humboldt Bay is also a harbor that generates sandy dredged material, which suggests the potential to restore diked Humboldt baylands to tidal marsh that supports *Chloropyron maritimum ssp. palustre* as well as stabilized dredge spoil sites in Coos Bay. The Coos Bay dredge disposal sites were not designed as wetland habitat, yet they support the largest populations of this subspecies there. Pilot projects to restore salt marsh and *Chloropyron maritimus* populations (along with habitat for listed species and other species of concern) should be planned and implemented in diked baylands of Humboldt Bay, emphasizing available diked bayland parcels with low existing habitat values, high restoration potential, and preferably low agricultural value (poorly drained, flood-prone sites). Sites near existing populations (conducive to natural dispersal and colonization) would be preferable. All remaining populations of *Chloropyron maritimum ssp. palustre* from the Eel River to Arcata Bay should be monitored annually for estimated population size and distribution.

The expanding populations of *Chloropyron maritimum ssp. palustre* in Bodega Harbour should be monitored periodically. The marshes in which they occur should be protected against impacts of navigational improvements, maintenance dredging, dredge disposal, recreational development, trail development, and encroachment of non-native vegetation (particularly *Carpobrotus edulis* [iceplant] near the dredge disposal levees).

Seeds have been collected from some populations of *Chloropyron maritimum ssp. palustre* for seed bank conservation (Kaye *et al.* 1991). Range-wide and systematic sampling of seed representing all populations, particularly those with distinct populations, should be conducted following adapted genetic sampling guidelines detailed in Guerrant *et al*. (2004).. Multiple year collections are preferable to avoid biased genetic sampling in years of favorable seedling establishment. To avoid adverse impacts of seed collection, no more than 1 percent of any colony's seed production should be harvested in any year. Seed should be stored at a facility approved by the Center for Plant Conservation. Population size objectives for reintroductions should in most cases aim to reach periodic peak years exceeding 10,000 plants in dynamically stable habitat.

Public education and outreach efforts, including outreach to professionals in wetland conservation and management, is essential to make all substantive conservation tasks feasible for *Chloropyron maritimus*. Tasks such as land acquisition, local restriction of land uses such as grazing, conversion of diked baylands to tidal action, and use of uncontaminated dredge materials in marsh restoration are generally controversial, and are likely to fail if attempted without well-planned and implemented efforts to develop understanding from potential opponents and the support of likely advocates. Public outreach and education would also be essential to develop volunteer population monitoring programs and local stewardship programs to protect populations against some threats, such as trampling. Government planning programs pertaining to flood control planning, public shoreline access, or restoration projects would be less likely to include potential conflicts with conservation of *Chloropyron maritimus* if the species' needs are well publicized and considered early in the planning process.

California sea-pink, *Armeria maritima* (Miller) Willd. ssp. *californica* (Boiss.) Pors (syn. *Statice arctica* var. *californica* Blake, *Armeria andina* var. *californica* Boiss.), salt marsh populations only

Armeria maritima (California sea-pink) is a low tussock-forming perennial herb in the Plumbaginaceae (leadwort) family. It has a disjunct distribution in Europe and North America where it occurs in widely different sparse low vegetation of salt marshes, coastal cliffs and bluffs, alpine and high montane vegetation, tundra, and salt marshes (Chapman 1964). In salt marshes it is confined to the high marsh zone, usually in sandy substrates (Chapman 1964). It is easily recognized by its cushion-like tussocks of low grasslike leaves and long naked scapes with heads of pink flowers with five united petals, subtended by papery bracts (Abrams 1951, Munz 1959).

In California, *Armeria maritima* ssp. *californica* is commonly found on coastal bluff grasslands and some stabilized coastal dunes near salt spray (McClintock 1993), but only rarely in salt marshes. The only verified modern populations in California salt marshes are in Point Reyes, primarily the eastern end of Limantour Spit along the sandy backbarrier shoreline. Most of the population is found on relict spit recurves and stabilized old washover fans. Minor unstable colonies occur in upper Drakes Estero, where they are subject to damage and extirpation by intensive cattle trampling (P. Baye unpubl. data). Suitable habitat would be expected in the vicinity of the Golden Gate where it occurs in bluff habitats today (P. Baye unpubl. data).

To conserve this species in California salt marshes, the unique Limantour Spit population should be monitored and protected against damage from recreational trail use (pedestrian, equestrian). Populations in Drakes Estero shorelines should be encouraged to regenerate by excluding cattle trampling from sensitive high salt marsh edges. If it fails to regenerate there, it should be reintroduced from the Limantour Spit seed source. The Limantour salt marsh population should be compared with bluff populations to determine whether it is a geographically, ecologically, and genetically distinct population. If so, its conservation priority should be increased.

Asters of tidal marshes

Suisun Marsh aster, *Symphyotrichum lentum* E. Greene, (syn. *Aster chilensis* var. *lentus* (E. Greene) Jepson, *A. chilensis* Nees var. *sonomensis* (E.Greene) Jepson, *A. sonomensis* Greene)

Chilean aster, Californian aster, *Aster chilensis* Nees, (syn. *Aster menziesii* Lindl. in Hook., *A. chamissonis* A. Gray, *A. militaris* E. Greene)

Slim aster, *Symphyotrichum subulatum* Michaux var. *ligulatus* Shinn., (syn. *Aster exilis* Ell., *Aster divaricatus* Nutt.)

Description and Taxonomy

Aster taxa were formerly widespread and abundant in the upper brackish edges of salt marshes in the San Francisco Bay Estuary (Greene 1894, Jepson 1925, Cooper 1926, Munz 1959, Ferris 1960, Thomas 1961). Information regarding their historical distribution and abundance, however, is obscured by both natural ambiguity (intergrades) among taxa and changes in taxonomic interpretation.

Symphyotrichum lentum and A. chilensis

Symphyotrichum lentum is a tall perennial herb with long creeping rhizomes that form colonies of plants. Its leaves are linear to narrowly lance-shaped and hairless. The violet-rayed flowerheads occur at branch tips in clusters. *Aster chilensis* is similar in form, but has *oblanceolate* (lance-shaped, wider toward the end) leaves that are somewhat hairy with flowerheads similar to those of *Symphyotrichum lentum*. There are subtle and variable differences that make identification difficult, especially in populations that exhibit variability in these traits. Both species occur at the edges of salt or brackish marshes, but *Aster chilensis* is widespread and ecologically wide-ranging, occurring in many coastal and non-coastal plant communities (Munz 1959, Allen 1993).

The tall, perennial, colonial (short-rhizomatous) asters found along the tidal marsh borders of San Francisco Bay, northern San Pablo Bay, Suisun Marsh, and Sacramento/San Joaquin delta have been variously assigned to *Aster chilensis* (Chilean aster, a widespread species), related taxa also placed within the species *Symphyotrichum lentum* (*Aster sonomensis*, Aster *chilensis* var. *sonomensis*, *Aster chilensis* var. *lentus*), and *Symphyotrichum lentum*. *Symphyotrichum lentum* is a rare species (Skinner and Pavlik 1994, Allen 1993), which apparently intergrades with the common *Aster chilensis* making definitive analysis of historical distribution problematic. Thomas (1961) included "*Aster chilensis* var. *sonomensis*," now treated as *Symphyotrichum lentum* (Allen 1993), within *Aster chilensis*. *Symphyotrichum lentum* was collected from Alviso. The type locality of *"Aster sonomensis* (also placed in synonymy with *Symphyotrichum lentum*; Allen 1993) was in the Sonoma Valley, but *Symphyotrichum lentum* was not distinguished from *Aster chilensis* in the Sonoma County flora (Best *et al.* 1996). Ferris (1960) reported the distribution of *Aster chilenesis* var. *sonomensis* (also placed in synonymy with *Symphyotrichum lentum*; Allen 1993) as "marshes at the northern end of San Francisco Bay…Sonoma and Napa Counties, and in similar situations at the southern end in Santa Clara County."

The distribution of *Symphyotrichum lentum* in the tidal marshes of the Suisun Marsh area, western delta, and the Contra Costa shoreline is better documented than in other parts of the estuary (California Natural Diversity Database 1999). As currently interpreted, *Symphyotrichum lentum* also occurs in brackish or alkaline non-tidal interior marshes of the Sacramento/San Joaquin delta region (Skinner and Pavlik 1994). The modern distribution of *Symphyotrichum lentum* in the San Francisco Bay Estuary outside of Suisun Marsh clearly requires re-investigation in the field. Even within Suisun Marsh, focused surveys that distinguish *Aster chilensis, Symphyotrichum lentum*, and intergrades are needed (B. Grewell pers. comm. 1999). *Symphyotrichum lentum* and *Aster chilensis* populations in tidal marshes tend to occur in peaty marsh soils that remain relatively well-drained and low in salinity but moist throughout the growing season, similar to most other perennial or subshrubby aster family plants of brackish tidal marshes. In salt marshes, *Asters* are typically limited to brackish marsh soils near localized freshwater influences, such as groundwater discharges areas (seeps) or small freshwater surface drainages (P. Baye pers. observ. 1992-2000).

Symphyotrichum subulatum var. *ligulatus*

Symphyotrichum subulatum Michaux var. *ligulatus* Shinn. is an annual herb with a large taproot that may be confused with young perennial rootstocks. It has linear to ob*lanceolate* leaves like the perennial asters of tidal marshes in the region, but it occurs as solitary plants. Its flowers are distinctly less showy, with very short violet ray florets (petal-like parts). *Symphyotrichum subulatum* var. *ligulatus* is found in wetlands, particularly those with subsaline or alkaline soils (Munz 1959, Ferris 1960, Allen 1993). It is locally common in Suisun Marsh (B. Grewell pers. comm. 1999). It was a former component of the salt marsh ecotonal vegetation (Cooper 1926), where it was reported from salt marshes at numerous localities of south San Francisco Bay (Thomas 1961), and at least one salt marsh locality near San Leandro (*G.T. Robbins 3949*, JEPS25087, Oct. 1958). Early accounts variously suggest that it was widespread and locally abundant in saline wetlands (Greene 1894, Cooper 1926), or not common elsewhere in the region (Jepson 1911, Thomas 1961). *Symphyotrichum subulatum* var. *ligulatus* has not been reported from south San Francisco Bay recently, and is presumed extirpated over most of this subregion. It could possibly occur in brackish reaches of Coyote Creek where marginal habitat may persist, but no focused searches have been conducted. It has not been reported from suitable habitat in Marin or Sonoma County tidal marshes.

The highest priorities for conservation of salt marsh aster species are (1) protection of scarce brackish tidal marsh near known or past localities, particularly near ecotones with natural alluvial soils or seeps; and (2) focused, seasonally timed surveys that discriminate among taxa and distinguish intermediate or ambiguous populations. Lack of high-resolution field data on the distribution and abundance of *Symphyotrichum lentum* is the only reason this taxon is not currently confirmed as a species of concern. If surveys confirm that most existing perennial tidal marsh asters are variants of *Aster chilensis*, then *Symphyotrichum lentum* should be re-examined for eligibility for Federal listing as threatened or endangered. Where tidal marsh restoration projects include brackish, moist upper marsh edges, tidal marsh asters should be included in reintroduction plans. Source populations for restored tidal marsh edges should be derived from the nearest estuarine populations in the subregion, if size of the donor population is adequate.

Astragalus tener* A. Gray var. *tener
Alkali milkvetch

Astragalus tener var. *tener* (milkvetch, locoweed) is an erect to ascending annual herb in the Fabaceae (pea) family. It typically occurs in alkali or subsaline vernal pools, seasonally wet alkaline lowland grasslands, or sparsely vegetated flats. Its stems are approximately 30 centimeters (1 foot) long, and bear compoundly pinnate leaves with up to 17 blunt-tipped leaflets. Flowers are borne in racemes of 3 to 12 flowers with purple petals. The pods are nearly stalkless, straight, or slightly curved, and bear up to about 14 seeds (Munz 1959).

Astragalus tener var. *tener* is one of the numerous rare species of *Astragalus* in California (Skinner and Pavlik 1994). Most populations occurred historically in grasslands of the Central Valley and Sacramento/San Joaquin delta region, but it also occurred in saline to alkaline seasonal wetlands of south San Francisco Bay in tidal marshes or peripheral to them, including sites marginal to salt evaporation ponds. The known records of *Astragalus tener* var. *tener* along the edges of San Francisco Bay probably represent either small remnants or artificial refugia derived from formerly more extensive populations in ecotonal tidal marsh/subsaline alluvial grassland habitats. It was believed extinct in the bay area for the last four decades (Skinner and Pavlik 1994) but was rediscovered at the Stem Parcel at Warm Springs, Fremont (Alameda County) during grading for vernal pool reconstruction in an area of historical rangeland and vernal pool grassland. The species has presumably regenerated there from exhumed dormant seed banks (J. Albertson pers. comm. 2000).

The principal conservation strategy for *Astragalus tener* var. *tener* was developed for interior populations in the *Recovery Plan for Vernal Pool Ecosystems of California* (U.S. Fish and Wildlife Service 2005*c*). The conservation strategy for this species in San Francisco Bay tidal marsh ecosystems should include the following tasks:

(1) Historical localities with potential habitat, and equivalent habitat within the historical range, should be resurveyed at times keyed to the flowering of the rediscovered Warm Springs population. Surveys conducted by botanists with expertise in recogniction and identification of this species should be done before development of areas of suitable habitat.

(2) Soils in, or marginal to, historic tidal marsh in the South Bay should be examined for viable seed banks of this species using germination tests of shallow soil samples, or by monitoring previously graded, disked, or other disturbed soils in spring. This is particularly important for derelict agricultural lands rezoned for development in and near Alviso.

(3) The Warm Springs population, and any other rediscovered populations, should be protected in reserves that, to the greatest extent possible, preserve hydrologic conditions and vegetation that promote the regeneration and persistence of this species.

(4) Seeds of *Astragalus tener* var. *tener* from the Warm Springs population, and any other rediscovered populations, should be collected and stored according to guidelines for genetic sampling of conservation collections (Guerrant *et al*. 2004).

(5) When appropriate ecotonal habitat is developed in tidal marsh or vernal pool restoration projects in south San Francisco Bay, reintroduction experiments with *Astragalus tener* var. *tener* should be conducted on protected lands.

Atriplex californica Moq. (salt marsh populations)
California saltbush

Atriplex californica (California saltbush) is a low perennial herb in the Chenopodiaceae (goosefoot) family. It has a semi-woody caudex, thick large taproot, and a prostrate to ascending growth habit. Its foliage is greenish gray to whitish-green, with waxy-scaly covering. The lance-shaped to *elliptic* leaves are usually less than 1 centimeter (0.4 inch) in length (Munz 1959). Flowers are small, clustered in leaf *axil*s, and monoecious (pollen-bearing and seed-bearing flowers separate, but on the same plant). *Atriplex californica* resembles *Cressa truxillensis* (alkali-weed), which occurs in the eastern portions of the San Francisco Bay Estuary (P. Baye pers. observ.).

Atriplex californica was formerly collected from salt marshes of central San Francisco Bay between Berkeley and Bay Farm Island (Alameda County), where sandy barrier beaches and salt marshes occurred before urbanization. The San Francisco Bay salt marsh populations, probably the largest, are now extinct. Salt marsh populations today occur locally in parts of Carpenteria Marsh (occasional to common on berms, sandbars; Ferren 1985); Morro Bay (infrequent, southeastern shore); Elkhorn Slough (infrequent to rare, western end); Limantour Estero, Point Reyes (locally abundant, east end along sandy salt marsh margin of Limantour Spit); Tomales Bay (Marin County; small infrequent populations in the vicinity of Inverness and Millerton), and Bodega Harbour (Best *et al.* 1996, P. Baye unpubl. data 1997-2000). Populations are infrequent in most of its range, but may be locally common (Munz 1959, P. Baye unpubl. data 1997-1998).

Atriplex californica grows in coastal habitats, including salt marsh, coastal dunes, coastal bluffs and cliffs, beaches, and other sandy coastal soils. It occurs in highly contrasting types of substrates, ranging from dry, steep marine cliffs of granite, sandstone (Montara, Pescadero, Pillar Point, San Mateo County; Salt Point, Sonoma County; Thomas 1961, Best *et al.* 1996, P. Baye unpubl. data 1997), coastal serpentine landslides (Presidio, San Francisco; Howell *et al.* 1958, P. Baye unpubl. data 1996), coastal dunes (Marina, Monterey County), and sandy edges of salt marshes. Salt marsh populations of *Atriplex californica* are usually restricted to the high tide line and ecotones between salt marsh, washover fans, and sand dunes with well-drained substrates, and generally do not extend into typical terrestrial habitat (dunes or bluffs) adjacent to them, even though sandy coastal terrestrial habitats are prevalent for the species over most of its range (P. Baye pers. observ.). This suggests the possibility of ecologically differentiated, locally adapted populations (or ecotypes).

Common salt marsh plants associated with *Atriplex californica* include *Distichlis spicata* (saltgrass), *Spergularia macrotheca* (sand spurrey), and *Frankenia salina* (alkali-heath). Species of concern and listed plant species associated with *Atriplex californica* in salt marshes include *Atriplex watsonii* (Watson's saltbush; Morro Bay, Carpenteria Marsh), *Lasthenia glabrata* ssp. *coulteri* (Coulter's goldfields; Morro Bay, Carpenteria marsh), *Chloropyron maritimus* ssp. *maritimus* (northern salt marsh bird's beak; Morro Bay, Carpenteria Marsh), *Chloropyron maritimum ssp. palustre* (salt marsh bird's beak; Bodega Harbour, Limantour Estero), *Suaeda californica* (California sea-blite; Morro

Bay), and rare salt marsh populations of *Armeria maritima* ssp. *californica* (California sea-pink; Limantour Estero).

There is the potential for reintroduction of *Atriplex californica* to be integrated with recovery measures for *Suaeda californica* in central San Francisco Bay. In fact, because both species are found in sandy high salt marsh and ecotones between salt marsh and sand beach, in 2000-2001, *Atriplex californica* was reintroduced to a restored salt marsh in the Presidio, San Francisco, using founders from the Limantour salt marsh population (Golden Gate National Parks Conservancy 2000). This population experienced 98% survival three months after reintroduction, but the success of the population since then is not known (Golden Gate National Parks Conservancy 2000). Existing salt marsh populations elsewhere along the central California coast should be protected against impacts from dredging, filling, shoreline stabilization, or other detrimental influences. It may not be desirable to protect individual populations against natural erosion, since periodic disturbance of sandy high marsh may be needed to maintain suitable habitat and potential for seedling regeneration. *Atriplex californica* should be the object of focused searches in botanical surveys of salt marshes. The number, location, and size of colonies found on public lands should be reported to local or regional land management agencies.

Baccharis douglasii **DC**
Marsh baccharis, salt marsh baccharis, Douglass' baccharis

Baccharis douglasii (marsh baccharis) is an erect, subshrubby perennial herb in the Asteraceae (aster) family. It forms clonal colonies of relatively unbranched erect shoots about 1 meter (3 feet) tall. Its stems and *lanceolate* leaves are hairless and sticky with glandular resin. Flowerheads are grouped in flat-topped clusters, which consist of glandular-sticky green *phyllaries* (green appendages on flowerheads) and white florets.

Baccharis douglasii was formerly a major component of the "willow-composite" community that occupied the tidal marsh-alluvial ecotone of south San Francisco Bay (Cooper 1926). Although records are sparse, it was probably an occasional to common component of high marsh vegetation of brackish tidal marshes in the northern portion of the San Francisco Bay Estuary and elsewhere. It was described by Jepson (1911) as "abundant in the salt marshes about San Francisco Bay," but was considered "occasional" in the South Bay (Thomas 1961). Best *et al.* (1996) assessed it as uncommon in Sonoma County. Howell (1949) reported it only from Mill Valley (estuarine) marshes in Marin County.

In the San Francisco Bay Estuary, *Baccharis douglasii* grows along the upper edges of brackish tidal marshes and in moist brackish diked baylands. It occurs occasionally along the upper borders of brackish tidal marshes and dike edges of the Napa-Sonoma Marshes and Mare Island, and the Suisun Marsh area. Large stands are sometimes found in diked bayland refugia, even when the species is absent in adjacent tidal marshes. In fact, it is probably more common today in such diked refugia than in tidal marsh edges affected by dikes. *Baccharis douglasii* is seldom, if ever, observed along edges of salt marshes with prevailing marine salinities, except where the edges are influenced by local freshwater inputs or brackish tidal marshes. It is uncommon and local along brackish tidal marsh edges of Elkhorn Slough (Monterey County); and Drakes Estero, Limantour Estero, and Tomales Bay (Marin County; P. Baye unpubl. data).

The decline of *Baccharis douglasii* in tidal marsh edges is probably due to loss of gently sloping tidal marsh edges influenced by freshwater discharges from seeps, high groundwater, or surface drainages. Diking and channelization of alluvial terraces around the bay have converted such areas to steep terrestrial borders, stormwater drains, and flood control channels. Like *Grindelia stricta* var. *angustifolia* (gumplant), *Baccharis douglasii* colonies are locally extensive semi-evergreen, dense, tall vegetation that may provide tidal flooding refugia for marsh wildlife. Where appropriate slopes and salinity gradients can be developed in restored tidal marshes, *Baccharis douglasii* should be incorporated in tidal refugia designs and included in revegetation plans for brackish tidal marshes or their ecotones. Existing populations in tidal marshes should be noted in vegetation surveys, and should be protected and enhanced. Populations in diked brackish marshes proposed for tidal restoration should be salvaged, propagated, and transplanted to gently sloping tidal marsh edges within suitable ranges of local salinity gradients determined by soil salinity profiles of reference sites in tidal marshes.

***Centaurium trichanthum* (Griseb.) Robinson (syn. *Erythrea trichantha* Griseb.]
Alkali centaury**

Centaurium trichanthum (alkali centaury) is an erect, slender-stemmed, showy annual herb in the Gentianaceae (gentian) family. It grows from 5 to 45 centimeters tall (about 2 inches to 1.3 feet), with small lance-shaped to egg-shaped leaves and pink 5-petalled flowers borne either singly or in flat-topped clusters. Flowers appear in early summer (occasionally mid-summer in years of late rainfall). *Centaurium trichanthum* may intergrade with a related species, *Centaurium venustum*, and the two may constitute a single taxon (Hickman 1993). *Centaurium trichanthum* can be confused with *Centaurium muehlenbergii* (Muehlenberg's centaury), a species with larger flowers that is relatively more common today in seasonally wet grasslands near tidal marshes around San Francisco Bay and elsewhere in the region. *Centaurium muehlenbergii*, in turn, can be confused with some naturalized annual European species of *Centaurium*, such as *Centaurium erythraea* or possibly other European and West Asian species. In practice, it can be difficult to distinguish these species in the field because of much variability in key characters. Interpretation of taxonomic treatment in older floras is somewhat uncertain.

Centaurium trichanthum formerly occurred along edges of coastal salt marshes in California, and saline or alkaline flats remain among its typical habitats today (Munz 1959, Hickman 1993). There are relatively few site-specific records of *Centaurium trichanthum* from tidal salt marsh localities, and its natural frequency in this habitat is not clear. It was collected from a locality near sea level in West Berkeley, presumably tidal marsh edge or peripheral habitat, and from Belmont, San Mateo County, at the same elevation. Howell (1949) reported it from "low ground bordering the salt marsh near Burdell Station [northeast of Novato, Marin County]."

Centaurium trichanthum is identifiable only when in flower, and then only with some difficulty. It may occur in subsaline grassy depressions or salt pans in diked baylands, and possibly along the edges of intact tidal marshes. It should be included in seasonally timed, focused surveys of diked baylands proposed for restoration to tidal marsh or other land-use changes. Local populations should be protected if found in natural habitat, and should be subject to seed collection, propagation, and translocation to restored or suitable natural tidal marsh edge habitat in the vicinity if it is found in diked baylands.

***Cicuta maculata* L. var. *bolanderi* (S.Watson) Mulligan (syn. *Cicuta bolanderi* S. Watson)**
Bolander's spotted water-hemlock

Cicuta maculata (spotted water-hemlock) is a widespread North American perennial herb in the Apiaceae (carrot) family. It occurs mostly in freshwater marshes. In California, *Cicuta maculata* is represented by two varieties distinguished primarily by geographic distribution and ecology. The variety *bolanderi*, formerly treated as a distinct species (*Cicuta bolanderi* S. Watson; Abrams 1951), is a geographically restricted coastal marsh ecotype of the wide-ranging species, with the core of its range in the eastern San Francisco Bay Estuary. Suisun Marsh is the type locality of the variety *bolanderi* (Abrams 1951). The erect plant in Suisun Marsh was reported to reach nearly to 3 meters (10 feet) in height (Jepson 1911, Abrams 1951), but more accounts describe shorter plants up to 1.5 meters (7 feet; Constance 1993). The hairless, purplish-spotted, hollow stems grow from short rhizomes that support twice-pinnate compound leaves, and terminate in umbels (clusters of stalked flowers radiating from a central point) of white flowers. It is distinguished from the widespread *Cicuta douglasii* (Douglas' water-hemlock) by its ovate (versus round) seed-like fruits and the wider spacing of ribs on the fruits. It differs from *Cicuta maculata* var. *angustifolia* in having mostly twice-pinnate leaves (versus once-pinnate) and longer styles. It is among the most toxic native plants in California.

Populations of *Cicuta maculata* var. *bolanderi* were recorded in brackish tidal marshes of the western Sacramento delta and the Suisun Marsh area (historically to Benicia and near Martinez), and very rarely at disjunct non-tidal coastal marsh localities in Marin County (Olema Marsh, Drakes Estero [Point Reyes]; Howell 1949) and San Luis Obispo County (Santa Maria River mouth; Smith 1998; Morro Bay [1996], Atascadero [1969] and Newport Lagoon [1932]; (University of California, Berkeley and Jepson Herbaria). Most of the records of *Cicuta maculata* var. *bolanderi* are more than 50 years old, and although its presence has been confirmed in remnant tidal marshes in parts of Suisun Marsh (B. Grewell pers. comm.), there are few reliable contemporary records to determine even its approximate overall distribution and abundance. It is infrequently detected in surveys of Suisun Marsh, but adequate surveys depend on boat as well as marsh plain access to detect flowering specimens along tidal creek banks. Comprehensive seasonally timed surveys for this species have not been conducted. What is clear is that its former status as "abundant and conspicuous" in Suisun Marsh (Jepson 1911) has declined to scarcity, possibly extirpation, in both its type locality and disjunct populations. This decline was undoubtedly due to the historical conversion of brackish-fresh tidal marsh to managed waterfowl marshes. The decline may also be related to changes in tidal hydrology (operation of salinity control gates that alter tidal datums as well as mean salinity of channel water), or changes in the seasonal distribution or total outflow from the Sacramento/San Joaquin delta.

The first step in the conservation of *Cicuta maculata* var. *bolanderi* should be to determine its contemporary distribution and abundance in the Suisun Marsh area, and to determine its presence in the Point Reyes vicinity coastal marshes. Surveys should be conducted over a series of high rainfall years in likely habitats (brackish tidal and non-tidal marshes). In years of ample seed production, the largest populations representing its known range on the central coast should be collected and stored as insurance against local extinction and loss of genetic diversity (Guerrant *et al.* 2004). Verified populations should be protected against destruction or habitat degradation.

***Eleocharis parvula* (Roemer & Schultes) Link (alternate spelling "*Heleocharis*")**
Least spikerush

Eleocharis parvula (least spikerush) is a diminutive tufted grasslike plant in the Cyperaceae (sedge) family. Plants consist of either discrete tufts or extensive turfy mats of individuals, with fine thread-like or soft needle-like leaves, typically only a few centimeters (about an inch) tall. In tidal brackish marshes it can easily be misidentified as the more common *Scirpus cernuus* (fiber optic grass), or overlooked altogether in tall dense vegetation cover. *Eleocharis parvula* occurs in brackish ditches, dried pond bottoms, tidal brackish marshes, and subsaline flats. It has been described as an annual (Mason 1957) or perennial (Cranfill 1993). Within the central California region it appears to act as an annual in summer-desiccated wetlands, and as a perennial in perennial wetlands (P. Baye pers. observ.).

Historical collections and records are sufficiently incomplete to prevent assessment of *Eleocharis parvula* status in the San Francisco Bay Estuary prior to urbanization and agriculture. Munz (1959) described it as a local element in coastal salt marsh habitats, and it is ranked as uncommon in the modern California flora (Cranfill 1993). Though apparently uncommon in tidal marshes, it rarely undergoes population explosions in new habitats, such as seasonally flooded flats in diked baylands (*e.g.*, Cullinan Ranch, Vallejo, Solano County) and sheltered high mudflats in tidal marsh restoration sites (Pond 2A, Napa Marsh; P. Baye pers. observ.).

Eleocharis parvula should be treated as a watch species for tidal marshes of central California, deserving of monitoring (Skinner and Pavlik 1994) because insufficient information is available to assess its conservation status.

Glaux maritima L., Sea-milkwort

Glaux maritima (sea-milkwort) is a perennial herb in the Primulaceae (primrose) family. It is found in tidal marshes and inland saline wetland meadows of northern Eurasia, northeastern North America, and the Pacific Northwest south to San Francisco Bay. It has succulent stems that spread and branch at their bases, and that ascend to erect, relatively unbranched shoots with numerous simple stalkless fleshy leaves. In California tidal marshes, *Glaux maritima* seldom exceeds 20 to 30 centimeters (8-12 inches) tall (P. Baye pers. observ.). The small flowers (3 to 4 millimeters [0.14 inch] across) emerge in summer. They are drab reddish or purplish-brown, with five petal-like sepals and no true petals (Hickman 1993). The flowers are ant-pollinated, at least in some portions of its wide range (Faegri and Van der Pijl 1979).

While this species is common worldwide and in the Pacific Northwest north of California, it has apparently undergone a significant decline in distribution and abundance in the southern portion of its range, the San Francisco Bay Estuary and Marin County coast. Greene (1894) described it as "frequent.... along the seabord," and it formerly occurred in both northern and southern parts of the San Francisco Bay Estuary (Jepson 1911). Former localities include Palo Alto tidal marshes (Santa Clara County; Thomas 1961) and Burdell (Petaluma marshes, Marin County; Howell 1949). Isolated populations occur further south on the coast in dune slacks of the Santa Maria River dune complex. Today, *Glaux maritima* appears to be confined to brackish marshes of the northern portions of the San Francisco Bay Estuary, particularly the Suisun Marsh area and Contra Costa shoreline. It was located after a series of high rainfall years near the mouth of Tolay Creek, San Pablo Bay (P. Baye pers. observ.), where it is locally abundant in the marsh plain associated with *Distichlis spicata* (saltgrass) and *Sarcocornia pacifica* (pickleweed). This suggests that it is likely to persist in brackish upper reaches of the Petaluma River, Sonoma Creek, and Napa River, but it has not been reported or observed recently from these areas. It is also rarely observed or reported from tidal marshes of the Point Reyes vicinity. Best *et al.* (1996) rank it as rare in Sonoma County. It has not been confirmed in San Francisco Bay for many decades.

The decline in abundance of *Glaux maritima* near its southern limit in California, and its possible extirpation in San Francisco Bay, is probably due to the reduction of brackish tidal marsh and its replacement with diked baylands and narrow strip marshes with exaggerated salinity gradients. Conservation of *Glaux maritima* in the San Francisco Bay Estuary and Marin coastal marshes should begin with surveys in relatively high rainfall years to determine approximate distribution and abundance. In particular, brackish marshes of the South Bay (*e.g.*, Triangle Marsh, Coyote Creek), the Petaluma Marsh, and the Napa-Sonoma Marshes should be surveyed. Populations should be protected, and at least occasionally revisited to reconfirm their status. Verified populations should be protected against destruction or habitat degradation. State, Federal, and local regulatory, land use planning, and natural resource agencies should be notified of the location and conservation significance of populations within their jurisdiction. *Glaux maritima* is readily propagated by seed or rooted stem cuttings during early-season vegetative growth, and should be included in reintroduction programs associated with brackish tidal marsh restoration in the San Francisco Bay Estuary.

Heliotropium curassavicum **L.**
Seaside heliotrope

Heliotropium curassavicum is a widespread prostrate to ascending perennial herb in the Boraginaceae (borage) family. It has fleshy pale blue-green to yellow-green oblanceolate leaves, and dense coiled spikes of bell-shaped, five-lobed whitish to dull purplish flowers (Munz 1959). It occurs in subsaline to saline wetlands of both non-tidal interior basins (playas, alkali basins, saline vernal pools) and coastal non-tidal and tidal habitats. Coastal California populations are widely scattered, usually occurring in sandy lagoon shores with seasonal flooding and drawdown patterns (Rodeo Lagoon, Abbotts Lagoon [Marin County]), subsaline dune slacks (Manchester, Mendocino County), or seeps in coastal bluffs exposed to chronic salt spray (Halfmoon Bay, San Mateo County) where it is often associated with *Distichlis spicata* (saltgrass; P. Baye unpubl. data 1990-2000).

Cooper (1926) cited *Heliotropium curassavicum* as a common component of the extinct willow-composite community, an alluvial forb-dominated vegetation that occupied the ecotone between tidal salt marsh and chaparral in south San Francisco Bay. There are rare collections from shoreline localities of the San Francisco Bay Estuary, such as Bay Farm Island, Alviso, west Berkeley, western Suisun Marsh near Goodyear, Cordelia, and an unspecified Suisun Marsh locality. *Heliotropium curassavicum* is now seldom reported from the margins of the San Francisco Bay Estuary. The few known localities in saline lowlands adjacent to tidal marsh include northwestern Suisun Marsh (B. Grewell pers. comm.) and a *Distichlis* swale along the southwest shore of Mare Island (P. Baye unpubl. data 2000). Its apparent decline is due to diking that virtually eliminated relatively flat or depressional seasonally flooded topography and subsaline soils at the upper edges of tidal marshes. It should be given priority in surveys of salt marsh vegetation, particularly around sandy or gravelly shorelines near historical localities. If found, habitats and populations should be monitored and protected. Seed should be collected from remnant populations for potential reintroduction to enhanced or restored brackish salt pan or tidal marsh edge habitats.

Spikeweeds of tidal marsh edges

***Hemizonia parryi* ssp. *congdonii* (Robinson & Greenman.) Keck; (syn. *Hemizonia congdonii* Robinson & Greenman., *Centromadia congdonii* C. P. Smith, *Centromadia pungens* var. *congdonii* Jepson.)**
Congdon's spikeweed,

***Hemizonia parryi* E. Greene ssp. *parryi* (syn. *Centromadia parryi* Greene, *Centromadia pungens* var. parryi Jepson)**
Parry's spikeweed

***Centromadia pungens* (Hook. & Arn.) Torrey & A. Gray ssp. *maritima* (E.Greene) Keck (syn. *Centromadia pungens* Greene)**
Maritime spikeweed

Spikeweeds are members of the Asteraceae (aster) family, and have been variously placed in the genera *Hemizonia* or *Centromadia*. They are typically glandular aromatic herbs, often with spiny bracts in flowerheads or short sharp-pointed leaves. The flowerheads are generally yellow, intermediate in aspect between those of *Taraxacum* (dandelions) and *Grindelia* (gumplant), and surrounded in heads by bristly green bracts. Flowerheads form at the ends of branched terminal shoots. Spikeweeds are familiar in California as common species that may become abundant in degraded rangeland (*e.g., Hemizonia fasciculata, Hemizonia congesta*). They may be casually confused with ecologically similar common species in related genera (*Holocarpha, Madia*) that have a similar aspect and conspicuous, pungent, resinous scent. However, many species of *Hemizonia* are either endemic, rare, or endangered (Skinner and Pavlik 1994).

Spikeweeds are most often associated with grassland habitats, and many occur specifically in alkaline or subsaline seasonal wetland depressions or flats. In pre-historical and early historical San Francisco Bay, they were probably elements of what Cooper (1926) described as a willow-composite community, a vegetation type that dominated alluvial fans on lowland (seasonal wetland) gradients between tidal salt marsh and chaparral. Among the most common species in the forb-dominated phase of this lowland vegetation were spikeweeds, *Hemizonia congesta* ssp. *luzulifolia* and *Centromadia pungens* ssp. *maritima* (Cooper 1926). *Hemizonia parryi* subspecies were locally common in this area (Munz 1959). Other species in this historical vegetation include *Aster chilensis, Symphyotrichum subulatum* var. *ligulatus, Baccharis douglasii, Iva axillaris, Heliotropium curassavicum, Euthamia occidentalis* (Cooper 1926). This formerly extensive plant community is now extinct, but remnant or re-emerged populations of its component species still occur at a few sites in south San Francisco Bay.

Hemizonia parryi ssp. *congdonii—Hemizonia parryi* ssp. *congdonii* is a globally rare spikeweed, formerly locally common (Munz 1959), but now nearly extirpated from the San Francisco Bay area (Skinner and Pavlik 1994). It is a coarse annual herb, prostrate to erect in habit, reaching up to 0.8 meter (2.6 feet) in height. *Hemizonia parryi* ssp.

congdonii is distinctive among its related subspecies, and most species of *Hemizonia*, in its lack of resinous glands. Its type locality is Salinas, Monterey County (an alluvial grassland valley with alkali/subsaline soils). Over its entire range, ssp. *congdonii* inhabits lowland fields (seasonally wet or poorly drained, dry in summer), often in alkaline or subsaline soils, and margins of salt marshes (Munz 1959, Skinner and Pavlik 1994). There are two historical records of *Hemizonia parryi* ssp. *congdonii*, localities marginal to diked historical baylands in Alameda County, San Francisco Bay: San Leandro and Warm Springs. The Warm Spring locality probably corresponds with more recent records (*C.W. Sharsmith 5866* [Oct. 26, 1951]), and recent field surveys at Warm Springs (Stem parcel) grasslands (J. Albertson pers. comm. 2000) and Alviso (M. Littlefield pers. comm. 2000). The Alviso and Warm Springs populations are probably the only ones left in the San Francisco Bay Estuary. The Warm Springs site is proposed for restoration (to habitat of uncertain suitability for this species), while the Alviso site is proposed for commercial development with a small on-site preserve (J. Albertson pers. comm. 2000, M. Littlefield pers. comm. 2000).

Hemizonia parryi ssp. *parryi*—*Hemizonia parryi* ssp. *parryi* (Parry's spikeweed) is similar overall to ssp. *congdonii*, but is densely hairy, glandular, with nearly stalkless glands. It also grows in lowland alkali fields and grasslands in central California. Although it is reported to occur in salt marshes (Munz 1959, Keil 1993), there appear to be no specific historical records of its occurrence in tidal marsh edges of San Francisco Bay, and no recently verified reports. It is possible that, despite the relatively widespread distribution of this subspecies as a whole, coastal salt marsh edge populations have been extirpated, or its reported occurrence in salt marsh was due to confusion with ssp. *congdonii*.

Centromadia pungens ssp. *maritima*—*Centromadia pungens* ssp. *maritima* is another spikeweed that was formerly a dominant species along San Francisco Bay tidal marsh edges (Cooper 1926), but is now infrequent to rare in this ecosystem. The subspecies as a whole is not rare, persisting in weedy vegetation of old fields in valley grasslands. The abundance of this and related subspecies in disturbed derelict pastures and roadsides has obscured the extreme decline of salt marsh populations from historical dominance to rarity. It occurs occasionally in scarce undiked upland/tidal marsh ecotones of San Pablo Bay and Suisun Marsh (P. Baye pers. observ. 1992-1999, Grewell 1993) as well as in subsaline seasonal wetlands within diked baylands.

The two known San Francisco Bay populations of *Hemizonia parryi* ssp. *congdonii* in Alviso and Warm Springs should be protected against habitat destruction at least until new populations can be established in appropriate estuarine-margin habitats that are permanently protected. Seed of these populations should be collected and stored according to guidelines for genetic sampling of conservation collections (Guerrant *et al*. 2004). Surveys should be conducted for this subspecies and *Hemizonia parryi* ssp. *parryi* in potentially suitable habitats in the San Francisco Bay Estuary and adjacent lands. Similarly, the distribution and abundance of *Centromadia pungens* ssp. *maritima* populations in tidal marsh ecotone habitats should be determined through focused regionwide field surveys. Tidal marsh restoration projects that include broad, gently sloping high marsh/upland transition zones should include appropriate *Hemizonia* species of concern as reintroduction components.

***Juncus* species**
Tidal marsh edge rushes

Several perennial *Juncus* (rush) species were historically described as common in the San Francisco Bay Estuary, but are now rare or extirpated in tidal marsh ecosystems in that region. None of these species is rare over its whole range, and most can be found in intact brackish/subsaline tidal marsh edges of maritime salt marshes of Marin County (P. Baye pers. observ.). Their decline in the salt marsh flora of central California is very likely due to a combination of diking and elimination of brackish/freshwater ecotones along tidal marsh edges, their typical niche in tidal marshes.

Juncus effusus L. var. *brunneus* Engelm. (soft brown rush), a clump-forming species, was described as common in the salt-marshes about San Francisco Bay (Brewer *et al.* 1880, Brandegee 1892). There are no populations known in San Francisco or San Pablo Bay tidal marshes today, but this species occurs in alluvium near tidal marshes at China Camp and the Petaluma Marsh in Marin County, and is locally common in fresh-brackish tidal marsh edges of maritime salt marshes near Point Reyes (P. Baye pers. observ.).

Juncus xiphioides E. Meyer (irisleaf rush) was also reported as a common species of salt marshes (Jepson 1911) with localities from Berkeley, Belmont, and Suisun marshes. Similarly, Thomas (1961) reported it as occasional in tidal sloughs from Palo Alto and near Alviso. In tidal marshes, *Juncus xiphioides* is apparently now largely restricted to edges of Suisun Marsh and Point Pinole.

Juncus balticus (Baltic rush) and *Juncus lesueurii* (salt rush) are creeping rhizomatous species that intergrade and are not always distinct in the San Francisco Bay region (Howell 1949). They are still abundant to co-dominant in Suisun Marsh in both tidal and diked non-tidal brackish marshes, and are often locally dominant in upper edges of maritime tidal marshes, particularly in seeps or sandy substrates (P. Baye unpubl. data). *Juncus balticus/J. lesueurii* is notably absent in large portions of San Francisco Bay (P. Baye pers. observ.), probably because of loss of marginal brackish sub-habitats in high marsh.

Juncus acutus L. ssp. *leopoldii* (Parl.) Snog. (southwestern spiny rush) is a very large (nearly 2 meters [over 6 feet] tall), clump-forming perennial rush with rigid, pungent, cylindrical leaves. It occurs in moist brackish soils such as alkaline seeps, brackish edges of salt marshes or coastal stream mouths, and dune slacks (Swab 1993). The northernmost coastal tidal marsh populations occur in Morro Bay where they are locally common in the brackish edges of salt marshes associated with groundwater flows from adjacent sand dunes. *Juncus acutus* ssp. *leopoldii* is also locally abundant in salt marsh at the advancing edges of high mobile sand dunes at the south end of the bay (P. Baye unpubl. data 1997-2000). The salt marsh edge populations at Morro Bay constitute a large proportion of the remaining salt marsh populations in California. It is otherwise found in scattered southern California coastal salt and brackish marshes (Zedler 1982, Beauchamp 1986, Smith 1998).

Perennial rushes are a conservation concern only for the San Francisco Bay estuarine flora and for Morro Bay. It is likely that they would resume their niche in brackish tidal marsh edges of the San Francisco Bay Estuary if steep dike-edged tidal marshes are restored to conditions resembling alluvial fans or terraces with local subsurface freshwater influence or minor surface flows. *Juncus acutus* of Morro Bay should be protected by ensuring that groundwater and shallow surface drainages flow uninterrupted to emerge at edges of tidal marshes there, and that tidal marsh edges are protected against shoreline stabilization and armoring, intensive trampling, or habitat conversion.

Goldfields (*Lasthenia*) species of tidal marshes
Lasthenia conjugens E. Greene
Contra Costa goldfields
Lasthenia glabrata Lindley ssp. _glabrata_
Smooth goldfields
Lasthenia glabrata Lindley ssp. _coulteri_ (A. Gray) Ornd.
Coulter goldfields
Lasthenia platycarpha (A. Gray) E. Greene
Alkali goldfields
Lasthenia glaberrima A. DC.
Short-rayed smooth goldfields

Lasthenia species (goldfields) were formerly prominent elements of the annual flora of tidal marsh edges in central California (Jepson 1911, 1925; Munz 1959; Ornduff 1964). Several species of *Lasthenia* have been recorded historically in tidal marsh edge habitats of the central California coast: *Lasthenia conjugens* E. Greene (Contra Costa goldfields), *Lasthenia glabrata* Lindley ssp. *glabrata* (smooth goldfields), *Lasthenia glabrata* Lindley ssp. *coulteri* (A. Gray) Ornd. (Coulter goldfields), *Lasthenia platycarpha* (A. Gray) E. Greene (alkali goldfields); *Lasthenia glaberrima* A. DC. (short-rayed smooth goldfields), and rarely, *Lasthenia minor* (small goldfields).

Lasthenia are annual yellow-flowered herbs in the Asteraceae (aster) family that usually grow in conspicuous colonies. Individual plants have slender stems and linear leaves, with flowerheads that resemble small all-yellow daisies (except *Lasthenia glaberrima*, which has highly reduced petal-like ray florets and resembles small plucked daisies). *Lasthenia* today are rare and local components of tidal marsh edges in the central California coast. *Cotula cornopifolia* L. (brass-buttons), a South African perennial species that was introduced early in California (Behr 1892), is ecologically similar to the wetland *Lasthenia* species, and has largely displaced them in tidal marsh edges along with other non-native plants. *Lasthenia* have not been reported from tidal marsh edges of northern California.

The tidal marsh *Lasthenia* occur mostly in vernal pools (hogwallows; Jepson 1925) and wetland habitats that are shallow pools in winter and desiccated in summer, and that sometimes accumulate alkali or sodium salts. In this respect, saline or alkaline vernal pools are similar to some tidal marsh sub-habitats, such as shallow brackish pans or flats along high marsh edges. *Lasthenia* species exploit both ecosystems. *Lasthenia* species of tidal marshes today are not only rare in the tidal marsh ecosystems, they are declining along with their principal vernal pool ecosystems.

Lasthenia glabrata ssp. *glabrata* was probably the most widespread and abundant of the tidal marsh goldfields. It is still locally abundant in a few of the remaining coastal salt marshes in southern California (Callaway *et al.* 1990, Callaway and Sabraw 1994). This species has an erect growth habit, but relatively weak stems supported by adjacent vegetation. Large, branched plants from Point Pinole may have over 70 flowerheads. In the San Francisco Bay Estuary it was recorded from many salt marsh borders (Jepson 1911), particularly in Alameda County: Bay Farm Island, near Newark, Denverton Slough, west of Mt. Eden, and Point Richmond. Ambiguous records include localities at Belmont, Millbrae, Redwood City, Mayfield, Alameda, Mt. Eden (Union City), Berkeley, Point Richmond, and Burdell (Novato).

Nearly all potential habitat for *Lasthenia glabrata* ssp. *glabrata* at historical San Francisco Bay Estuary localities has either been filled in for urban development or displaced by dikes. The only population currently reported from tidal marsh edges in the San Francisco Bay Estuary is at Point Pinole, Richmond (P. Baye unpubl. data 1997-1999), where it occurs with *Castilleja ambigua* ssp. *ambigua* (salt marsh owl's-clover), *Spergularia macrotheca* (large-fruited or salt marsh spurrey), and *Sarcocornia pacifica* (pickleweed). It has also been reported from Suisun Marsh (Grewell 1993), and an ephemeral colony appeared on a dike at Sonoma Baylands (a tidal restoration project near the mouth of the Petaluma River) in 1998 (P. Baye unpubl. data 1998, Philip Williams and Associates pers. comm. 1999). In Point Reyes, a single small colony of *Lasthenia glabrata* ssp. *glabrata* occurs along the sandy backbarrier shoreline of Limantour spit in association with *Distichlis spicata* (saltgrass), *Armeria maritima* ssp. *californica* (sea-pinks), and *Atriplex californica* (California saltbush; P. Baye unpubl. data 1995-1999).

Lasthenia glabrata ssp. *coulteri*, a similar subspecies with hairy achenes, occurs at a few southern California tidal marsh edges (Callaway and Sabraw 1994), and at one central coastal salt marsh locality (Sweet Springs Marsh, Morro Bay). This subspecies is globally rare, and has been in serious decline since the mid-1960s. Its current distribution is unclear, but it is presumed to be extirpated at many historical localities (California Native Plant Society 2008). It occurs in locally high density at two adjacent Morro Bay locations in high salt marsh. At the northern colony, several hundred relatively large branched plants occur in a low well-drained sandy vegetated spit dominated by *Distichlis spicata*, *Sarcocornia pacifica*, *Frankenia salina* (alkali-heath), and occasionally *Atriplex californica* and *Atriplex watsonii* (saltbush). A smaller sub-colony of few-rayed, short, unbranched plants occurs amid *Triglochin concinna* (creeping sea-arrowgrass), *Jaumea carnosa* (fleshy jaumea), and *Chloropyron maritimus* ssp. *maritimus* (salt marsh bird's-beak). The nearby southern colony also consists of smaller, relatively unbranched plants in a *Triglochin concinna* association at slightly lower intertidal elevations. These colonies are apparently localized and stable.

Other *Lasthenia* species appear to have had more localized distribution in California tidal marshes, based on the relative number of historical reports and collections. The type locality of *Lasthenia platycarpha*; = *Layia carnosa* E. Greene (alkali goldfields) was “salt marshes at Vallejo” (probably Mare Island; Greene 1894), with one other salt marsh occurrence known from Redwood City (D. Keck [1932], DS695549). It is otherwise reported only from vernal pools and similar inland environments. Behr (1888) reported *Lasthenia glaberrima* from salt marshes. This species is known today only from vernal pools or similar habitats; no other tidal marsh records are known.

There are no modern examples known of *Lasthenia minor* growing along tidal marsh edges, but Brandegee (1892) reported “*Baeria uliginosa*” (now placed in synonymy with *Lasthenia minor*; Munz 1959, Ornduff 1993) from three salt marshes localities in San Francisco. This species otherwise is found in the region primarily in vegetation gaps on coastal bluffs or dunes exposed to salt spray.

In salt marsh habitats today, *Lasthenia* tend to occur either at the sparsely vegetated ecotones between high salt marsh and salt pans, or in well-drained high marsh with relatively low vegetation. The stunted growth of *Lasthenia glabrata* ssp. *coulteri* plants growing in *Triglochin concinna* associations (upper middle marsh zone) at Morro Bay suggest that they require ample drainage during growth (P. Baye pers. observ. 1997-1999). This may explain why they are today associated with substrates at gently sloping sandy or silty salt marsh edges at relatively high tidal elevations, and why *Lasthenia* are scarce along modern salt marsh edges, where dikes and flood protection prevail.

Flowering of salt marsh *Lasthenia* typically occurs from March or April to June. Reproductive output varies with plant size and branching. Well-branched, vigorous individuals of *Lasthenia glabrata* from salt marsh populations may bear from one to over 100 seedheads, each typically containing 50 to 90 achenes. Achenes lack specialized dispersal structures for floating, blowing, or attaching to animals. *Lasthenia glabrata* grows readily in cultivation and is easily propagated (P. Baye pers. observ.)

Tidal marsh edges that support *Lasthenia* species along the central California coast are rare today and warrant high conservation priority. Because of their apparent affinity for sparse or low vegetation, *Lasthenia* are threatened by invasion of tall, dense non-native plants in the high marsh zone, such as *Lepidium latifolium* (perennial pepperweed) or *Salsola soda* (Mediterranean saltwort).

Tidal marsh restoration projects in the vicinity of historical populations should include reintroduction of appropriate species of concern. Source populations of adequate size (minimum 50 parent seed sources) should be derived from the nearest salt marsh populations. Seed numbers for reintroductions should be amplified by propagating 1 to 2 generations in cultivation, avoiding artificial selection of genotypes. Seeding should occur in vegetation patches that are similar to reference sites of natural populations.

Long-term monitoring of reintroduced populations and reference (source) populations, and publication of results, is recommended. If long-term monitoring of reintroduced populations is not feasible because of limited resources, herbarium voucher specimens, at least, should be prepared and submitted to document the origin of reintroduced colonies.

Smooth tidy-tips, smooth layia, *Layia chrysanthemoides* (DC.) A. Gray (halophytic ecotypes)

Layia chrysanthemoides is a widespread annual member of the Asteraceae (aster) family. It occurs in many grassland habitats with heavy, clayey soils that are seasonally wet, including vernal pools, swales, valley grasslands, and ecotones between alluvial grasslands and tidal marshes. Howell (1949) described it as locally common on flats bordering the salt marshes of eastern Marin County, citing localities at Ignacio and Novato. It was also collected in similar peripheral salt marsh habitats in the region in Redwood City (San Mateo County), Sears Point (Sonoma County), west of Sonoma Creek, and at Newark (Alameda County).

Layia chrysanthemoides has not been recorded as a component of high tidal marsh/grassland ecotones in the San Francisco Bay Estuary in recent years, and is presumably another lost element of the once-diverse flora of high salt marsh edges of the San Francisco Bay Estuary. Seasonally timed surveys for this species should be conducted in the diked baylands in the vicinity of historical localities where remnant populations might occur. If found, they should be salvaged if under threat, or seed should be sampled for either propagation or direct reintroduction to suitable restored habitat within or near its known historical range in the estuary. Surveys should also be extended to suitable habitats, such as alluvial flats along salt marsh edges, brackish marsh edges, and diked seasonal wetlands along the Petaluma Marsh, Napa-Sonoma Marshes, and Suisun Marsh area.

Annual cresses of tidal marsh edges and alkali/saline soils

Littlefruit peppergrass, *Lepidium oxycarpum* Torrey & A. Gray
Dwarf peppergrass, *Lepidium latipes* Hook.
Alkali peppergrass, *Lepidium dictyotum* A. Gray)
Prostrate hutchinsia, *Hutchinsia procumbens* (L.) Desv.; syn. *Lepidium procumbens* L., *Capsella procumbens* Fries., *Capsella divaricata* Walp., *Bursa divaricata* (O. Ktze) Nutt., *Capsella elliptica* C.A. Mey., *Hutchinsia californica, H. desertorum* A. Davids)

Several native annual (or ephemeral) herbs in the Brassicaceae (mustard) family typical of alkali grassland or vernal pool habitats formerly occurred in tidal marsh edges of the San Francisco Bay Estuary. Some occasionally occur there locally today. These are all low decumbent to erect herbs less than 25 centimeters (6.35 inches) tall (usually much less in saline open habitats) with linear toothed or lobed leaves and roundish flat dry fruits (Rollins 1993). Three native *Lepidium* species were the typical peppergrasses (peppercresses) of San Francisco Bay tidal marshes before the noxious, non-native *Lepidium latifolium* became a dominant species of brackish marshes there.

Lepidium oxycarpum (littlefruit peppergrass) is a regionally uncommon herb that formerly occurred along salt marsh edges near Vallejo (Solano County); Alameda (Alameda County); Novato (Marin County); Redwood City (San Mateo County); Cooley's Landing, Palo Alto, and Mayfield (Santa Clara County); Mt. Eden Station, Alviso, and possibly other localities (Oakland; Greene 1894, Jepson 1911, Howell 1949, Munz 1959, Thomas 1961). *Lepidium latipes* (dwarf peppergrass), another alkali grassland species, was less widespread in saline soils and alkali flats along San Francisco Bay near Martinez (Contra Costa County) and Alameda (Greene 1894). *Lepidium dictyotum* (alkali peppergrass) less widely distributed along San Francisco Bay marsh borders, is represented by a single collection from Alameda (Greene 1894). *Hutchinsia procumbens* (prostrate hutchinsia) is part of the annual high marsh flora of southern California tidal marshes (Callaway and Sabraw 1994, Callaway *et al.* 1990), and was formerly reported from salt marsh edges in San Francisco Bay (Greene 1894, Jepson 1911, Thomas 1961), but is not represented by herbarium collections from this habitat.

Native *Lepidium* species and *Hutchinsia procumbens* may be somewhat underreported from the San Francisco Bay Estuary today because they are ephemeral and inconspicuous herbs. But it is more likely they are indeed extirpated because their historical estuarine-margin habitats (saline to alkaline flats along tidal marshes) have mostly been replaced by steep dikes lacking ecotones. Potential habitat may persist near Point Pinole and Suisun Marsh, but these areas containing surviving high marsh ecotones are not closely associated with the historical centers of abundance of the species in the estuary. They may also occur cryptically in grazed or cropped subsaline diked baylands. The Warm Springs area of Fremont, where alkali/subsaline vernal pool grasslands occur, is a potential refugium for this component of the historical bay flora and should be searched. The conservation of native peppergrasses in the estuary would depend on the restoration of flat depressional topography in high marsh/alluvial ecotones. If this is done, these species should be reintroduced to such subhabitats. In the interim, they should be the object of focused surveys in diked baylands, and adjacent flatlands and seasonal wetlands, with subsaline soils near the estuary. If found, populations should be conserved in suitable habitat or, as a last resort, salvaged through seed bank collection and storage.

Salt marsh edge grasses

Creeping wildrye, *Leymus triticoides* (Buckley) Pilger, *Leymus* x*multiflorus* (Gould) Barkworth & Dewey [halophytic ecotypes]
Pacific alkali goosegrass, *Puccinellia nutkanensis* (J.S. Presl) Fern. and Weath.(syn. *Puccinellia grandis* Swallen)
Marsh bentgrass, *Agrostis exarata* Trin.
California semaphore-grass, *Pleuropogon californicus* (Nees) Vasey

Numerous native species of the Poaceae (grass) family were formerly common in, and particularly along, the edges of tidal marshes of the central California coast. Grasses in tidal marshes, other than the familiar dominant *Distichlis spicata* (saltgrass), have generally declined significantly in frequency and abundance within the San Francisco Bay Estuary. They do persist as vestiges along relatively undisturbed tidal marsh shorelines, or occasionally in residual secondary populations.

In lowland grasslands near the edges of tidal marshes, such as alluvial fans and stream deltas, *Leymus triticoides* (Buckley) Pilger (creeping wildrye), and its natural hybrid *Leymus* x*multiflorus* (Gould) Barkworth & Dewey), probably dominated extensive brackish edges of salt marshes in the San Francisco Bay Estuary. *Leymus triticoides* forms colonial rhizomatous stands and cohesive mats. It has light green to glaucous gray-green foliage that persists in summer long after non-native annual grasses have died. Its hybrid, *Leymus* x*multiflorus*, is similar but generally more robust (wider leaf blades, taller culms, longer and thicker spikes). Though described as clump-forming (Barkworth 1993), spreading colonial forms of the variable *Leymus* x*multiflorus* appear to be locally prevalent in tidal marsh edges of northern San Pablo Bay (P. Baye pers. observ.). A related hybrid, *Leymus* x*vancouveriensis*, is still a local dominant of sandy maritime salt marsh edges and sheltered beaches and low dunes in Marin and Sonoma counties. In some parts of the San Francisco Bay area, hybrid wildryes are more common than their parent species. Both *Leymus triticoides* and *Leymus* x*multiflorus* are widespread taxa that occur in a wide range of grassland habitats, including saline and alkaline soils. They occur within infrequently flooded portions of wetlands of both diked (nontidal) baylands and tidal marsh edges, extending rhizomatously into saline soils and vegetation variously dominated by *Sarcocornia pacifica* (pickleweed) or *Distichlis spicata*. The density of creeping *Leymus triticoides* stands along tidal marshes varies from open and sparse to dense tall swards with 100 percent cover (P. Baye pers. observ.). The dense perennial grass cover provided by *Leymus triticoides* provides substantial cover for rodents, but specific habitat benefits for estuarine rodents, such as salt marsh harvest mice, have not been studied.

Substantial stands of *Leymus triticoides* along tidal marsh edges are now infrequent to rare in the San Francisco Bay Estuary. They are restricted to widely scattered colonies in relatively undisturbed natural salt marsh edges (*e.g.,* Rush Ranch, Solano County; China Camp, Marin County; upper Newark Slough, Alameda County; Whittell Marsh, Contra Costa County), or undisturbed vegetation of dikes and diked baylands adjacent to tidal marsh (*e.g.,* Cullinan Ranch, Solano County; P. Baye unpubl. data). Small populations occur in the Petaluma Marsh area, the Hayward shoreline (particularly Roberts Landing), and Suisun Marsh. Despite the natural niche of *Leymus triticoides* in the high tidal marsh ecotone, and its utility in dike stabilization and wildlife cover, it is seldom included as a significant component of tidal marsh revegetation plans, which tend to emphasize shrubs and subshrubs (*Grindelia stricta* [gumplant], *Baccharus* [coyote-brush], and even a regionally non-native saltbush, *Atriplex lentiformis*). Populations from brackish tidal marsh edges and diked baylands should be conserved through (1) focused surveys of grasses in tidal marshes and potential restoration sites, (2) protection and management of tidal marsh edge populations, and (3) appropriate inclusion in plans for tidal marsh restoration and dike revegetation.

Puccinellia nutkaensis (J.S. Presl) Fern. and Weath (Alaska alkali goosegrass) is a tufted perennial grass, similar to *Poa* (bluegrasses), which occurs in tidal marshes from San Francisco Bay to Alaska (Davis 1993). It is relatively more common in maritime tidal marshes of Marin, Sonoma, and Humboldt counties than in San Francisco Bay (P. Baye unpubl. data), but its historical frequency along the central Calfornia coast is unclear because of a lack of collections. Robust forms from maritime marshes of Marin County have been treated as a distinct species, *Puccinellia grandis* Swallen, but this taxon is not currently recognized (Davis 1993). Thomas (1961) reported it from levees and salt marshes along San Francisco Bay, and very small colonies have been identified from tidal marsh at Roberts Landing (San Leandro), upper Newark Slough, and Ravenswood salt marshes. It is locally common on tidal marsh plains and high salt marsh in Drakes Estero, Tomales Bay, and northward (P. Baye unpubl. data 1998-2000). The species is inconspicuous most of the year, and is readily overlooked when not in flower or seed. Its conservation is a concern only at the southern limit of its range in San Francisco Bay. Point Reyes populations do not currently appear to be threatened, possibly because the salt marsh *Puccinellia* species are stimulated by grazing and varied tidal marsh microtopography (Gray 1992). *Puccinellia nutkanesis* in San Francisco Bay should be conserved by (1) focused surveys in tidal marshes in appropriate seasons for recognition and identification (late spring/early summer), (2) protection and management of remnant populations, and (3) inclusion in plans for tidal marsh restoration in the vicinity of known populations of San Francisco Bay.

Agrostis exarata Trin. (syn *Agrostis asperifolia* Trin.; Pacific bentgrass) is a variable and widespread cespitose (clump-forming, non-rhizomatous) grass of moist or wetland soils. It was described by Jepson (1911) as “common in...salt marshes and other wet places...Berkeley...San Francisco...Martinez,” but has not been recently reported from tidal marshes of the San Francisco Bay Estuary. A non-native bentgrass, *Agrostis stolonifera* L., is markedly more common and abundant in brackish tidal marshes and coastal stream mouths today (P. Baye pers. observ.). Because of the floristic significance of *Agrostis exarata* in tidal marshes, it should be included in focused floristic surveys of San Francisco Bay tidal marshes, and occurrences should be reported and protected. It may be expected in brackish or seasonally ponded subsaline borders of tidal marshes, near stream mouths, and in brackish non-tidal (or damped tidal) marshes.

Pleuropogon californicus (Nees) Vasey (California semaphore-grass) is a widespread amphibious native California grass typically found in seasonally ponded wetlands, including vernal pools, swales, and marshes (Barkworth 1993). It grows as a floating-leaved form in flooded conditions, and becomes decumbent to erect in terrestrial conditions. It occurs in transitional alkaline-subsaline vernal pools and salt marsh pans near historical estuarine margins in the vicinity of Warm Springs, Fremont, and formerly occurred in diked baylands near sea level adjacent to salt ponds near Mt. Eden and diked baylands near Novato, Marin County. It was probably a widespread component of grassy vernal marshes on alluvial terraces ecotonal to tidal marshes in the San Francisco Bay Estuary. Its conservation as part of the tidal marsh ecotone flora would depend on protection and restoration of relatively flat topography with depressional microrelief and clay soils just above sea level along tidal marsh edges. There are few areas left where this may be feasible: the Warm Springs (Fremont) area, Alviso, portions of the eastern Petaluma Marsh (Sonoma County), the Schellville/Huichica area (Sonoma and Napa counties), and remaining undeveloped lowlands near Cordelia, Suisun, and Potrero Hills (Suisun Marsh).

Mason's lilaeopsis, *Lilaeopsis masonii* Mathias & Constance

Lilaeopsis masonii (Mason's lilaeopsis or grasswort) is a prostrate, creeping, grasslike perennial herb in the Apiaceae (carrot) family that grows in turf-like colonies. Most of the plant consists of a widely spreading network of filament-like rhizomes with tufts of narrowly cylindrical, hollow leaves up to 7.5 centimeters (3 inches) long. The above-ground stems are scarcely developed except in the inflorescence, which consists of a tiny flower stalk 2 to 20 millimeters (0.08 to 0.8 inch) long with umbels of extremely small whitish five-petalled flowers. It closely resembles, and is closely related to, the more widespread coastal species *Lilaeopsis occidentalis* Coult. & Rose (= *Lilaeopsis lineata* var. *occidentalis* Jepson; western grasswort). The field identification traits that separate the two taxa are the presence of well-defined cross-walls, or septa, in the leaves of *Lilaeopsis occidentalis*, in contrast with obscure cross-walls in *Lilaeopsis masonii*, and the production of some flattened leaves in the former (Constance 1993). eEtensive field sampling and laboratory research failed to demonstrate clear morphological or genetic discontinuities between the two taxa (Fiedler and Zebell 1993, Zebell and Fiedler 1996). Further field surveys, sampling of variation among populations, and genetic studies are needed to verify whether the two taxa are indeed distinct.

Lilaeopsis masonii ranges from the extreme east end of San Pablo Bay (lower Napa River) east through the freshwater tidal marshes of the Sacramento/San Joaquin delta (Fiedler and Zebell 1993). The brackish tidal marshes of the Suisun Marsh area consitute the core of its geographic distribution. A disjunct population has been recorded on the Point Reyes shoreline along Tomales Bay, near Inverness.

The habitat of *Lilaeopsis masonii* is typically confined to short turfs along the eroding marsh surfaces above peaty channel banks in brackish tidal marshes, where vegetative cover of larger marsh plants is either very sparse or lacking. It can also occur on sheltered shallow mud deposits over rocks or other intertidal structures that are too small to support larger vascular plants (P. Baye pers. observ. 1999). Zebell and Fiedler (1996) found that the species is intolerant of competition in experimental greenhouse conditions. Survival of *Lilaeopsis masonii* in a given area depends on the ability of plants to spread faster than erosion destroys them. The relative contribution of seedling versus rhizome regeneration to colonization of new sites is unknown.

Salinity is probably a significant factor restricting *Lilaeopsis masonii* to brackish to freshwater tidal marshes. Growth of *Lilaeopsis masonii* is limited by the salinity ranges ordinarily found in salt marshes. Zebell and Fiedler (1996) found that virtually no growth occurs at 24 parts per thousand salinity. Salinity also inhibits and delays seed germination, but seeds can germinate at salinity as high as 12 parts per thousand.

Intensive survey efforts suggest that *Lilaeopsis masonii* colonies are too widespread (Fiedler and Zebell 1993) for the species to be in imminent threat of range collapse or subregional extinction. Long-term viability remains a concern, however, because its habitat is unstable, and populations may be vulnerable to climate changes that increase erosion rates to the point at which extinction of local populations outpaces the species' ability to establish new colonies. Tidal marsh restoration is unlikely to provide significant additional habitat for this species in the foreseeable future, since its principal habitat is derived from erosion of previously matured tidal marsh peats that take many decades to form. In the long term, tidal marsh restoration that allows unrestricted formation of tidal creeks would benefit this species. The natural instability of its colonies on erosional bank habitat also precludes ordinary plant conservation protocols that are based on stabilizing existing populations or habitat, and establishing buffers and monitoring programs. Avoidance of dike maintenance practices that over-stabilize banks, or armor their surfaces, is likely to benefit the species.

Annual coast plantain, *Plantago elongata* Pursh (syn. *Plantago bigelovii* A. Gray ssp. *californica* [E. Greene] I.J. Bassett)

Plantago elongata (coast plantain) is an inconspicuous, small, low rosette-forming annual herb in the Plantaginaceae (plantain) family. It is found in many saline coastal wetlands and interior alkaline to saline flats along the Pacific North American coast and western states, particularly salt marshes, coastal lagoons, sheltered beaches, and vernal pools. Its short linear leaves may be prostrate or erect, and the erect scapes of coastal populations typically range from less than 2 centimeters (nearly 1 inch) long to (rarely) more than 5 centimeters (about 2 inches). It occurs in similar open, flat, pan-like high saline marsh shorelines with other annuals such as *Juncus bufonius* (toad rush) and *Limosella* spp. (mudworts). It is now seldom reported from historical localities in the San Francisco Bay Estuary, such as Mt. Eden (Baumberg) salt pond marginal habitats, Alvarado (Union City); Cuttings Wharf, Napa River; and coastal seasonal wetlands near Suisun Marsh. Today, *Plantago elongata* is more frequent along the margins of brackish lagoons and stream mouths along the central and northern California coast than it is in the San Francisco Bay Estuary (Rodeo Lagoon, Abbotts Lagoon, Sonoma-Mendocino coast stream mouths; Howell 1949, P. Baye unpubl. data). Its apparent scarcity in the San Francisco Bay Estuary may be due in part to its inconspicuousness, but most of its historical localities have lost suitable habitat, probably resulting in widespread regional extirpation. Habitat loss is specifically due to the conversion of high tidal marsh ecotones between salt marsh, brackish marsh pans, and alluvial flats and lowland grasslands. It may also be due to expansion of abundant non-native annual vegetation, such as *Polypogon monspelienesis* (rabbit's-foot grass), *Cotula coronopifolia* (brass-buttons), and *Salsola soda* (Mediterranean saltwort), in seasonal wetlands. Its conservation in the San Francisco Bay Estuary should occur through a combination of (1) detection and reporting of remnant populations, (2) protecting dynamic habitat at known locations, and most importantly, (3) restoring suitable seasonally inundated subsaline wetlands on flats and alluvial plains adjacent to tidal marsh.

Popcornflowers of tidal marsh edges

Petaluma popcornflower, *Plagiobothrys mollis* (A. Gray) I.M. Johnston ssp. *vestitus* E. (Greene) I. M. Johnston

Smooth popcornflower, *Plagiobothrys glaber* (A. Gray) I. M. Johnston

In California, *Plagiobothrys* species (popcornflowers) in the section *Allocarya* are mostly prostrate to low erect annual (few perennial) herbs in the Boraginaceae (borage) family associated with seasonal wetlands or ponds, particularly vernal pools, with sparse or low open vegetation.

Plagiobothrys glaber (smooth popcornflower), an annual species, was historically associated with the margins of San Francisco Bay salt marshes and alkali vernal pools (Abrams 1951, Munz 1959), but is probably extinct near San Francisco Bay (Skinner and Pavlik 1994), and has been presumed extinct globally (Messick 1993). All of the most recent collections are from interior alkaline seasonal wetlands in the vicinity of Hollister, Santa Clara County (Skinner and Pavlik 1994). It was otherwise known from the Mt. Eden area of Alameda County in the late 19th century. *Plagiobothrys glaber* is distinguished by the fleshy base of the slightly bent calyx; thick, hollow pedicels; and the relatively short scar (attachment point) of the seed-like nutlet (Messick 1993). It is similar to the widespread species *Plagiobothrys stipitatus* in calyx and pedicel characters. *Plagiobothrys stipitatus* does rarely occur in tidal marsh edges and diked baylands of San Pablo Bay, such as Sears Point (Best *et al.* 1996) and near Port Sonoma (P. Baye pers. observ. 1996). Because of the rarity and few historical records of *Plagiobothrys glaber*, most of what is known of its ecology in the margins of the San Francisco Bay Estuary can be derived from comparisons with similar species.

Plagiobothrys mollis is a perennial popcornflower with two varieties. The more widespread, but uncommon, typical variety *mollis* occurs in seasonally wet alkaline basins or flats within arid sagebrush scrub (Abrams 1951, Messick 1993). Very little is known of the local endemic, and presumably extinct, *Plagiobothrus mollis* var. *vestitus*

(Petaluma popcornflower), which was collected once from near Petaluma, Sonoma County (Abrams 1951). The Petaluma Valley includes alluvial flats of the Petaluma River floodplain that grade down to tidal marsh. The valley was subject to intensive agricultural use for the past century, and has recently undergone extensive urbanization. Although the prospects for discovery of remnant populations is extremely low, it is possible that earthmoving in the rapidly developing area might exhume buried viable seed.

Seaside plantain, *Plantago maritima* L. (syn. *Plantago juncoides* Lam., *Plantago maritima* L. var. *juncoides* (Lam.) A. Gray)

Salt marsh populations of *Plantago maritima* (seaside plantain) in California are typically composed of plants with taprooted, clump-forming rosettes of succulent, linear, ascending leaves, and erect scapes and spikes that may reach up to 30 centimeters (1 foot) tall. They are usually found on well-drained sandy salt marsh plains with low or sparse vegetation, along high marsh edges in vegetation gaps, or on partially eroded coarse substrates. The species as a whole is widespread in northern coastal habitats of Eurasia and North America, and bluff/cliff ecotypes are widespread and locally abundant on seeps in California. In central California, it is relatively abundant in maritime coastal marshes with sandy substrates (P. Baye pers. observ.), but it was reported as uncommon to occasional in tidal salt or brackish marshes of San Francisco Bay in the 20th century (Jepson 1911, Howell 1949, Thomas 1961). Its affinity for sandy salt marshes (Greene 1894) may explain its scarcity in San Francisco Bay, where historical localities of sandy salt marshes supporting this species (Baye *et al.* 2000, Howell *et al.* 1958) have mostly been eliminated. Significant locally abundant populations in San Francisco Bay occur along shorelines of Richardson Bay (Sausalito, Marin City, Mill Valley) and recently restored or re-formed sandy salt marshes of San Francisco (P. Baye unpubl. data). *Plantago maritima* should be conserved in the San Francisco Bay Estuary by restoring local sandy salt marshes at appropriate locations (near natural sand sources), and reintroducing it if necessary using local remnant populations as sources.

Clustered goldenweed, *Pyrrocoma racemosa* (Nutt.) Torrey & A. Gray var. *racemosa* (syn. *Haplopappus racemosa* (Nutt.) Torr.; *Haplopappus racemosa* ssp. *longifolius* (Greene) H.M. Hall; *Pyrrocoma elata* E. Greene, *Pyrrocoma longifolia* E. Greene)

Pyrrocoma racemosa var. *racemosa* (clustered goldenweed) is a perennial herb in the Asteraceae (aster) family with a woody taproot. It may reach up to 0.9 meter (nearly 3 feet) in height, with narrowly elliptic to ob*lanceolate*, entire to serrate, clasping leaves, and clusters of yellow flowerheads resembling those of goldenrods. It is distinguished morphologically from other varieties of *Pyrrocoma racemosa* by the ciliate (finely hairy) phyllaries and hairless stems and leaves. It ranges from Oregon to San Benito County, California, and principal habitats include coastal valleys and saline soils (Brown 1993). Thomas (1961) reported it from San Francisco Bay at “edges of salt marshes, saline soils, and occasionaly disturbed areas...Cooley’s Landing, Near Alviso, Agnews, and San

Jose." It was also collected at bayside localities at Jarvis Landing, Alameda County, and Mt. Eden, Hayward. It was apparently an uncommon element of the high salt (or brackish brackish) tidal marsh ecotone flora of San Francisco Bay, and may have been an element of the ecotonal willow-composite community described by Cooper (1926). There are no current localities known for this taxon in this habitat and region, and it may be extirpated.

Pyrrocoma racemosa var. *racemosa* should be included as a focused search component of plant surveys in tidal marsh and diked baylands in San Francisco Bay, including peripheral environments. If it is found, remnant populations should be reported to resource agencies and landowners, and protected, monitored, and propagated for reintroduction to suitable restored high marsh ecotone habitat in San Francisco Bay.

Marsh fleabane, *Pluchea odorata* (L.) Cass. (invalid synonyms *Pluchea purpurascens* (Sw.) DC, *Pluchea camphorata* (L.) DC, missapplied to *P. odorata*)

Pluchea odorata (marsh fleabane) is a coarse, glandular annual to perennial herb in the Asteraceae (aster) family, with resinous foliage and stems and a rank scent. Leaves are egg-shaped and toothed, and shoots terminate in a head-like cluster of purple flowerheads. It is a wide-ranging species, found in alkaline or saline bottomlands in the United States, Caribbean, and northern South America (Abrams and Ferris 1960). *Pluchea odorata* is uncommon on the west U.S. coast, and in the San Francisco Bay region, it is known primarily from the Suisun Marsh area to the west delta (Behr 1888, Greene 1894, Jepson 1911). It is not cited in estuarine locations in the floras covering Marin County (Howell 1949, 1970), Sonoma County (Best *et al.* 1996), or the south San Francisco Bay (Thomas 1961). Coastal localities of herbarium collections (JEPS, UC) are all in the Suisun Marsh area, west to Benicia. Its historical occurrence outside of the eastern part of the estuary may be doubtful.

Pluchea purpurascens is uncommon in the remnant tidal marshes of Suisun Marsh, and there is little information about its distribution and abundance. The species is widely distributed outside of this region in other habitats, so its conservation significance here lies in retaining it in the ranks of aster family forbs that have declined in tidal marsh edges and in avoiding extirpation. In plant surveys around the estuary, if populations are found their location, size, and number should be recorded, reported to resource agencies, and monitored. At least several populations or representative stands should be given priority for protection, and its reintroduction should be included in tidal marsh restoration proposals in the Suisun Marsh area.

Ruppia maritima L., Ruppia, Widgeon-grass

Ruppia maritima (ruppia, widgeon-grass) is a cosmopolitan grasslike, rhizomatous, aquatic herb in the Potamogetonaceae (pondweed) family, although it is sometimes treated taxonomically as a unique family (Ruppiaceae). *Ruppia maritima* forms abundant submerged or floating mat-like colonies in brackish lagoons, ponds, ditches, impounded channels, and depressional salt pans with long periods of flooding in tidal marshes. It seldom occurs, or occurs sparsely, where tidal flows or exposure to estuarine wave energy is substantial, such as habitats typical of *Zostera marina* (eelgrass). *Ruppia* can resemble pondweeds such as *Potamogeton pectinatus*, especially when flowering or fruiting parts are not evident. Like pondweeds, eelgrass, and seagrasses, the submerged aquatic canopies of *Ruppia* provide complex and productive aquatic habitats for filamentous algae, invertebrates, fish, waterfowl, wading birds, and shorebirds (Kantrud 1991). Though the plant is perennial, it may appear to be annual following dieback in seasonally dry pond bottoms or salt pans; its dormant phase enables it to survive periods of hypersalinity. Although one of the least familiar and most inconspicuous of the common plants in tidal marshes of the San Francisco Bay Estuary (often mistaken for filamentous algal mats because of the epiphytic algae that often coat the plant), *Ruppia maritima* ranks among the dominant vascular plant species in tidal marshes if salt pan sub-habitats are considered. It has been underestimated as a component of wetland marsh vegetation in Suisun Marsh (George *et al.* 1965).

The conservation significance of *Ruppia maritima* in the San Francisco Bay Estuary is based on its abundance and ecological function as an essential, unique, and fundamental keystone species. *Ruppia maritima* is the dominant vascular plant of depressional pans or marsh ponds today. Historically formed prograded tidal marshes (post-diking), which comprise the majority of tidal marsh area today, have minimal development of salt marsh pans and consequently are deficient in *Ruppia*. Fortunately, *Ruppia* is a rapid and efficient colonizer of new habitat; within 3 years of restoration of limited tidal circulation to diked baylands at Sonoma Baylands (lower Petaluma River) and the Figueris Tract (northwestern Mare Island), *Ruppia* colonized many dozens of acres of the new shallow submerged habitats (P. Baye unpubl. data 1996-1998). Conservation of *Ruppia* as a resource for the tidal marsh ecosystem will require (1) long-term development of new tidal marsh with ample potential to develop salt pans, and (2) short-term development of shallow brackish or saline lagoons (either microtidal, intermittently tidal, or non-tidal) to provide surrogate habitat for *Ruppia*. Permanent shallow tidally circulating ponds (lagoons) were recommended as a preferred hydrological regime for waterfowl management in Suisun Marsh by George *et al.* (1965), and these would favor expansive development of *Ruppia* beds. *Ruppia* is excluded by the seasonal flood/drain waterfowl management regimes prevalent in Suisun Marsh today.

***Sanicula maritima* S. Watson, marsh or adobe sanicle**

Sanicula maritima (marsh, or adobe, sanicle) is a very rare perennial herb in the Apiaceae (carrot) family. It grows from a thick taproot, and bears stout stems with heart-shaped to egg-shaped basal leaves with long petioles; stem-leaves are deeply 3-lobed or parted. The flowers are yellow, borne in rounded, dense, head-like inflorescences on branched stalks, with leaf-like bracts attached below the stalks of the inflorescence (Constance 1951, 1993). In San Francisco Bay *Sanicula maritima* was formerly known from the borders of salt marshes near Alameda, where it was collected in the late 19th century, as well as from non-tidal grassland habitats in Potrero Hills, San Francisco (Jepson 1911, Howell *et al.* 1958 *E. Greene* [JEPS 980, Apr. 10, 1891]). The English name “adobe” or “dobie” sanicle refers to its habitat preference for heavy clay soils in seasonally wet coastal grasslands or forblands, which are typical of the few surviving modern populations in non-tidal coastal habitats in San Luis Obispo County. Two occurrences are known from non-tidal coastal habitat in Monterey County (California Natural Diversity Database 1997). It is listed as rare by the State of California (California Department of Fish and Game 2005).

Sanicula maritima was probably a peripheral rare element of the tidal marsh-alluvial ecotone of south San Francisco Bay, along with many other species indicative of alkali-subsaline vernal marshes or seasonal wetlands. It was apparently extirpated early in the history of the bay as a result of successive land-use conversion from pasture, cropland, to urban land. The plant community in which it occurred is probably irretrievably lost from the vicinity of its historical locality near Alameda, but subsaline/alkaline vernal pool and swale grasslands with clay soils persist in the Warm Springs area in south Fremont, partly in the San Francisco Bay National Wildlife Refuge and partly in protected mitigation areas. Little is known about the specific soil requirements or the historical plant associates of *Sanicula maritima*, but the feasibility of reintroducing the species to rehabilitated or restored habitat in this area should be investigated as a species conservation task to restore lost floristic diversity to tidal marsh ecotones. This action could be integrated with recovery measures to restore limited or full tidal action to portions of the Warm Spring alluvial lowland grassland complex.

***Sarcocornia subterminalis* Parish (syn. *Arthrocnemum subterminale* Standley), Parish’s glasswort**

Sarcocornia subterminalis (Parish’s glasswort) is related to the familiar perennial *Sarcocornia pacifica* (pickleweed), which it resembles. The technical characters that distinguish it from *Sarcocornia pacifica* are the lack of flowers at the tips of flowering shoots (Wilken 1993), hairless seed coats, and an L-shaped seed embryo (Mason 1957), but field recognition in the vegetative condition is more easily based on the highly pyramidal (decurrent branching) angular growth form (P. Baye pers. observ.), which contrasts with the loose ascending habit of *Sarcocornia pacifica*. Although it has been described as a coastal salt marsh plant (Abrams 1944), most collections from California are from interior localities in saline or alkaline wetland habitats. It is more typical of southern California coastal salt marshes (Hoover 1970, Beauchamp 1986, Callaway and Sabraw 1994, Smith 1998) and seasonally flooded alkali basins (Mason 1957), but occurs at least locally in southern San Francisco Bay, in the edges of alkali/subsaline vernal pools near Warm Springs, Fremont, Alameda County (P. Baye pers. observ.). These may be related to populations from the Livermore Valley alkali basins. It is likely that other populations would be underreported in the estuary because of the difficulty in distinguishing this species from *Sarcocornia pacifica*. Other populations may potentially occur in the few remaining undeveloped diked baylands in south San Francisco Bay and along alluvial valleys adjacent to Suisun Marsh. It is not known or expected north of the San Francisco Bay Estuary along the coast.

Retaining *Sarcocornia subterminalis* in the tidal marsh flora of central California will require protection of the Warm Springs area population. Additional focused surveys for *Sarcocornia subterminale* are needed. Other populations, if found, should be reported to resource agencies, monitored, and protected.

Senecio hydrophilus **Nutt., salt marsh butterweed**

Senecio hydrophilus (salt marsh butterweed) is a short-lived perennial herb in the Asteraceae (aster) family that grows hollow erect shoots (about 0.5 to 1.5 meters [about 2 to 5 feet] tall) from a fleshy caudex and taproot. Its leaves are thick to fleshy, green to glaucous (whitish) green, elliptic to ob*lanceolate*, and shallowly toothed. Flowerheads are yellow with petal-like ray florets that appear in summer. Flowerheads are crowded in terminal clusters on erect shoots. *Senecio hydrophilus* is a widespread species of marshes and swamps, often in alkaline or subsaline soils (Abrams 1944, Barkeley 1993), and it also occurs in brackish coastal marshes.

Senecio hydrophilus was apparently widespread and at least locally abundant in brackish marshes throughout the San Francisco Bay Estuary, and was particularly abundant in Suisun Marsh (Jepson 1911). Its decline during the late 19th century was evident to Greene (1894), who noted that it was “formerly plentiful at West Berkeley, and on the lower Napa River; still abundant in the Suisun marshes.” It is still locally common in remnant tidal marshes of the Suisun Marsh area (B. Grewell 1993, P. Baye pers. observ. 1992-2000). There are few collections from San Francisco Bay where its decline was probably related to diking and destruction of brackish marsh edges by flood control channelization.

Senecio hydrophilus has only one major refuge in the San Francisco Bay Estuary, in Suisun Marsh where it is still locally common. It may be threatened by the aggressive spread of *Lepidium latifolium* (perennial pepperweed), which forms monotypic stands in its marsh plain habitat. Conservation of *Senecio hydrophilus* will probably depend on control and eradication of *Lepidium latifolium*, as well as tidal marsh restoration. The effect of *Lepidium latifolium* on *Senecio* seedling recruitment, adult survivorship, and reproduction should be scientifically investigated. *Senecio hydrophilus* should be given priority for focused plant surveys in the Napa-Sonoma Marshes and in the brackish reaches of tidal sloughs in southern San Francisco Bay. If found, populations should be reported to resource agencies and land managers/landowners, and protected. The species should be reintroduced to restored brackish tidal marshes within its historical range, using local populations as sources.

Sium suave Walter (syn. *Cium cicutaefolium* Schrank, *Sium heterophyllum* E. Greene), hemlock water-parsnip

Sium suave (hemlock water-parsnip) is a tall (0.6 to 1.2 meters [about 2 to 7 feet]) perennial herb in the Apiaceae (carrot) family. It is morphologically and ecologically similar to *Cicuta maculata* var. *bolanderi* (Bolander's water-hemlock), from which it can be distinguished in the vegetative state by its simple lance-shaped leaflets (not twice-pinnate, as in *Cicuta*). *Sium suave* is a widespread plant found primarily in freshwater marshes of the northern hemisphere, but it is uncommon to rare in Suisun Marsh, and apparently absent elsewhere in the San Francisco Bay Estuary. It tends to occur along the banks of tidal creeks, like *Cicuta*, and may be underreported and underdetected because of difficult accessibility of this habitat, or confusion with tall forms of the common *Oenanthe sarmentosa* (water-parsley). More information is needed on the contemporary distribution and abundance of *Sium suave* in the San Francisco Bay Estuary, and it should be included in focused surveys for *Cicuta maculata* var. *bolanderi*. Specific conservation measures may be required to retain it in the Suisun Marsh flora.

Solidago confinis Nutt. (syn. *Solidago confinis* var. *luxurians* Jepson, *Solidago guiradonis* A. Gray var. *luxurians* (Hall) Hoover, *Solidago sempervirens* L. misapplied), southern goldenrod

Solidago confinis (southern goldenrod) is a showy summer/fall-flowering perennial herb in the Asteraceae (aster) family. It grows in clumps from a tough semi-woody base, and develops tall (0.7 meter [2.5 feet], up to 2.1 meters [nearly 7 feet]), unbranched densely leafy shoots topped by large club-shaped or pyramidal highly branched panicles of bright yellow flowerheads. The leaves are fleshy (especially in wet saline or alkaline soil), nearly sheath the stem, and range in size and shape from almost scale-like (below the inflorescence) to long (up to 25 centimeters [10 inches]) and ob*lanceolate* (lance-shaped, widest near the tip), and entire or nearly so (Munz 1959). The Morro Bay tidal marsh population commonly develops shoots that terminate in clusters of vegetative offsets instead of an inflorescence (P. Baye unpubl. data 1998).

Solidago confinis occurs in a wide range of wet soils (wet/mesic grassland, marshes, streambanks, springs). On the California coast it is common in brackish to subsaline dune slacks of the Santa Maria dune complex, San Luis Obispo County (P. Baye pers. observ. 1997), and it occurs in freshwater wetlands confluent with tidal marsh at Carpenteria Marsh, Santa Barbara (Ferren 1985). The only known tidal marsh population of the species occurs at the southern end of Morro Bay in brackish peaty tidal marsh edges dominated by *Juncus lesueurii* (rushes) and *Potentilla anserina* (silverweed). It is apparently excluded from Morro Bay salt marshes with marine salinity (P. Baye unpubl. data 1998-2000). *Solidago confinis* historically occurred in San Francisco Bay, known from a single collection by H. Bolander in 1863 from salt marshes "near San Francisco," and was originally identified as the ecologically and morphologically similar *Solidago sempervirens* (seaside goldenrod) of the eastern U.S. coast (Jepson 1911). Like *Suaeda californica* (California sea-blite), *Solidago confinis* appears to have been a relatively rare relict species of a salt marsh flora more abundantly represented today in Morro Bay. By the 20th century, this apparently relict southern component of San Francisco Bay salt marsh flora was extirpated.

Although *Solidago confinis* is very rare in tidal salt/brackish marshes, it is not uncommon in other wetland habitats in southern California, and for this reason has not been treated with conservationconcern. It is not currently known whether the Morro Bay population is a genetically differentiated locally adapted salt-tolerant ecotype of the species. The Morro Bay tidal marsh population should be monitored and protected, including groundwater and surface water outflows that maintain local brackish marsh edges in the marine-salinity estuary. Its salt tolerance should be studied in comparison with the Pismo/Oceano dune slack populations to the south. *Solidago confinis* is easily propagated and cultivated (P. Baye pers. observ.), and it may be feasible and appropriate to re-introduce the species locally in San Francisco Bay where brackish tidal marshplain ecotones are restored, using Morro Bay stock.

***Suaeda moquinii* (Torrey) E. Greene; *Suaeda orreyana* Wats.; *Suaeda fruticosa* (L.) Forsk. misapplied; *Dondia torreyana* Standl., alkali-blite or bush seepweed**

Suaeda moquinii (alkali-blite, bush seepweed) is a low (usually less than 0.4 meter [1.3 feet] in coastal populations) spreading shrub or subshrub in the Chenpodiaceae (goosefoot) family with glaucous (grayish cast) foliage and stems, short linear leaves attached directly by the base (sessile), and clusters of inconspicuous greenish flowers at the ends of shoots. The species occurs mostly in alkali sinks or saline flats in deserts or other arid interior California habitats, but was recorded in the southeast end of San Francisco Bay early in the 20th century (McMinn 1939), and it has persisted in non-tidal wetlands adjacent to San Francisco Bay in subsaline/alkaline vernal pools at Warm Springs, Fremont, and diked historical baylands at the former Fremont Airport (P. Baye pers. observ. 1995-1997; G. Holstein pers. comm. 1995). The southern Fremont population was once misidentified as *Suaeda californica* (*L.R. Heckard w/ L. Feeney, P. Faber, & J. Hickman 6253* [JEPS86406, May 13, 1986]). Munz (1959) reported it as occurring in "Coastal Salt Marsh," but this is not apparent from examination of herbarium collections from central California. The Warm Springs population is apparently a unique coastal population in central California. Prior to diking of this portion of San Francisco Bay, *Suaeda moquinii* was presumably found within the ecotone between high tidal salt marsh and alkaline/subsaline vernal pool grasslands. This unique population should be conserved and replaced in a restored tidal marsh/vernal pool grassland ecotone at this location. There appears to be little prospect or justification for its reintroduction to other parts of the San Francisco Bay Estuary, except parts of eastern Suisun Marsh, the other location of potential tidal marsh/alkali vernal pool ecotones.

Trifolium depauperatum Desv. var. *hydrophilum* (E. Greene) Isely, salt marsh bladder clover

Trifolium depauperatum var. *hydrophilum* (salt marsh bladder clover) is a little-known and inconspicuous annual native clover in the Fabaceaea (pea) family. It is varietally distinct from the widespread bladder clover, *Trifolium depauperatum* var. *depauperatum*. One salt marsh population is known from the vicinity of Sears Point, Sonoma County (Best *et al.* 1996). The taxon is extremely rare globally, and was considered to be possibly extinct (Isely 1993, Best *et al.* 1996). Because almost nothing is known of its ecology other than its associated species and habitat, its conservation priorities are: focused surveys in tidal marsh edges and diked baylands of the San Francisco Bay region, retrieval and monitoring of the locality of the Sears Point population and locality, and protection of the Sears Point locality.

Zostera marina L., eelgrass

Zostera marina (eelgrass) is a submerged aquatic grasslike plant in the exclusively marine aquatic Zosteraceae (eelgrass) family, which has acosmopolitan distribution outside of the tropics. *Zostera marina* grows from rhizomes that spread through shallow marine and estuarine sediments forming extensive colonies. The vegetative plant consists of short stems with long, flat, ribbon-like submersed green leaves (Thorne 1993). The leaves are often covered with epiphytic algae. *Zostera marina* is a prominent feature of the beds of shallow marine embayments with sandy bottom sediments and low turbidity. It is a keystone species, essential in its ecosystem, because it provides sheltering/nursery effects, productivity, foraging habitat, substrate stabilization, food chain support, organic debris, and effects on bottom current velocities (Zieman 1982). Amount of light, which is affected by turbidity, is an important limiting factor for its establishment and growth (Dennison and Alberte 1986), and a determinant of the depth at which it occurs. Current velocity and sediment mobility are also important factors affecting its distribution (Fonseca 1983) in estuaries. Despite high turbidity and current velocities in San Francisco and San Pablo bays, extensive *Zostera marina* beds occur in the western San Francisco Bay Estuary (Wyllie-Echeverria and Rutten 1989). Numerous small colonies have been observed during high salinity (drought) periods in sandy subtidal waters of Mare Island Strait, lower Napa River (P. Baye pers. observ. 1992), but large colonies have historically been centered around Richmond and Point Richmond, Point Molate, Emeryville, Alameda, Richardson Bay, and Tiburon (Wyllie-Echeverria and Rutten 1989). *Zostera marina* is highly abundant in fully tidal marine lagoons and stream mouths of the central coast (Humbolt Bay, Big River [Mendocino], Bodega Harbor, Tomales Bay, Drakes and Limantour Esteros, Bolinas Lagoon, Elkhorn Slough, Morro Bay; Browning 1972, Gerdes *et al.* 1974, Standing *et al.* 1975, Barnhart *et al.* 1992, P. Baye unpubl. data).

Conservation of *Zostera marina* as an ecological resource is significant for recovery of tidal marsh ecosystems as a whole, and for some listed species. The nutrient-rich tidal litter formed by *Zostera marina* detritus provides locally significant nutrient inputs to the high tide line of Morro Bay, where it fertilizes linear colonies of endangered *Suaeda californica* (California sea-blite). Vegetation gaps in high salt marsh caused by cyclic deposition and removal of *Zostera marina* tidal litter patches may facilitate maintenance of sparse, gap-rich vegetation that is conducive to colonization by *Chloropyron maritimus* (salt marsh bird's beak). *Zostera marina* colonies should be given priority in comprehensive local conservation of tidal marshes at the subregional level.

Other uncommon tidal marsh plant species at risk of decline

There are numerous other plant species that have historically been reported from tidal marshes, particularly brackish tidal marshes and their upper edges. These taxa are infrequently found or no longer reported in subregions of the San Francisco Bay Estuary where tidal wetlands and their ecotones have been sharply reduced or simplified. They are noteworthy if found in tidal marsh surveys, and should be reported or re-surveyed periodically. They include:

• marsh morning glory (*Calystegia sepium* ssp. *limnophila*, occasional in Suisun and upper Napa marshes)

• salt marsh edge sedges: clustered field sedge, *Carex praegracilis*; dense sedge, *Carex densa*, black-head water sedge, *Carex aquatilis* var. *dives* (widespread species formerly found in brackish edges of salt marshes, now scarce

• bugleweed (*Lycopus asper*)

• popcornflower (*Plagiobothrys stipitatus* var. *stipitatus*)

• western dock (*Rumex occidentalis*, occasionally abundant in brackish marshes in wet years, but erratic)

SPECIAL STATUS MAMMAL SPECIES

California sea lion (*Zalophus californianus*)

California sea lions (*Zalophus californianus*) are eared seals (order *Otariidae*). The species consists of three geographically distinct races or subspecies, of which the Californian subspecies, *Zalophus californianus californianus*, is the most abundant and wide-ranging. It is found from the north central California coast (Point Reyes, Farralon Islands) to the Tres Marias Islands, Gulf of California, Mexico (King 1983). Females are smaller than males, measuring 1.8 meters (6 feet) long and weighing around 113 kilograms (250 pounds). Males measure 2.3 meters (7.5 feet), and weigh around 338 kilograms (750 pounds). Fur is brown to tan. California sea lions were heavily hunted commercially in mid- to late 1800s. By the 1930s, only 7,000 California sea lions were found in California. They were given special protection by California Department of

Fish and Game and the Marine Mammal Protection Act of 1972. The population recovered rapidly, and Bonnell *et al*. (1983) estimated the current world population to be 156,000, with 50 percent found in California. Currently, the non-breeding range of California sea lions extends from British Columbia, Canada, south to the Tres Marias Islands, and the breeding range from the Farallon Islands south to the tip of Baja California.

California sea lions, like all pinnipeds, require land for birthing. Their breeding season occurs in May-July, but most pups are born in June. Pupping and breeding sites are primarily on sandy beach and rocky flat areas on islands. The largest breeding colony occurs on San Miguel Island in southern California. After the breeding season, seals migrate from their breeding grounds, but still come onshore to rest at traditional haul-out sites. Immature sea lions have become increasingly frequent on northern California haul-out sites such as Ano Nuevo, Point Reyes and southwest Farallon Island during the summer. A colony has established inside the Golden Gate, San Francisco Bay, along the urban San Francisco shoreline (Pier 39). Unlike harbor seals, California sea lions are not regular visitors to tidal flats or salt marshes, but feed on fish that may spend part of their life-cycles in tidal sloughs.

Harbor seal (*Phoca vitulina richardsi*)

Description. Harbor seals (*Phoca vitulina*), also known as the common or spotted seal, are the smallest and most widespread of all pinnipeds in the eastern Pacific. Males are only slightly larger than females; both measure around 5 to 6 feet in length and weigh 58.5 to 90 kilograms (130 to 200 pounds). The hue and lightness of the adult coat is variable, usually with some spotting. Local breeding populations of harbor seals in San Francisco Bay typically have rusty or reddish pelage (Allen *et al*. 1993). Elsewhere, they tend to be pale to dark grayish. Their diet consists of a wide range of fish, squid, and lampreys. Parasites are common in the subspecies. In California, pupping season is in spring months, and females as young as 3 years old can mate.

Distribution. Harbor seals are shore-dwellers found principally, though not exclusively, in nearshore areas such as estuaries with gently sloping intertidal flats or sloping shingle (pebble/cobble) beaches with easy access for haul-outs. The species is widely distributed on the north Atlantic and north Pacific coasts, where five different races or subspecies are currently recognized. The Pacific coast subspecies, *Phoca vitulina richardsi*, occurs along the eastern north Pacific coast from Baja California (to Cedros Island) north to the Gulf of Alaska and Aleutian Islands. The population size of the Pacific harbor seal has been estimated to be 300,000 or more (King 1983). However, there is not free exchange of seals throughout this range. The population consists of regional breeding subpopulations, or stocks, with limited genetic exchange. Seals on the southern Channel Islands, and in central and northern California, are thought to form separate stocks (Boveng 1988).

Bonnell *et al.* (1983) considered Point Reyes to be the most important harbor seal hauling ground (areas where seals move from water onto land) in central and northern California with a breeding population of over 2500 individuals, approximately 20 percent of the California population. Drakes Estero and western Limantour Estero are heavily used by harbor seals for foraging and rearing pups. Bolinas Lagoon is also a major haul-out and foraging area, mainly on sand shoals adjacent to tidal channels. Harbor seals are also common in Humboldt Bay (mainly the South Bay), with breeding populations near 300. They utilize mudflats and shoals as haul-outs there, mostly adjacent to small tidal channels at low tide in Arcata Bay and South Bay. Pupping occurs mainly in the South Bay (Lidicker and Ainley 2000). Morro Bay supported relatively small populations of harbor seals (fewer than 30) through the 1970s. In San Francisco Bay, important high tide haul-out sites are located near the mouths of Newark and Mowry sloughs (Dumbarton Marsh), where salt marsh is locally barren of vegetation because of seal trampling. Other sensitive haul-out sites have been observed at Guadalupe Slough, lower Bair Island, Strawberry Point Spit (Richardson Bay) Red Rock/Castro Rocks, and Tubbs Island (Allen *et al.* 1993).

Life history. Harbor seals characteristically congregate onshore in groups to rest and rear their young at traditional sites that are generally used year round. The abundance onshore at any particular location varies with season, time of day, state of sea, tide, age and sex class, and human disturbance (Brown and Mate 1983, Allen *et al.* 1984, Yochem *et al.* 1987). The substrates upon which they prefer to haul-out range from rocky intertidal areas to tidal mudflats and sandy beaches. Harbor seals are the least *pelagic* of the pinnipeds and haul-out on an almost daily basis (Yochem *et al.* 1987). Daily activity pattern studies indicate that seals spend between 30 to 44 percent of the time per day resting, and 56 to 70 percent either traveling to feeding areas or engaged in foraging activities (Yochem *et al.* 1987).

Threats. There are numerous potential threats to resident seal populations in San Francisco Bay. Contaminants in San Francisco Bay sediments and fish, particularly heavy metals, polyaromatic hydrocarbons, and PCBs (Monroe and Kelly 1992), may pose risks to health and reproductive success of species such as seals. Urban runoff (particularly when contaminated with dog feces or sewer overflows) and wastewater discharges may carry pathogens of uncertain impact to aquatic mammals. As the urban residential population of the South Bay increases rapidly, these threats are likely to increase and become significant. Recreational boating (jet-skis, motorized boats, and even sea kayaks) may disturb seals unaccustomed to human presence, and commercial navigation (ferries and wakes of larger vessels) may affect seals indirectly by inducing erosion of marsh or beach haul-out sites. Large quantities of bittern brines (concentrated toxic by-products of salt making, consisting of magnesium and potassium salts in saturated solution) are stored in hundreds of acres of salt ponds adjacent to seal colonies near the mouth of Newark Slough. Catastrophic failure of the unengineered, erosion-prone bayfront containment dikes of bittern ponds could cause major skin or eye injury to seals exposed to released bittern. A potential threat to seal colonies in the South Bay may be tidal marsh restoration. Large, rapid increases in tidal prism in South Bay sloughs could cause rapid erosion and loss of established haul-out and breeding sites. Without adjustment of local populations to suitable interim replacement habitat, this could cause failure of South Bay colonies.

Conservation strategy. Harbor seals are well-protected in Drakes Estero. They suffer some risk of illegal hunting in areas of commercial fishing where they are presumed to compete with commercial harvest of fish stocks. Conservation measures to protect local breeding populations in San Francisco Bay populations are needed to offset threats from contaminants, runoff, wastewater, catastrophic bittern/brine releases, and rapid erosion of haul-out sites. Waste discharge requirements for water quality should include evaluation and contingent mitigation for pathogens that could affect harbor seals. Any new wastewater discharge points should be located away from seal colonies unless scientific studies demonstrate with confidence that adverse impacts of discharges are highly unlikely. Mitigation of urban runoff or wastewater discharges may include expanded requirement and use of water quality treatment wetlands and restriction of direct urban discharges into the bay. Treated wastewater discharges should be evaluated for pathogen potential (including viruses) and other indirect impacts on seals. Stored bittern should be relocated away from bayfront containment levees, or be disposed permanently in environmentally benign ways (commercial re-use, gradual dilution and discharge). Regional wetland restoration planning should require phased, gradual tidal restoration at a pace that will be unlikely to "blow out" marsh haul-out sites. Marsh erosion rates in the vicinity of haul-out or breeding sites should be monitored before and after tidal restoration projects.

SPECIAL STATUS FISH SPECIES

Some fish species regularly associated with estuarine habitats in central and northern California are in serious decline, including several federally listed species. Three fish species are associated with brackish upper reaches of California estuaries linked to major rivers: delta smelt, longfin smelt, and Sacramento splittail. These species may benefit from recovery actions aimed at tidal marsh species, or they could be adversely affected if they are not considered in planning of recovery actions for tidal marsh species. Longfin smelt and Sacramento splittail are covered in the *Sacramento/San Joaquin Delta Native Fishes Recovery Plan* (U.S. Fish and Wildlife Service 1996). That document is currently under revision and will cover Sacramento perch as well as the above three species.

Longfin smelt (*Spirinchus thaleichthys*)

Description. Longfin smelt, a true smelt of the Osmeridae family, is considered to be a species of concern, but currently has no special legal status. It is distinguished from other California smelt by long pectoral fins and other morphological traits. It has a silvery translucent appearance on its sides, and an iridescent dull green to pinkish back. On April 2, 2012, the Service found that listing the longfin smelt rangewide was not warranted, but that listing the Bay-Delta distinct population segment (DPS) of longfin smelt was warranted (U.S. Fish and Wildlife Service 2012). However, listing the Bay-Delta DPS of longfin smelt was found to be precluded by higher priority actions to amend the Lists of

Endangered and Threatened Wildlife and Plants. Upon publication of that 12-month finding, the Service added the Bay-Delta DPS of longfin smelt to the candidate species list. Although this species has a wide geographic range that extends from Alaska to California, the Bay-Delta DPS is most relevant to the geographic area covered by this recovery plan. Therefore, the following discussion will be restricted to the Bay-Delta DPS.

Historical distribution and abundance. The Bay-Delta DPS of longfin smelt historically occurred mostly in the northern upstream brackish part of the estuary (Suisun Bay, San Pablo Bay vicinity), but seasonally also occurred throughout San Francisco Bay. They were rarely collected offshore from the Golden Gate. Longfin smelt were formerly among the most abundant fish of the Sacramento-San Joaquin Estuary (western San Francisco Bay Estuary).

Current distribution and abundance. The Bay-Delta DPS of longfin smelt is still found between the brackish part of the estuary and downstream to the Golden Gate. Their distribution within the San Francisco Bay Estuary varies with salinity, retreating upstream towards the west delta in years of lower outflows and higher estuarine salinities, and extending closer to the Golden Gate in years of high outflows and low estuarine salinity (U.S. Fish and Wildlife Service 1996).

However, abundance of the DPS has decreased drastically. Longfin smelt numbers in the Bay-Delta have declined significantly since the 1980s (Moyle 2002, p. 237; Rosenfield and Baxter 2007, p. 1590; Baxter et. al. 2010, pp. 61-64). Rosenfield and Baxter (2007, pp. 1577-1592) examined abundance trends in longfin smelt between 1980 and 2004 and detected a significant decline in the Bay-Delta longfin smelt population. They (Rosenfield and Baxter 2007, pp. 1577-1592) confirmed a positive correlation between longfin smelt abundance and freshwater flow, noting that abundances of both adults and juveniles were significantly lower during the 1987-1994 drought than during either the pre- or post-drought periods (Rosenfield and Baxter 2007, pp. 1583-1584).

Despite the correlation between drought and low population in the 1980s and 1990s, the declines in the first decade of this century appear to be caused in part by additional factors. Abundance of longfin smelt has remained very low since 2000, even though freshwater flows increased during several of these years (Baxter et al. 2010, p. 62). Longfin smelt abundance over the last decade is the lowest recorded in the 40-year history of CDFG's Fall Mid-Water Trawl monitoring surveys. The declines of longfin smelt and these other pelagic fish species in the Bay-Delta since the early 2000s has come to be known as the Pelagic Organism Decline, and considerable research efforts have been initiated since 2005, to better understand causal mechanisms underlying the declines (Sommer et al. 2007, pp. 270-277; MacNally et al. 2010, pp. 1417-1430; Thomson et al. 2010, pp. 1431-1448).

Life history. Longfin smelt feed mostly on opossum shrimp (*Neomysis mercedis*), but copepods and other crustaceans may be important food items for smaller fish. Food availability depends on phytoplankton in the water column. For this reason their summer distribution tracks the fluctuating zone of the estuary where salinity is two parts per thousand salinity, the highly productive mixing zone, or null zone. Their position in the water column also tracks vertical plankton movements, following upward shifts in plankton at night and downward shifts by day (U.S. Fish and Wildlife Service 1996).

Habitat. As indicated by their distribution, longfin smelt are anadromous; they hatch in freshwater rivers, migrate to sea as they mature, and return to freshwater to spawn. They tolerate salinity from marine to freshwater concentrations. The seaward limit of their spawning in the estuary is eastern Montezuma Slough between Suisun Bay and the west delta. The upstream spawning limit is near Rio Vista. The habitat condition of this short estarine segment is highly important for the survival of the species. Longfin smelt spawning habitat includes the submerged portions of aquatic or wetland vegetation, rocks, or other firm substrate for adhesive eggs. They require essentially freshwater conditions (or extremely low salinity) for spawning. The extent of spawning habitat, therefore, expands during years of high river outflow and near-freshwater brackish spring conditions in Suisun Marsh creeks. Longfin smelt in the Bay-Delta may spawn as early as November and as late as June, although spawning typically occurs from January to April (CDFG 2009, p. 10; Moyle 2002, p. 36).

Threats.
Current and future threats to the Bay-Delta DPS of longfin smelt include the effects of reduced freshwater flows (U.S. Fish and Wildlife Service 2012). Additionally, introduced species, such as the nonnative overbite clam, and high ammonium concentrations constitute a threat to the Bay-Delta DPS of longfin smelt. Entrainment is a potential threat to the DPS, but information currently available does not indicate that entrainment threatens the continued existence of the Bay-Delta longfin smelt population. Although entrainment results in mortality of longfin smelt, Baxter et al. (2010, p. 63) concluded that these losses have yet to be placed in a population context, and no conclusions can be drawn regarding their effects on recent longfin smelt abundance. Also, even though a number of Federal and State regulatory mechanisms exist that can provide some protections for the DPS, the continued decline in longfin smelt trend indicators suggests that existing regulatory mechanisms, as currently implemented, are not adequate to reduce threats to the DPS.

Conservation strategy. Conservation actions for longfin smelt in the San Francisco Bay Estuary overlap with recovery actions for delta smelt as well as with recovery actions for listed species that inhabit brackish tidal marshes (*e.g., Suaeda californica* [soft bird's-beak], *Circium hydrophilum* var. *hydrophilum* [Suisun thistle]) and with conservation actions for species of concern (*e.g.*, California black rail [*Laterallus jamaicensis coturniculus*]). Tidal marsh restoration that results in high densities of tidal creeks of variable dimensions, particularly in the brackish Suisun Marsh area, would substantially increase spawning habitat for longfin smelt. Similarly, modifying the non-tidal flood-and-drain waterfowl management wetlands of the Suisun Marsh to microtidal brackish marsh and lagoons should reduce episodic entrainment impacts, and possibly supply additional foraging or spawning habitat. Recovery actions for tidal marsh species in the Suisun Marsh area are not expected to have any adverse impacts on longfin smelt.

Conservation actions for longfin smelt in northern Calfornia estuaries would also overlap with recovery actions for California clapper rails (*Rallus longirostris obsoletus*), and conservation of some tidal marsh species of concern (*e.g., Chloropyron maritimum ssp. palustre* [northern salt marsh bird's-beak], *Castilleja ambigua* ssp. *humboldtiensis* [Humboldt Bay owl's-clover]). Restoration of tidal marshes with brackish upper reaches in Humboldt Bay would, over a period of decades, be likely to re-expand spawning habitat there, and provide opportunities for recolonization of Humboldt Bay by longfin smelt from the nearest population at the Van Duzen River mouth. It would also be compatible with planned reintroduction of longfin smelt, if necessary.

Sacramento splittail (*Pogonichthys macrolepidotus*)

Description. The Sacramento splittail (*Pogonichthys macrolepidotus*) is a large silvery to olive-gray cyprinid fish (family Cyprinidae; minnow relatives), reaching over 30 centimeters (12 inches) in length. The species is distinguished from other cyprinids by the asymmetric caudal fin lobes. During the breeding season, the fins become reddish-orange. The Sacramento splittail is endemic to the Central Valley and portions of the San Francisco Bay Estuary. Sacramento splittail was listed as threatened on February 8, 1999 (64 FR 5963). This listing was challenged and, after a thorough review, the Service removed the Sacramento splittail from the list of threatened species on September 22, 2003 (68 FR 55139). Following the 2003 determiniation, the Service was challenged on the removal of splittail from the list of threatedned species. However, on October 7, 2010, the Service published a finding that listing the Sacramento splittail was not warranted (Federal Register 75[194]:62070-62095; U.S. Fish and Wildlife Service 2010).

Distribution. As summarized in the 12-month finding (U.S. Fish and Wildlife Service 2010), Sacramento splittail were historically found as far north as Redding on the Sacramento River. Splittail were also found in the tributaries of the Sacramento River as far as the current Oroville Dam site on the Feather River and Folsom Dam site on the American River. In the San Francisco Bay area, splittail have historically been reported at the mouth of Coyote Creek in Santa Clara County and the Southern San Francisco Bay. Splittail were documented in Suisun and Napa marshes, as well as Suisun Bay in the 1950's. Splittail occur in the San Francisco estuary and its tributaries and are found most often in slow moving sections of rivers and sloughs, including dead end sloughs and shallow edge habitats. Recent studies have shown the splittail's range in the Sacramento, San Joaquin, Napa, Mokelumne and Petaluma rivers is significantly greater than previously thought when it was first petitioned in the early 1990's to be listed under the Endangered Species Act (U.S. Fish and Wildlife Service 2010).

Life history. Sacramento splittail are relatively long-lived, about 5 to 7 years, and have high reproductive potential. Females can lay up to 100,000 eggs. They reach sexual maturity about two years after hatching. Spawning in the upper Sacramento delta occurs between March and May, but in the estuary it begins in late January or early February and continues through July. Most spawning occurs from February through April. Spawning habitat includes inundated floodplains and shallow submerged vegetation. The annual abundance of Sacramento splittail corresponds with delta outflows, which promote favorably low salinity in the lower delta and eastern parts of the estuary. Population size fluctuates among years, but there has been a strong long-term decline in abundance due to diversion of delta outflows, loss of spawning habitat, and displacement of preferred prey by introduced invertebrates (U.S. Fish and Wildlife Service 1996, Sommer 2000).

Habitat. Sacramento splittail is primarily a freshwater fish, as its historical range suggests, but a substantial portion of its range is estuarine. In the San Francisco Bay Estuary, it occurs mostly in shallow water of tidal brackish marsh creeks and embayments with salinity of 2 to 3 parts per thousand, but tolerates salinity up to 10 to 18 parts per thousand. Within the limited tidal brackish marshes of Suisun Marsh, it occurs most frequently in small dead-end sloughs with some connection to freshwater drainages, conditions that favor other native delta/estuarine fish species. In recent years, Sacramento splittail have been most common in brackish tidal waters of Suisun Marsh and the Sacramento-San Joaquin delta. The core of the distribution of adult Sacramento splittail in summer lies between Suisun Bay and the west delta, with abundant adults and young in the lower Napa and Petaluma rivers. Population size corresponds with delta outflows, which is consistent with its apparent distribution in relation to salinity. Spawning habitat in the estuary consists of submerged vegetation, including submerged portions of emergent intertidal marsh vegetation, either in dead-end sloughs or larger sloughs such as Montezuma Slough. Larvae remain in this habitat, then move into deeper open water as they mature. They are opportunistic benthic feeders, consuming crustaceans, detritus, insect larvae, and other invertebrates. Like longfin smelt, much of their diet consists of opossum shrimp. Splittail, in turn, are a preferred prey of striped bass (*Morone saxatilis*), and have been used as bait for sport fishing (U.S. Fish and Wildlife Service 1996, Sommer 2000)

Conservation strategy. Conservation actions for Sacramento splittail in the San Francisco Bay Estuary overlap with recovery actions for delta smelt as well as with recovery actions for listed species that inhabit brackish tidal marshes (*e.g.*, *Chloropyron molle* ssp. *molle*, *Cirsium hydrophilum* var. *hydrophilum*) and conservation actions for other species of concern (*e.g.,*California black rail). Tidal marsh restoration that results in high densities of tidal creeks of variable dimensions, particularly in the brackish Suisun Marsh area and northern San Pablo Bay, would substantially increase spawning and foraging habitat for Sacramento splittail. Similarly, modifying the non-tidal flood-and-drain waterfowl management wetlands of the Suisun Marsh to microtidal brackish marsh and lagoons would reduce episodic entrainment impacts and supply some additional foraging or spawning habitat. Recovery actions for tidal marsh species in the Suisun Marsh area are not expected to have any adverse impacts on Sacramento splittail and are likely to be beneficial.

Green sturgeon (*Acipenser medirostris*)

The green sturgeon (*Acipenser medirostris*) is a very large (over 2.3 meters [7.5 feet] long), olive-green fish. It has a distinctive form, with a long, snout-like subterminal and barbeled mouth, and shark-like tail. Green sturgeon spawn in freshwater habitat and are presumably adapted to cold, deep, non-turbid river segments with cobble and gravel beds. Adults range from estuarine to nearshore marine waters along the Pacific coast from the Bering Sea to Ensenada, Mexico, and inhabit rivers from British Columbia, Canada, to the Sacramento River. Adults are numerous in Humboldt Bay. They have been most abundant in the Columbia River Estuary, Oregon, but there is no evidence of their spawning in the Columbia River or northward. In California spawning is known only in the Sacramento River drainage, and the largest spawning population is in the Klamanth River basin. Successful spawning probably occurs sporadically rather than annually (U.S. Fish and Wildlife Service 1996).

Green sturgeon are bottom feeders, preying on shrimp, invertebrates (possibly including clams), and anchovies. Threats to this species of concern include overexploitation from sport and commercial fisheries, loss of spawning habitat (especially in the Sacramento River drainage basin), entrainment in water diversions of the Sacramento-San Joaquin delta, and possibly contaminants (U.S. Fish and Wildlife Service 1996).

Tidal marsh recovery actions for listed species and conservation actions for other species of concern are not expected to have adverse impacts on green sturgeon or its estuarine habitats. Protection and restoration of California tidal marshes in Humboldt Bay, Tomales Bay, and the San Francisco Bay Estuary are expected to provide indirect benefits to green sturgeon because of increased support of its prey base and general subtidal and tidal habitat area.

SPECIAL STATUS REPTILE SPECIES

Western pond turtle (*Clemmys marmorata*)

The western pond turtle is widespread, but in decline, through most of its range between northern Baja California, Mexico, and the Columbia River drainages, Washington. It has a drab-colored (brown or yellow-olive), moderate-sized carapace (shell) up to 21 centimeters (8 inches) in length. It is potentially long-lived, up to 42 years. Although they are generalists, the western pond turtle diet consists primarily of slow-moving aquatic invertebrates or carrion. They are principally a freshwater species that inhabits perennial marshes, streams, ditches, and ponds with abundant aquatic invertebrate prey (Jennings 2000). Western pond turtles also occur in brackish tidal marshes in the Suisun Marsh area, but appear to be sensitive to variations in salinity, which could make them useful as an indicator species for monitoring (Suisun Ecological Workgroup 2001).

The U.S. Fish and Wildlife Service was petitioned to list the western pond turtle in the early 1990s. On August 11, 1993, the U.S. Fish and Wildlife Service announced in a 12-month finding on a petition to list the western pond turtle that the species meets neither the definition of an endangered nor a threatened species (U.S. Fish and Wildlife Service 1993*c*; FR 58 (153) 42717). The species is thought to be in decline throughout its range, but particularly so in southern California and the San Joaquin Valley (Jennings 2000). Populations in urban areas often consist primarily of older adults, indicating a decline in reproductive success that could result in population failure in portions of its range. Habitat loss through urbanization and agricultural development, and habitat degradation (*e.g.*, exotic predators such as bullfrogs [*Rana catesbiana*] and largemouth bass [*Micropterus salmoides*], and increases in raccoon [*Procyon lotor*] populations), are principal causes of decline (Jennings 2000)

Tidal marsh restoration in Suisun Marsh and in the upper reaches of the Petaluma Marsh and Napa-Sonoma Marshes is likely to provide additional long-term habitat for western pond turtles. In addition, establishment of new shallow microtidal lagoons for shorebird and waterfowl conservation in the San Francisco Bay Estuary, particularly in the upstream tidal reaches of major drainages, is likely to provide habitat for the species, especially in years of high outflows or rainfall. The Suisun Marsh area may become an important refugium for western pond turtles because the fresh-brackish salinities largely exclude exotic predators and the marsh is among the largest permanently protected wetland reserves in California.

SPECIAL STATUS INVERTEBRATES

Brine shrimp (*Artemia franciscana*, syn. *Artemia salina*)

Brine shrimp of San Francisco Bay are small crustaceans, not true shrimp, in the order Anostraca. Individuals reach up to about 10 millimeters (0.39 inch) in length, have stalked compound eyes and 11 pairs of swimming legs that move in undulating patterns. In San Francisco Bay, brine shrimp occur in vast quantities (hundreds of billions) in the hypersaline waters of salt pans, particularly industrial salt evaporation ponds. In mass, they create huge dense purplish plumes in salt pond brines in summer and fall. In pre-historical conditions, they presumably were the dominant organism of large hypersaline salt pans, such as Crystal Salt Pond near San Lorenzo and similar ponded hypersaline environments. Because of the large historical increase in salt pan habitats in San Francisco Bay, brine shrimp abundance has undoubtedly increased by orders of magnitude. They are the principal grazers of the salt pond food chain, and consume the hypersaline phytoplankton, chiefly *Dunaliella salina*, a unicellular green alga with reddish pigments that brine shrimp accumulate. Brine shrimp are commercially harvested as fish food, and dormant cysts are sold as novelty “instant sea monkeys.”

Brine shrimp have a potentially rapid life-cycle; individuals live fewer than 70 days. In favorable conditions for growth, larvae develop through about 15 molts, and eggs develop directly into nauplii (the free-swimming, first larval stage of crustaceans) and larvae (Larsson 2000). In harsh conditions, eggs can form hard shells to become resistant dormant cysts that may remain viable for decades. Cysts enable brine shrimp populations to survive the unfavorable periods of desiccation or extreme hypersalinity (salt saturation or crystallization) that occur in both natural and industrial salt ponds. Cysts hatch into developing larvae when favorable conditions return.

Brine shrimp are a very important food source for specialized waterbirds such as avocets (*Recurvirostra americana*), black-necked stilts (*Himantopus mexicanus*), eared grebes (*Podiceps nigricollis*), and phalaropes. Many other generalist waterbirds that forage in salt ponds include brine shrimp in their diets. Brine shrimp also provide a base for detrital food chains; decomposing dead masses deposited in driftlines along salt pond shorelines cause proliferation of brine flies, which are consumed by a wide range of waterbirds, including western snowy plovers (*Charadrius alexandrinus nivosus*).

After the cessation of industrial solar salt evaporation in San Francisco Bay, this recovery plan proposes to convert most salt ponds to either shallow microtidal lagoons to replace habitat for waterbirds currently dependent on salt ponds or to tidal mudflat/marsh ecosystems. These environments would not support brine shrimp or their food chains, and natural succession would probably not regenerate significant amounts of brine shrimp habitat in tidal conditions. This would significantly reduce the bay population of brine shrimp and the food chains upon which other species depend. Conservation of brine shrimp in this recovery plan is provided by restoration of salt pan complexes within Newark and Redwood City salt crystallizer beds when they become available. Brine shrimp would certainly persist in restored salt pan habitats dedicated to shorebirds, western snowy plovers, and least terns (*Sterna antillarum*). Establishing deeper depressions with long hydroperiods within restored salt pan complexes would increase habitat for brine shrimp and their consumers. Brine shrimp would probably also continue to survive in local marginal habitats around San Francisco Bay, such as roadside hypersaline ditches, railroad rights-of-way across, etc.

Tiger beetles (*Cicindela* spp.)
sandy beach tiger beetle *(Cicindela hirticolis gravida)*
mudflat tiger beetle (*Cicindela trifasciata sigmoidea*)

Tiger beetles are large insects in the order Coleoptera, family Cicindelidae. They are highly active terrestrial predators and eat any arthropod they can overpower. Fast runners and agile fliers, tiger beetles are most active on warm sunny days from spring to fall on mud or sand near permanent bodies of water. Their larvae build vertical burrows in the sand in the same area as adults. They are commonly found along the southern California coastline (Nagano 1982*b*). Threats to tiger beetles include oil spills, urban expansion, and any trampling impacts that can crush the burrows of the larvae. Three species occur in estuaries of the central California coast: *Cicindela hirticolis gravida, Cicindela trifasciata sigmoidea,* and *Cicindela senilis senilis* (see Section II.A.2.g).

The range of the mudflat tiger beetle (*Cicindela trifasciata sigmoidea*) is from Morro Bay, San Luis Obispo County, south to the Cape region of Baja California, Mexico (Nagano 1982*a*). This subspecies lives in mudflats and dark-colored moist to wet sand in coastal estuarine areas. The upper foreshore of the intertidal flats and sandy tidal marshes of Morro Bay provide habitat and a potentially productive prey base for tiger beetles. There are typically *wracks* of decomposing eelgrass and other organic tidal debris, which support many detritus-eating insects. Fringing Morro Bay tidal marshes provide abundant insect habitat.

The range of the sandy beach tiger beetle (*Cicindela hirticolis gravida*) is from the San Francisco Bay south along the coast to Baja California Norte, Mexico. This subspecies is generally found on sand in estuarine areas (Nagano 1982*a*). San Francisco Bay formerly supported abundant sandy tidal marshes and sandflats from Fleming Point (now Albany) to Bay Farm Island (Alameda), and locally around the northern San Francisco peninsula (U.S. Coast Survey maps, 1853-1856). Currently, sandy San Francisco Bay foreshores are mostly confined to highly urbanized shorelines (Emeryville, Berkeley, Oakland), but significant sandy foreshores have re-formed or persist adjacent to tidal marshes at Point Pinole, Emeryville Crescent, and Roberts Landing (San Leandro, near the mouth of San Lorenzo Creek). Sheltered sandy estuarine foreshores occur in limited abundance at the west end of Elkhorn Slough and Moss Landing (Monterey County), but are most extensive in Morro Bay (P. Baye pers. observ. 1991-1999).

Jamieson's Compsocryptus Wasp (*Compsocryptus jamiesoni*)

Jamieson's compsocryptus wasp (*Compsocryptus jamiesonii*) is a recently discovered moderate-sized, rusty red-brown wasp with banded wings. It is known only from short grass and forb vegetation in or near salt marshes in southern San Francisco Bay (Maffei 2000*b*). It was first collected in 1981 at Alviso, Santa Clara County (Nolfo 1982), and additional populations have been identified within or in the vicinity of salt marshes of the East Bay (Newark, Union City, Hayward shoreline, and San Leandro). No comprehensive surveys have been conducted for this species, so its regional distribution is uncertain (Maffei 2000*b*). It appears, however, to be a local endemic species.

Little is known of the biology of Jamieson's wasp. Related wasp species are parasitic, laying eggs on cocoons and pupae of other insects or egg sacs of spiders. Adults appear from April to October and are most often observed in flight in summer. They utilize dew on foliage as a moisture source and also exploit flower nectars when available (Maffei 2000*b*). The wasp appears to be closely similar to two other species found outside of salt marsh habitats, *Compsocryptus calipterus brevicornis* and *Compsocryptus aridus*.

Jamieson's wasp is a species of concern because it appears to be narrowly restricted in salt marsh edge habitat in San Francisco Bay. Wetland laws and policies ordinarily cannot protect the ecotones and peripheral non-jurisdictional wetland habitats of surrounding uplands, so the species could be threatened by development, dike maintenance, or tidal marsh habitat restoration. The first and most essential action needed to conserve this species is to conduct surveys of its distribution around San Francisco Bay, including surveys in structurally suitable habitat outside the vicinity of the bay's edge. Projects affecting low grassland or forbland adjacent to salt marshes in the South Bay should incorporate seasonally timed surveys for this species. If present, projects should be reconfigured or phased to avoid local extirpation of colonies. Research on the basic reproductive biology and habitat requirements of the species should be conducted promptly, before large-scale tidal restoration projects are initiated, as these could threaten the species if not adequately considered in planning.

Brine flies (*Ephydra cinerea, Ephydra millbrae, Lipochaeta slossonae*)

Brine flies are small insects; adults are 2 to 5 millimeters (0.08 to 0.2 inch) long. They often occur in massive populations associated with decaying detritus in salt ponds, salt pans, or other tidal pools. Brine flies tend to fly very little, and remain close to the ground, which makes them extremely accessible to shorebird predators. They apparently feed on microorganisms in hypersaline waters.

Lipochaeta slossonae (whitish gray) is particularly associated with extreme hypersaline waters, and is commonly found in or near crystallizer ponds and brine ponds. *Ephydra cinerea* (opaque bluish gray) and *Ephydra millbrae* (brownish gray) are widespread. Their importance in the food chain, particularly for shorebirds and waterfowl, as well as native rare insects such as tiger beetle species, is very high (Maffei 2000*c*)

Brine flies are ecologically significant primarily in terms of their role in the food chain and the range of predator species they support, including federally-listed species such as western snowy plovers. Conservation of brine flies in this recovery plan is provided by the establishment of salt pan complexes in crystallizer beds at Newark, Napa, and Redwood City, and also in some microtidal lagoons throughout the San Francisco Bay Estuary, particularly in the South Bay.

Western tanarthrus beetle (*Tanarthrus occidentalis*)

The western tanarthrus beetle (*Tanarthrus occidentalis*, family Anthicidae) is an insect endemic to San Francisco Bay (Chandler 1979). It is specialized for life in salt pans. The western tanarthrus beetle was first collected from salt ponds now within the San Francisco Bay National Wildlife Refuge, adjacent to the Dumbarton Bridge, Alameda County, but additional populations were subsequently discovered from salt pans near Baumberg (Mt. Eden Creek area; presumed extant) and Bay Farm Island, Alameda County (now extirpated). Surveys have so far revealed no further localities. The salt pan habitats in which it occurs consist of extensive unvegetated flats of fine silt and thin salt crusts, with shallow, brief inundation during the rainy season (Maffei 2000*d*).

The western tanarthrus beetle is approximately 3 to 5 millimeters (0.1 to 0.2 inch) in length, black and reddish or reddish-yellow in color. It is distinguished from similar beetles in the region by the morphology of the antennae and other technical characters, and its narrow and extreme adaptation to hypersaline environments. Little is known about its biology. It has been observed feeding on dead brine flies in spider webs (family Ephydridae). Adults are mostly active between May and October. Larvae have not been observed, and nothing is known of its reproductive biology. Western snowy plovers have been observed feeding them to their young (Maffei 2000*d*).

The Western tanarthrus beetle is currently dependent on salt pan habitats that have developed in artificial salt pond systems (Maffei 2000*d*). It presumably occurred in pre-historical natural salt pans along the edge of alluvial fans or terraces, and moved to artificial salt pan refugia after the original habitats were displaced by diked urban areas or salt ponds. The species could be threatened by tidal restoration of salt ponds unless its conservation is carefully planned and coordinated with tidal restoration recovery actions. Its long-term conservation should be compatible with the establishment of extensive managed salt pan habitats at locations currently occupied by industrial salt crystallizers. Successful conservation of the western tanarthrus beetle would depend on establishment of viable populations in restored extensive salt pan complexes before its existing populations and habitats are eliminated by tidal restoration. This will require an orderly sequence of tidal marsh and pan restoration, including (1) interim conservation of existing beetle refugia; (2) salt pan restoration preceding salt pond conversion; and (3) verification through annual monitoring that viable populations of the beetle have established in restored, permanently secured salt pan habitats. Conservation of this species should also include comprehensive bay-wide surveys in suitable habitats.

Although the narrow endemic western tanarthrus beetle is not currently legally protected, its conservation as a species of concern is a high priority for this recovery plan.

California brackish water snail, Mimic tryonia snail (*Tryonia imitator*)

The California brackish water snail (*Tryonia imitator*), or mimic tryonia snail, is a mollusk (class Gastropoda, family Hydrobiidae) that inhabits coastal brackish water sloughs, lagoons, and estuaries. Its shell is dark, smooth, nearly translucent, and very small, about 3 to 5 millimeters (0.1 to 0.2 inch) long. The fine spiral shell has four to five whorls (Taylor 1978). Historically, this snail was distributed from Salmon Creek Lagoon, Sonoma County, to Ensenada, Baja California. Its current patchy distribution is now Alameda, Santa Clara, San Mateo, San Luis Obispo, Monterey, Santa Barbara, San Diego, Ventura, Los Angeles and Orange counties. Estuarine population localities are portions of Elkhorn Slough and possibly the Pescadero Creek Estuary and parts of Morro Bay.

Very little is known of the life history, current distribution, or population viability of this species. It is likely that the jetty construction and tidal inlet stabilization of Elkhorn Slough reduced the extent of its brackish estuarine habitat. Similarly, the realignment and stabilization of Morro Bay inlet may have reduced the extent of suitable brackish habitat for this species.

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Appendix D

Agencies, Organizations, and Websites Associated with Tidal Marsh Recovery

Federal, State, and Multi-agency Government Agencies:

California Coastal Commission
45 Fremont Street, Suite 2000
San Francisco, CA 94105-2219
(415) 904-5200
http://www.coastal.ca.gov/

California Coastal Conservancy
11th Floor, 1330 Broadway
Oakland, CA 94612
(510) 286-1015
http://www.coastalconservancy.ca.gov/

California Department of Fish and Wildlife
1416 Ninth Street
Sacramento, California 95814
(916) 445-041
http://www.dfg.ca.gov/

Delta Stewardship Council (formerly, CalFed/California Bay-Delta Authority)
650 Capitol Mall, 5th Floor
Sacramento, CA 95814
(916) 445-5511
http://calwater.ca.gov/
for the IRWM project: www.irwm.org
for the BREACH II project: depts.washington.edu/calfed/breachii.htm)

Clean Estuary Partnership
http://www.cleanestuary.org/

Delta Protection Commission
14215 River Road
P.O. Box 530
Walnut Grove, CA 95690
(916) 776-2290
http://www.delta.ca.gov/default.asp

Marin Audubon Society
P.O. Box 599
Mill Valley, Ca 94942-0599
http://www.marinaudubon.org

National Estuary Program
http://www.epa.gov/owow/estuaries/programs/pac.htm

NOAA Fisheries, Southwest Region
501 West Ocean Blvd.
Long Beach, CA 90802
(562) 980-4000
http://swr.nmfs.noaa.gov/

San Francisco Bay Area Wetlands Restoration Program
San Francisco Estuary Project
1515 Clay Street, Suite 1400
Oakland, CA 94612
http://www.sfwetlands.ca.gov

San Francisco Bay Conservation and Development Commission
50 California Street, Suite 2600
San Francisco, California 94111
(415) 352-3600
http://www.bcdc.ca.gov

San Francisco Estuary Project
c/o RWQCB
1515 Clay Street, Suite 1400
Oakland, CA 94612
(510) 622-2465
http://www.abag.ca.gov/bayarea/sfep/sfep.html

Sonoma Land Trust
966 Sonoma Avenue
Santa Rosa, Ca 95404
(707) 526-6930
http://www.sonomalandtrust.org

South Bay Salt Pond Restoration Project
http://www.southbayrestoration.org/

State Regional Water Quality Control Board, San Francisco Region
1515 Clay Street, Suite 1400
Oakland, CA 94612
(510) 622-2300
http://www.waterboards.ca.gov/sanfranciscobay/

Suisun Marsh Program, California Department of Water Resources' Interagency Ecological Program
http://www.iep.ca.gov/suisun/

U.S. Army Corps of Engineers, San Francisco District
333 Market Street
San Francisco, CA 94105
(415) 977-8659/8601
http://www.spn.usace.army.mil/

U.S. Environmental Protection Agency
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460
(202) 272-0167
http://www.epa.gov/

U.S. Fish and Wildlife Service, Sacramento Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825
(916) 414-6600
http://sacramento.fws.gov/

San Francisco Bay National Wildlife Refuge Complex
1 Marshlands Road
Fremont, CA 94560
(510) 792-0222
http://www.fws.gov/sfbayrefuges/index.htm

U.S. Geological Survey, San Francisco Bay and Delta
http://sfbay.wr.usgs.gov/

***Non-Governmental Organizations*:**
(not a complete list; see links pages at these sites for more organizations)

Bay Institute of San Francisco
500 Palm Drive, Suite 200
Novato, CA 94949
(415) 506-0150
http://www.bay.org/

Invasive Spartina Project
c/o Coastal Conservancy
2560 Ninth Street, Suite 216
Berkeley, CA 94710
http://www.spartina.org/

Point Reyes Bird Observatory
4990 Shoreline Hwy.
Stinson Beach, CA 94970
(415) 868-1221
http://www.prbo.org/

San Francisco Bay Joint Venture
530C Alameda del Prado #139
Novato, CA 94949
(415) 883-3854
http://www.sfbayjv.org/

San Francisco Estuary Institute
7770 Pardee Lane
Oakland, CA 94621
(510) 746-SFEI (7334)
http://www.sfei.org/

Save San Francisco Bay
350 Frank H. Ogawa Plaza, Ste 900
Oakland, CA 94612-2016
(510) 452.9261
http://www.savesfbay.org/

Appendix E

Environmental Contaminants in San Francisco Bay

Mercury:

California is geologically enriched with mercury, and anthropogenic activities such as mining for mercury and gold have released large amounts of mercury in northern California and San Francisco Bay. Total mercury production in California between 1850 and 1981 was more than 220 million pounds (Churchill 1999). Many of the old mercury mines are located in watersheds tributary to San Francisco Bay. Approximately 12 percent of this mercury was used in gold recovery at both placer and hardrock mining sites in the Sierra Nevada Mountains (U.S. Geological Survey 2000). For every pound of mercury used and recovered, some fraction of a pound (up to 25 percent) was lost to the environment. Inoperative mercury mines and the downstream contaminated sediments and waste piles which resulted from mining activities continue to provide an ongoing and significant source of mercury to the bay.

Contemporary sources of mercury to the Estuary as a whole, in declining order of magnitude, include: Central Valley riverine inputs, bay sediment remobilization, mercury mine waste and mine contaminated sediments of bay tributaries, wastewater discharges, and direct atmospheric deposition. Annual mercury input to the bay is estimated at 2,310 kilograms. The relative magnitude and significance of various mercury sources shifts within specific reaches of the bay. Mercury mines in the Petaluma, New Almaden and Mount Diablo mining districts are known sources of mercury to the watershed. In the South Bay, over 85 percent of the total mercury input is due to within basin sources such as the Guadalupe River, which has received mercury waste from the New Almaden mining district for over 150 years (Abu-Saba and Tang 2000). In addition, much of the mercury used in the Sierra Nevada has now been transported to estuarine sediments, or is between the Estuary and original mine site, and will ultimately arrive in San Francisco Bay via hydraulic transport.

The most important factor determining both rates of bioaccumulation (the buildup of a chemical in the tissues of a living organism) of mercury from sediment and water and the toxicity of sediment mercury is the rate of conversion of inorganic mercury to organic, or methylmercury. Methylmercury typically comprises only about 1% of the total of all forms of mercury in water or sediment, but it is the form that is readily accumulated in the food web and poses a toxicological threat to highly exposed species. Factors enhancing methylmercury formation, which is accomplished by sulfur reducing bacteria, include anoxic conditions, appropriate bacterial populations, salinity, sulfate, pH, and abundant organic carbon sources. In contrast to total mercury, methylmercury is not persistent and methylmercury concentrations are highly variable over brief periods of time and small intervals of space and do not closely correspond with total mercury concentrations (San Francisco Estuary Institute 2008).

According to San Francisco Estuary Institute's latest monitoring results, water from the lower South Bay had the highest average concentration of methylmercury (0.11 nanograms/liter [ng/L]) of any segment in 2006 and 2007 (San Francisco Estuary Institute 2008). Concentrations of methylmercury in sediment south of the Bay Bridge have been consistently higher than those in the northern Estuary. In contrast to methylmercury, long-term average total mercury concentrations in sediment generally have been highest in San Pablo Bay (0.27 parts per million [ppm]), slightly lower in the Central Bay (0.24 ppm), South Bay (0.22 ppm), and lower South Bay (0.26 ppm), and lowest in Suisun Bay (0.14 ppm) (San Francisco Estuary Institute 2008). For comparison, U.S. Geological Survey examined mercury concentrations in pre-gold rush sediment cores from the North Bay. These concentration averaged 0.06 ppm dw (dry weight [weight of a sample after all moisture has been removed]; Hornberger *et al.* 1999).

Preliminary results suggest that one factor with a major influence on methylmercury concentrations in sediment is slough order. Primary channels were statistically distinct from the wider and deeper tertiary channels with respect to methylmercury. More information is needed to understand the factors controlling mercury methylation in tidal wetlands. San Francisco Estuary Institute's 2008 report stated that subsided tidal marshes in the South Bay may have lower methylmercury production than non-subsided marshes and that higher elevation portions of tidal marshes in the North Bay generate more methylmercury than lower elevation portions, even though total mercury in the former areas is lower (San Francisco Estuary Institute 2008).

Toxicology: Symptoms of acute methylmercury poisoning in birds include reduced food intake leading to weight loss, progressive weakness in wings and legs, difficulty flying, walking, and standing, and an inability to coordinate muscle movements (Scheuhammer 1987). In addition to well-identified acute effects of mercury at high concentrations, there are also significant adverse effects at lower tissue-mercury concentrations representing chronic mercury exposures. Reproduction is one of the most sensitive toxicological responses, with effects occurring at 20 percent of the dietary concentrations that produce lethal effects in adult birds (Scheuhammer 1991). The documented effects of mercury on reproduction range from embryo lethality to sublethal behavioral changes in juveniles at low dietary exposure. Concentrations in the egg are typically most predictive of mercury risk to avian reproduction.

Embryos of birds are extremely sensitive to low concentrations of mercury in the egg. Almost all of the mercury in bird eggs is methylmercury. Toxic effects of mercury in bird eggs have been documented by many investigators in both laboratory and field studies (*e.g.*, Wolfe et al. 1998). In a field study of common terns, Fimreite (1974) estimated the threshold level in eggs for impaired nest success to be between 1.0 and 3.6 ppm fww (fresh wet weight [weight of a sample without moisture removed]). Heinz (1979) examined behavioral effects in mallard ducklings fed methylmercury. Over 3 generations each fed 0.5 ppm mercury, decreased reproductive success and altered duckling behavior were observed. The mean total mercury concentration in eggs was 0.86 milligrams/kilogram fww. This study remains the benchmark which established the lowest observed adverse effect concentration (LOEC) in an avian diet of 0.064

milligrams mercury /kilogram (body weight)/day (Sample *et al.* 1996). Fimreite (1971) found reduction in ring-necked pheasant (*Phasianus colchicus*) hatchability associated with egg mercury levels between 0.5 and 1.5 ppm fww. This study established the lowest adverse concentration observed in avian eggs. Heinz (1975) fed mallards 3.0 ppm methylmercury dicyandiamide over two successive years. Mean mercury concentrations in eggs accumulated to an average of 7,180 nanograms/gram ww (ng/g) after the first year, and to 5,460 ng/g in the second year, and resulted in brain lesions in hatched ducklings. In a joint study by U.S. Geological Survey and U.S. Fish and Wildlife Service, adult avocets had the lowest blood total mercury levels at 0.30±0.06 ppm, followed by scoters (0.41±0.03), stilts (1.0±0.31), and Forster's terns (1.49±0.29). The concentrations were highest in the South Bay, followed by North Bay and Central Bay (Ackerman *et al.* 2007).

The mean mercury concentration (fresh wet weight; fww) of all fail-to-hatch clapper rail eggs collected from the South Bay in 1992 (Schwarzbach *et al.* 2006) was elevated above the 0.5 to 1.5 ppm fww LOEC range in pheasant eggs for hatchability (Fimreite 1971). Fifty percent of all of the fail-to-hatch rail eggs were in or above this concentration range. Twenty-five percent of all the 1992 fail-to-hatch rail eggs were above the 0.86 ppm fww effects threshold estimated for mallards (Heinz 1979). Total mercury in sediment was not correlated with mercury in clapper rail eggs from the South Bay marshes in 1992. In addition, total mercury in prey and sediment samples from San Francisco Bay samples were not correlated, although both prey and sediment mercury concentrations were lower at the Corte Madera reference site. The lack of correlations was probably due, in part, to homogeneity of mean total mercury concentrations in South Bay marshes. Total mercury in sediment is of some predictive value, however, when comparing sites with elevated and background mercury concentrations. Clapper rail eggs in San Francisco Bay have elevated mercury levels compared with light-footed rail eggs (*Rallus longirostris levipes*) from Seal Beach, a coastal marsh in southern California. Total mercury concentrations in Seal Beach sediments are relatively low, below 0.1 ppm dw. Mercury concentrations in eggs of the light-footed clapper rail were correspondingly low at 0.07 ppm dw (Schwarzbach *et al.* 2006). In contrast, mean mercury concentrations in south San Francisco Bay marshes were 0.37 ppm dw in surface sediment and 2.2 ppm dw in rail eggs collected from the same areas. These sediment mercury concentrations in the South Bay are elevated 6 fold above the baseline concentrations of mercury found in pre-gold rush sediment cores (Hornberger *et al.* 1999).

In 1998 and 1999, a similar study was conducted in the North Bay (Schwarzbach *et al.* 2006). Mercury concentrations in 22 fail-to-hatch eggs ranged from 0.20 to 3.5 ppm fww. Concentrations in half of these eggs were above 1.00 ppm fww. Three embryos from Wildcat marsh (Contra Costa County) exhibited limb deformities. Mercury concentrations in 5 failed eggs from Hayward marsh in 1998-99 ranged from 1.28 to 2.12 ppm fww. Mercury concentrations in rail eggs appear to vary with position of the nesting territory within a given marsh. In addition, maximum methylmercury concentrations in marsh sediment were correlated with mean mercury concentrations in failed eggs.

In summary, the following conclusions may be drawn from contaminant studies conducted by the U.S. Fish and Wildlife Service, Environmental Contaminant Division, during the 1990s. 1) Mercury is accumulated in California clapper rails and deposited in their eggs at potentially embryo toxic concentrations within both the North and South Bay, producing failure in up to one third of clapper rail eggs laid. 2) Methylmercury in sediments is predictive of the mercury hazard to rail reproduction. 3) The mercury hazard of North Bay marshes is not less than the South Bay. In addition, mercury bioaccumulation and toxicity to clapper rails is not a simple function of mercury concentration in sediments, but depends on rates of methylation which are mediated by bacterial activity and other abiotic factors.

Selenium:

The two major potential sources of selenium to the San Francisco Estuary are irrigation drainwater from the San Joaquin River and discharges from the six major oil refineries. Both sources enter the estuary in the northern reaches of the bay. Mean selenium levels in San Francisco Bay are below the current aquatic life water quality criteria (water quality criteria developed by the U.S. Environmental Protection Agency for the protection of aquatic organisms and their uses) of 5 micrograms per liter (µg/L) (Environmental Protection Agency 2009). Delta water diverted to the Central Valley Project and State Water Project canals usually average about 1 µg/L selenium. The Regional Monitoring Program for 2008 (San Francisco Estuary Institute 2008) reported total selenium concentrations between 2002 and 2007 that ranged from 0.12 to 0.13 µg/L in all Bay segments, with the exception of the lower South Bay segment which had the highest concentration detected in the Bay at 0.25 µg/L. Surveys of selenium concentrations in surface sediments of South Bay marshes have not detected selenium at concentrations above 0.2 milligrams per liter (mg/L) dw (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2000). Despite selenium levels well below the water quality objectives established by the California Toxics Rule (5 µg/L) (San Francisco Estuary Institute 2008), tissue concentrations of selenium in some bay biota are elevated. Concerns still exist for human exposure as indicated by a duck consumption advisory and for wildlife exposure as indicated by studies on early life-stages of fish (San Francisco Estuary Institute 2008). San Francisco Bay is considered a selenium-impaired waterbody, primarily in San Pablo Bay, due to bioaccumulation of selenium in biota including subtidal clams, sturgeon, and diving ducks (Ohlendorf *et al.* 1986). Several investigations of selenium contamination have been conducted within San Francisco Bay and are summarized below.

In vertebrates selenium is an essential micronutrient, while at excessive concentrations, it functions as a toxic trace element. The effects of selenium poisoning on avian species include: gross embryo deformities, winter stress syndrome, depressed immune system function and reduced resistance to disease, reduced juvenile growth and survival rates, mass wasting, loss of feathers (alopecia), embryo death, and altered hepatic enzyme function (Whiteley and Yuill 1989, Heinz 1996). Selenium has been considered a contaminant of concern for wildlife in the bay since Ohlendorf *et al.* (1986) documented that selenium concentrations in diving duck livers collected in the South Bay in 1982 were comparable to concentrations in ducks at Kesterson. At Kesterson, selenium produced well-documented embryo deformities in aquatic birds and greatly reduced hatchability of avian eggs. However, the few rail abnormalities found by U.S. Fish and Wildlife Service investigations within the bay (Schwarzbach *et al.* 2006) thus far have not been linked to elevated selenium concentrations in eggs. Polydactyly and reduced digits and limbs were found in three clapper rail embryos in Wildcat Marsh (Contra Costa County) in 1998. Selenium concentrations in these three eggs were below known terratogenic (birth defect causing) thresholds in avian species.

In a follow-up study to the 1982 collections, Ohlendorf *et al.* (1988) reported that ducks in San Pablo and Suisun bays collected in 1985-1987 had higher selenium concentrations in livers than birds collected in the South Bay. This pattern is consistent with the fact that major selenium inputs to the Estuary enter via the North Bay and Delta. Clapper rail eggs collected from the North Bay in 1987 contained up to 7.4 ppm selenium dw (Lonzarich *et al.* 1992). Selenium concentrations found in North Bay eggs in 1986 were two to three times higher than selenium concentrations in the South Bay.

Since that time, refineries have made changes in selenium treatment and discharge practices. Investigations of fail-to-hatch clapper rail eggs in the South Bay in 1992, and in the North Bay in 1998, have not duplicated the elevated selenium results of Lonzarich *et al.* (1992). Maximum egg selenium concentrations in more than 60 eggs were less than 3.2 ppm dw. Mean selenium concentrations in fail-to-hatch rail eggs in San Francisco baylands varied between 1.9 and 2.3 ppm dw. No differences were observed in selenium concentrations between marshes (U.S. Fish and Wildlife Service unpubl. data). The *in ovo* threshold for selenium exposure that causes toxic effects on embryos of California clapper rails is unknown. The *in ovo* embryo toxicity threshold for selenium in black-necked stilt (*Himantopus mexicanus*), another benthic forager, is 6 micrograms per gram (μg/g) dw (Skorupa 1998). *In ovo* exposure of mallard ducklings to as little as 3.9 ppm dw selenium was sufficient to significantly increase mortality when ducklings were challenged with a pathogen (Whiteley and Yuill 1989). It seems unlikely that current selenium concentrations in the bay are having a significant impact on clapper rail reproduction, but that could change if selenium loadings to the estuary were increased.

Silver:

While silver has been demonstrated to accumulate in bivalves (Luoma and Cloern 1982) and diving duck livers (Ohlendorf *et al.* 1986), silver bioaccumulation does not occur in rail eggs (Schwarzbach *et al.* 2006). Concentrations of silver in 37 failed rail eggs from the South Bay in 1992 averaged 0.02 ppm dw. Effects of silver contamination upon rails are more likely to be indirect through alteration of prey and are more likely to have occurred in the past.

In the late 1970s and early 1980s severe local contamination of sediment and bivalves by silver was detected near the Palo Alto sewer outfall. Moderate silver contamination was also documented throughout the South Bay during that period. Mean concentrations of silver in resident bivalves sharply declined between the 1970s and 1991, in response to treatment upgrades and a silver source control effort begun in 1989 (Hornberger *et al.* 1999). Silver levels in transplanted mussels declined exponentially during this time (Stephenson and Leonard 1994). A similar pattern was reported in transplanted mussels throughout the bay (Smith 1986). The elevated silver concentrations in the South Bay were associated with reductions in population densities of clams (*Macoma* spp.), reduced community diversity, lowered percentage of clam population in reproductive status, reduced growth of resident and transplanted bivalves, periodic disappearances of clams from silver-impacted mudflats, and the development of silver tolerant subpopulations of clams nearer the discharge point (Hornberger *et al.* 1999).

U.S. Fish and Wildlife Service data from 1992 indicated that a residual footprint of silver contamination remained in the intertidal marshes of the South Bay as compared to a North Bay reference site, and that marshes closest to the Palo Alto sewage outfall (Faber and Laumeister, San Mateo County) had the highest concentrations of silver in sediment. This outfall had previously been documented as the source of elevated silver concentrations in bivalves (two-shelled animals such as clams and mussels) of the South Bay (Luoma and Cloern 1982, Thomson *et al.* 1984). Mean silver concentrations in marsh sediments in 1992 were negatively correlated ($r = -0.98$, $P = 0.004$) with the log of the distance from the sewer outfall. Mean silver concentrations in snails ranged from 0.9 to 26.5 ppm dw and were consistently higher than concentrations in crabs or mussels. Maximum silver concentrations were 1.59 ppm in crabs, 12 ppm in mussels and 43.8 ppm in snails.

Barium:

Barium was detected in 36 of 38 eggs in the South Bay in 1992 at a mean concentration of 0.34 ppm, whereas concentrations of barium in North Bay eggs in 1998 ranged from 0.45 to 4.13 ppm dw. The three embyos with deformities of the feet had barium concentrations ranging from 2.2 to 4.1 ppm. Higher barium concentrations were also somewhat associated with malpositioning of late-stage embryos. Mean barium concentrations of 1.28 and 0.51 ppm were found in malpositioned and normal late-stage embryos, respectively (Schwarzbach *et al.* 2006).

Chromium:

Chromium was detected in seven of 38 eggs from the South Bay in 1992 with concentrations ranging from 0.5 to 0.7 ppm dw. Three of nine eggs from the North Bay in 1998 contained chromium at concentrations of 0.46, 0.41, and 2.06 ppm dw. The maximum chromium concentration occurred in an embryo with reduced toes and wings from Wildcat Marsh. Embryo toxicity of chromium depends on the valence state (number of chemical bonds formed by the atoms of a given element), with Cr+6 being much more toxic than Cr+3 (Asmatullah and Shakoori 1998). Hui *et al.* (2002) reported elevated chromium in addled eggs (eggs whose contents have been removed for analysis of embryo development) of light-footed clapper rails from Seal Beach and Tijuana Slough; concentrations were as high as 3.85 ppm dw, but the species of chromium and the toxicological significance were unknown.

Organochlorines:

San Francisco Bay has a history of organochlorine (OC) contamination from the use of chlorinated hydrocarbon pesticides and polychlorinated biphenyls (PCBs) from the 1950s through 1975 (Venkatesan *et al.* 1999). Although no longer manufactured, a large proportion of PCBs are still in use and PCB loading is still occurring in San Francisco Bay (Davis *et al.* 2006). Average PCB concentrations in Bay sediment measured from 2004 to 2007 were highest in the southern reach of the Estuary, but concentrations were higher in all Bay segments than in previous years. The Bay-wide average for 2007 was 8.7 parts per billion (ppb), well above the overall long-term average of 5.7 ppb (San Francisco Estuary Institute 2008). OCs remain at the water- sediment interface due to the action of tides, wind and dredging. On a concentration-dependent basis, OCs have been demonstrated to affect reproduction of birds through embryo toxicity and effects to the eggshell (Blus 1996, Hoffman *et al.* 1996). As a benthic forager, rails could well be expected to be exposed to these compounds in sediment and benthic organisms.

Lonzarich *et al.* (1992) noted a substantial decline in rail egg OCs between 1975 and 1986-1987 random egg collections. In a follow-up study, 22 fail-to-hatch clapper rail eggs from the South Bay in 1992 were analyzed for organochlorines (Schwarzbach *et al.* 2001). Results from these eggs showed a continuing trend of decline in OC concentration, with the exception of mean PCB concentration. PCB concentration, while half of that found in the 1970s, was slightly greater on average than in the random eggs collected in the late 1980s. This may be partially due to a sampling bias in the 1992 eggs, as only fail-to-hatch (failed) eggs were collected. The patterns of detection and relative concentration of the OC compounds observed in 1992 eggs remained similar to those previously reported by Lonzarich *et al.* (1992). The pattern in rails was also similar to that found in eggs of other birds nesting in the South Bay, where PCB concentrations generally exceed those of all other OCs (Ohlendorf *et al.* 1988, Hothem *et al.* 1995). Neither 1986 random egg collections or the 1992 failed egg collections found a reduction in clapper rail eggshell thickness. Both studies concluded that OC pesticide concentrations were not likely to cause adverse effects on clapper rail reproduction (Lonzarich *et al.* 1992, Schwarzbach *et al.* 2001). Total PCB concentrations in 1992 eggs ranged from 0.65 to 5.01 ppm fww, with a mean of 1.30 ppm. The maximum egg PCB concentration of 5 ppm fww was found in an egg from Laumeister marsh (San Mateo County).

Failed clapper rail eggs were collected from Wildcat and Corte Madera marshes in 1998 and 1999. OC concentrations in eggs from these Central Bay marshes were similar to those from the South Bay in 1992. Specifically, levels of PCBs were lower than levels in South Bay in 1992 (Schwarzbach *et al*. 2006), lower than levels reported for North Bay in 1986-1987 (Lonzarich *et al.* 1992), and below toxic thresholds (Ohlendorf 1993). However, DDE (dichlorodiphenyldichloroethylene, a breakdown product of DDT, otherwise known as dichlorodiphenyltrichloroethane, one of the most well-known synthetic pesticides) and toxaphene were higher in the North Bay eggs. Higher DDE and toxaphene in the North Bay eggs likely reflects the greater proximity of the North Bay marshes to agricultural pesticide inputs to the Bay (Schwarzbach *et al*. 2006). In contrast, South Bay marshes were rapidly converted to urban and industrial areas; agriculture was much less prevalent (Goals Project 1999). The mean PCB concentration again exceeded concentrations of all other OCs detected. PCB concentrations in the Central Bay marshes in 1998-99 ranged from 0.12 to 1.08 ppm, with a mean of 0.56 ppm fww. This continues the trend of decreasing PCBs observed in South Bay marshes from 1975 to 1992.

Adelsbach and Maurer (2007) found that California clapper rails experience significantly increased exposure to dioxins, furans, and dioxin-like PCBs than would be expected based on their foraging ecology. It is unclear based on the small population size utilized in the study the extent to which this trend would be observed across the Bay-wide population and what processes may be leading to this increased exposure. Although their PCB concentrations were lower than the piscivorous species studied in this investigation, concentrations in clapper rail eggs were still at or above concentrations associated with adverse impacts in laboratory species (Adelsbach and Maurer 2007).

Interpretation of the toxicological significance of PCB concentrations in rail eggs is complicated by the lack of congener specific data (data from species in the same genus) in this data set and the unknown sensitivity of rails to PCBs. If rails (order Gruiformes) are as sensitive as chickens (order Galliformes), they may be at risk from PCBs. White leghorn chickens are the most sensitive avian species tested to date. Decreased hatching success in chickens was associated with total PCB egg residues of <1 µg/g (ww) in a feeding study with Aroclor 1242 (Britton and Huston 1973). In contrast, during a 39 week feeding study using white leghorn chickens and Aroclor 1254 (trade name for PCBs used by Monsanto Company), no adverse effects on egg hatchability were detected at concentrations less than 5 µg/g (ww) (Platanow and Reinhart 1973). Evaluating the 1992 rail egg residues on the basis of various Aroclor mixture results in chickens may lead to two different conclusions: that one of 22 eggs was above the threshold effect of 5 µg/g (ww), or that 18 of 22 eggs were above the threshold of 0.87 µg/g (ww). Since the PCB mixtures quantified in rail eggs were predominantly 1254 it may be more appropriate to use the former toxicity threshold to interpret PCB risk to rails.

Toxicity of PCB congeners (chemicals related to PCB) to avian embryos varies greatly. For example, the dose required for 50 percent lethality in test organisms (LD50) in chicken embryos is 0.4 ng/g (fww) for planar PCB 126 (Hoffman *et al.* 1998), and >14,000 ng/g for nonplanar PCB 153 (fww) (Hoffman *et al.* 1995). Thus, interpreting toxicity of total PCBs suffers not only from the usual interspecies extrapolation complication, but also from variable toxicity depending upon congener composition of the mixture, and additionally from altered congener composition from environmental weathering. Additional work is needed to characterize more accurately the PCB hazard to rail eggs as specific congeners at the appropriate detection limits. Emphasis should be placed on the 2 most toxic groups of congeners: planar PCBs and mono-*ortho* PCBs. While planar congeners are most toxic among PCBs, mono-*ortho* congeners are commonly found in environmental samples, and are frequently present at much higher concentrations relative to planar PCBs (McFarland and Clarke 1989).

Petroleum hydrocarbons:

San Francisco Estuary is highly urbanized, with six oil refineries, substantial ship and oil tanker traffic, and a large number of gas-powered vehicles. Petroleum hydrocarbons enter the San Francisco Estuary via petroleum spills, discharges from ships, runoff from roads and parking lots, discharges of industrial effluents, and atmospheric deposition. As a result, petroleum hydrocarbons are commonly detected in bay waters and sediment. Polycyclic aromatic hydrocarbons (PAHs) are among the most toxic hydrocarbons; many are carcinogenic (cancer causing) or mutagenic (mutation causing) (Eisler 1987). During the period 2002 to 2007, polycyclic aromatic hydrocarbons in sediment have been highest along the southwestern shoreline of the Central Bay (3.3 ppm), followed by South Bay (1.9 ppm), lower South Bay (1.6 ppm), San Pablo Bay (0.9 ppm), and Suisun Bay (0.4 ppm) (San Francisco Estuary Institute 2008). Rails may be exposed to petroleum hydrocarbons both internally and externally. Internal exposure for rails may occur through normal foraging. PAHs bioaccumulate in bivalves (Mix 1984), which are common prey items for rails.

External exposure generally results from an oil spill. Adverse effects of external exposure to petroleum hydrocarbons include loss of feather structure resulting in flightlessness, loss of water repellency of feathers resulting in hypothermia, chemical burns to the skin, and in extreme oilings, incapacitation (U.S. Fish and Wildlife Service 1997*b*). Oil exposure may not be immediately incapacitating and birds may remain vigorous enough to avoid capture for several days which may complicate rehabilitation efforts by increasing the secondary exposure of eggs and nestlings. Birds also ingest oil when preening oiled feathers. Ingestion of oil results in hemolytic anemia, liver damage, impaired reproduction, aspiration pneumonia and irritation of the intestines and is ultimately life threatening in even small doses (U.S. Fish and Wildlife Service 1997*b*). Some dispersants (substances added to a solution to improve separation of particles), when mixed with oil can also be quite toxic and even enhance the toxicity of oil if ingested.

Bromine-containing flame retardants:

Practically unheard of in the early 1990's, polybrominated diphenyl ethers (PBDEs, organobromine compounds that are used as flame retardants) increased rapidly over time and are now a pollutant of concern in the San Francisco Estuary. No regulatory guidelines exist yet for PBDEs. According to the Regional Monitoring Program for Water Quality, the highest average concentrations of PBDEs in water from 2002 to 2007 were found in Suisun Bay, suggesting the presence of PBDE inputs into the northern Estuary (San Francisco Estuary Institute 2008). In contrast to the results obtained from water monitoring, average concentrations of BDE 47 (one of the most abundant PBDEs and an index of PBDEs as a whole) in sediment from 2004 to 2007 were highest in the lower South Bay (0.81 ppb) and lowest in Suisun Bay (0.38 ppb). The cause of this disparity between water and sediment data for BDE 47 is not understood (San Francisco Estuary Institute 2008).

Oil Spills:

The threat of a major oil spill within the bay exists and contingency plans have been developed to cleanup and prevent distribution of oil to sensitive natural areas. To protect the clapper rail and salt marsh harvest mouse from such a catastrophe, one of the goals of any contingency plan for responding to a San Francisco Bay spill must be to effectively prevent and limit movement of oil into tidal marshes, particularly the more densely occupied marshes of the South Bay. The current oil spill contingency plan for San Francisco Bay ranks salt marshes and tidal flats as the two most sensitive shorelines to oiling (U.S. Fish and Wildlife Service 1997*b*). Both habitats are important to the rail and and the latter is important to the mouse. Barriers and berms are the preferred shoreline treatment method for these habitats; sufficient boom material should be kept available within the bay for prevention of oil movement into salt marsh habitat of the entire Estuary. Trampling of oiled mudflats by cleanup crews should be avoided because this pushes oil beneath the surface and prolongs its future availability to benthic prey of the rail.

There have been several major oil spills within San Francisco Bay in the last decades. These spills were due to a number of causes including shipping accidents, a pipeline rupture, an open valve at refineries, leaks from a sunken ship, etc. Many of the spills impacted the interior shoreline of the bay, with impacts to the Central Bay and Carquinez Strait. Numerous marshes in both areas support the rail and the mouse. Although no clapper rails were identified in salvage or cleanup operations, rails may have been oiled and escaped detection due to their normally secretive behavior. The effects of an oil spill depend on the degree of oiling and the nature and weathering of the oil. A large oil spill in the South Bay, where clapper rail populations are more densely concentrated, could have disasterous ramifications for the long-term survival of the species.

January 1971 - The collision of two tankers, the *Oregon Standard* and *Arizona Standard* released 27,600 barrels of bunker fuel oil at the Golden Gate Bridge. An estimated 4,000 seabirds were killed. Oil impacted the western shore of the Central Bay from the Tiburon Peninsula and Richardson Bay to 5 km (3.1 mi.) south of the Oakland Bay Bridge. The South Bay was unoiled due to northward moving surface flows. Most of the spilled oil was carried out to sea.

April 1988 - An open valve on a tank farm on the Shell Refinery in Martinez released 8,700 barrels of crude oil in the Carquinez Straits and contaminated 80.5 km (50 mi.) of shoreline habitat. The oil drained through Peyton Slough and Shell Marsh. Approximately 40.5 ha (100 acres) of tidal wetlands were contaminated by oil. While there is uncertainty about direct effects to rails because none were recovered, it is possible some rails were impacted (Page *et al.* 1989).

October 1996 - The *Cape Mohican* oil spill occurred when a valve on the ship's hull was opened during routine maintenance at the San Francisco Dry Dock. An estimated 96,000 gallons of fuel oil spilled into the dry dock and approximately 40,000 gallons of that oil entered San Francisco Bay. Tides and wind dispersed the oil around the Central Bay and out to sea. The areas contaminated with oil included the San Francisco shoreline from Pier 70 on San Francisco Bay to Sharp Park on the San Mateo County coast, the Marin County shoreline from San Rafael to Stinson Beach, and the shorelines of Alcatraz, Angel, and Yerba Buena islands. Approximately 688 hectares (ha) (1,700 acres [ac]) of shoreline habitat were oiled, including 40.1 ha (99 ac) of mudflats and wetlands. Approximately 4,000 birds were affected by the spill. Birds affected in greatest numbers included gulls, shorebirds, loons, grebes, cormorants, pelicans, waterfowl, and alcids. No oiling of California clapper rails was observed and major rail habitats were not affected.

September 1998 - Tanker vessel *MT Command* entered San Francisco Bay with a damaged fuel tank and spilled 50 gallons of bunker fuel oil into the bay. This bay spill was promptly detected, fully contained and did not damage wildlife. The U.S. Coast Guard directed the tank be repaired and not reused until permanent repairs could be implemented. A second, more disastrous, oil spill occurred when 3,000 gallons of oil spilled into the Pacific Ocean off the San Francisco and San Mateo coasts during the transfer of the oil back into the damaged tank. The oil slick dispersed in the ocean waters off the coast south of the Golden Gate, where it oiled seabirds and washed ashore on beaches in San Mateo County in the form of tarballs. At least 1,500 birds were killed, including brown pelicans and common murres.

November 2007 - The *M/V Cosco Busan* container ship collided with an Oakland/San Francisco Bay Bridge support, spilling 58,000 gallons of fuel oil into the San Francisco Bay. The California Department of Fish and Game's Natural Resource Damage Assessment website (http://www.dfg.ca.gov/ospr/spill/incidents/cosco_busan/cosco_busan.html) states that among other species impacted, 1,859 birds were collected dead, 1,084 birds were collected oiled but alive, and hundreds more were observed oiled but not captured.

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Appendix F

Population Persistence Modeling for Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California with Initial Application to California clapper rail

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Population Persistence Modeling for Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California with Intial Application to California clapper rail

Stuart B Weiss, Ph.D. Final version Dec 2005

Population assessment and modeling

The persistence of populations, and the converse probability of extinction, can be approached through Population Viability Analysis, or PVA. Habitat area, demography, environmental variation, predation, and other factors interact in complex combinations to drive changes in population size and likelihood of extinction.

A two-step modeling procedure has been applied to existing data on the California clapper rail. First, data were compiled on California clapper rail densities and used to estimate carrying capacities and potential population responses to increased tidal marsh area. Second, a stochastic model of population persistence was developed (after Foley 1994, described below) using available information on population size and variability to predict effects of carrying capacity, population size variability, initial population size, and long-term trends on mean time to extinction. Mean time to extinction (T_e, explained in detail below) is a rigorously derived probabilistic parameter. The sensitivity of T_e to factors driven by tidal marsh management and restoration provides a “clapper rail calculus” for shaping recovery criteria in the context of ongoing restoration scenarios, and a framework for monitoring and adaptive management during the multi-decadal time frame for tidal marsh restoration.

This approach provides an objective quantitative basis for certain recovery criteria, including habitat area, habitat distribution, population numbers, and monitoring requirements, and justifies them by comparing T_e estimates. This section describes methods, estimates initial parameters, presents results for a range of generic marsh restoration scenarios, and establishes the first set of recovery criteria, including a definition of a core population. As better data, further analyses, and empirical results from tidal marsh restoration projects become available, the California clapper rail PVA can be recalculated and modified in an adaptive manner.

Data sources

A variety of published and unpublished data sources have been consulted, along with meetings in the field with several California clapper rail biologists. Clapper rail populations have been estimated by high-tide airboat surveys in winter and call counts in the breeding season. Foin *et al.* (1997) provide compiled winter and summer data collected in the 1970s by Gill (1979). Winter data from the South Bay from 1989 - 2004 were provided by Joy Albertson and provide the most consistent and quality-controlled data set for initial time-series analyses. Breeding season (spring/summer) densities from 1980 through 1996 were taken from various sources (Foerster 1989, Harvey 1989, Harvey 1990, Collins *et al*. 1994, Garcia 1995, Harding *et al*. 1998). Efforts are currently underway at PRBO and other organizations to compile a master database of rail population estimates. The data and communication needs for recovery planning and adaptive management are discussed in detail in recovery actions.

Clapper rail population densities and habitat correlates

In the mid-1970s, summer California clapper rail densities in *Spartina* marshes ranged between 1 and 2 rails/ha, with lower densities (0.25-0.5) in more elevated and brackish marshes (**Figure F-1**). Winter densities from 1989-2004 were substantially lower: median (50^{th} percentile) South Bay winter density was 0.3 rails/ha; the 90^{th} percentile was 1.1 rails/ha and the maximum was 2.4 rails/ha (**Figure F-2**). Median breeding season (spring) densities across all N. Bay and S. Bay marshes from 1980 to 1993 were 0.32 rails/ha, the 90^{th} percentile was 1.4 rails/ha and the maximum was 2.1 rails/ha (**Figure F-3**). Same year winter and spring surveys are correlated (**Figure F- 4**), but can be off by a factor of ~2 in either direction.

Area of habitat is an important predictor of California clapper rail numbers but many local factors affect local California clapper rail population densities. California clapper rails require tidal channels that provide food and cover from aerial predators, so tidal channel complexity—especially 2^{nd} and 3^{rd} order channels—is positively correlated with rail occupancy (**Table F-1**; from Garcia 1995, Foin *et al*. 1997). Accreting marshes on San Pablo Bay, for example, have large areas but simple channel structure, and do not support high densities of rails. Higher vegetation along channels, especially *Grindelia*, and islands and levees provide critical high tide cover. California clapper rail densities are positively correlated with salinity: the upper reaches of the Estuary (*i.e*. Suisun Bay) and tidal rivers/creeks (*i.e*. Petaluma River) support lower densities of rails, despite extensive tidal marsh. High predator activity relates negatively to rail populations.

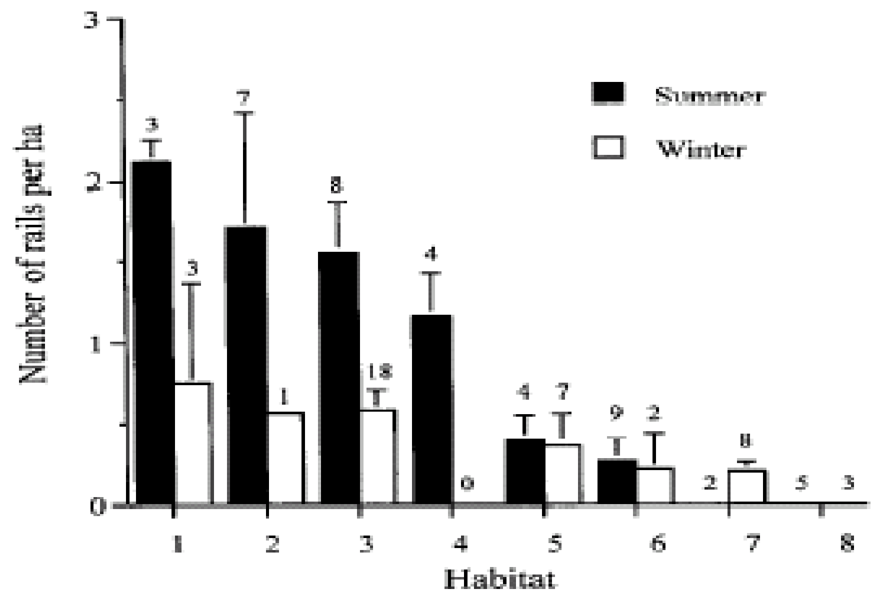

Fig. 4. Mean number of clapper rails detected per hectare (± SE) among different vegetation/habitat types in summer (16 March–15 October) and winter (16 October–15 March) throughout the San Francisco Estuary. Data are from Gill, 1979 and unpublished, representing 42 censuses each in winter and summer, conducted between 1971 and 1976. Vegetation types were classified according to the cover-dominant species of each site. 1 = *Spartina*; 2 = *Spartina–Salicornia–Scirpus* or *Spartina–Scirpus*; 4 = *Scirpus–Salicornia*; 5 = *Salicornia–Spartina*; 6 = *Salicornia–Scirpus*; 7 = *Salicornia*; 8 = *Scirpus–Juncus*.

Figure F-1. Mean number of clapper rails detected per hectare among different vegetation/habitat types in summer and winter throughout the San Francisco Estuary. (Fig 4 from Foin *et al.* 1997).

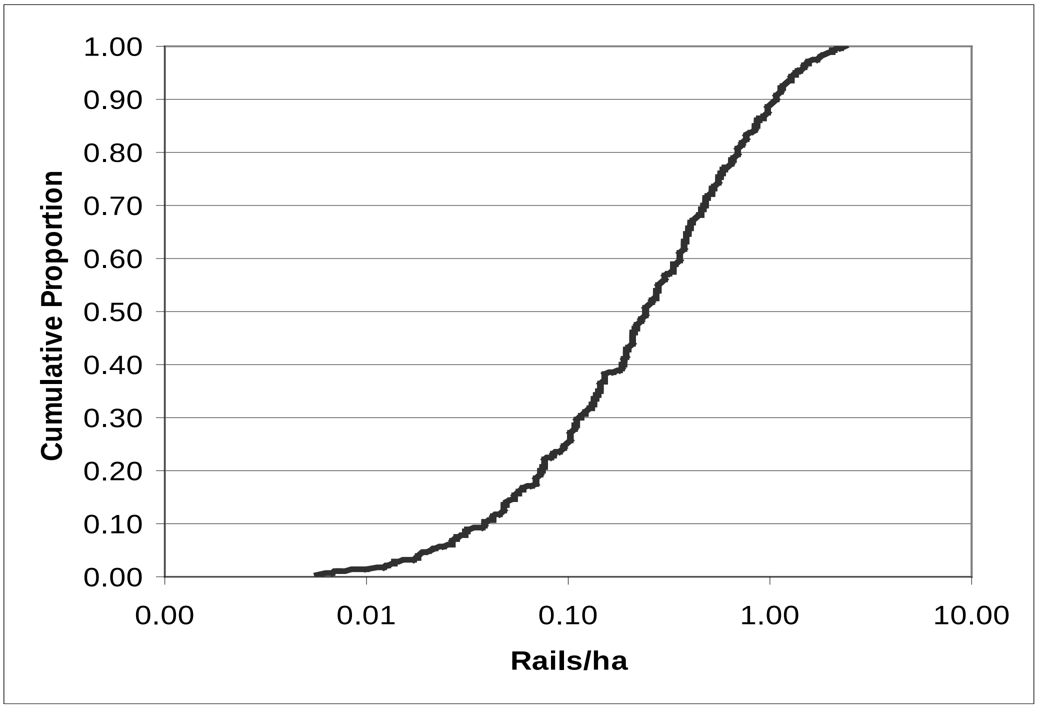

Figure F-2. California clapper rail winter densities in South Bay 1989-2004 (data from J. Albertson, SFBNWR; n = 289).

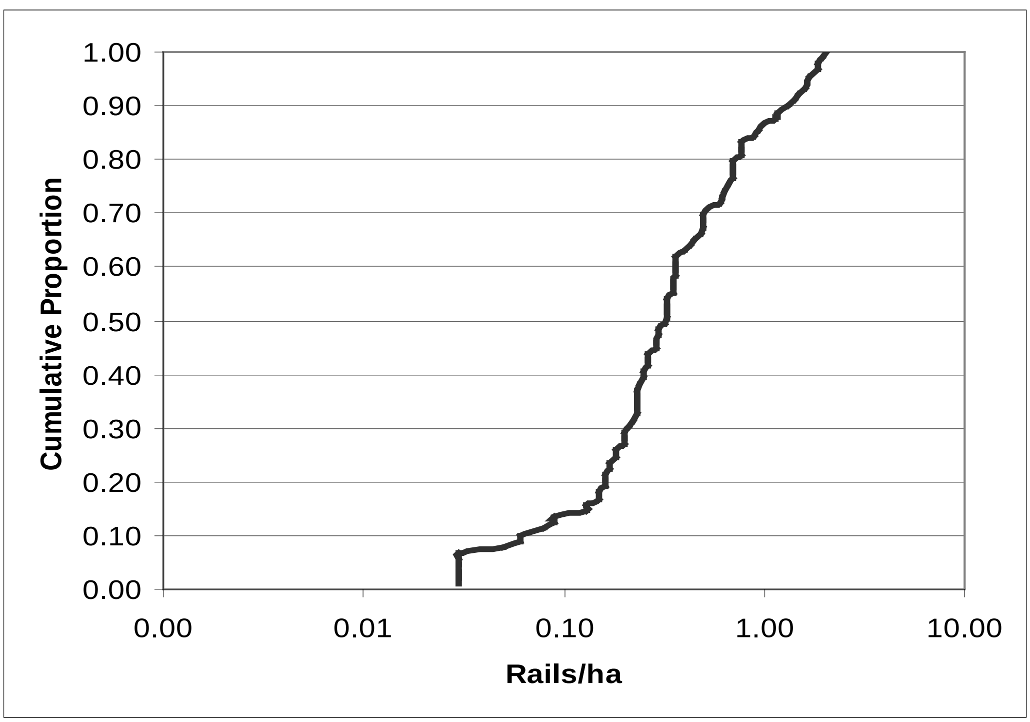

Figure F-3. California clapper rail Breeding season densities in South and North Bay, 1980-1996 (n = 88). Sources include Collins *et al*. 1994, Garcia 1995, Foerster 1989, Harvey 1989, Harvey 1990. Note that these data are incomplete, and will be updated as a comprehensive data base is compiled.

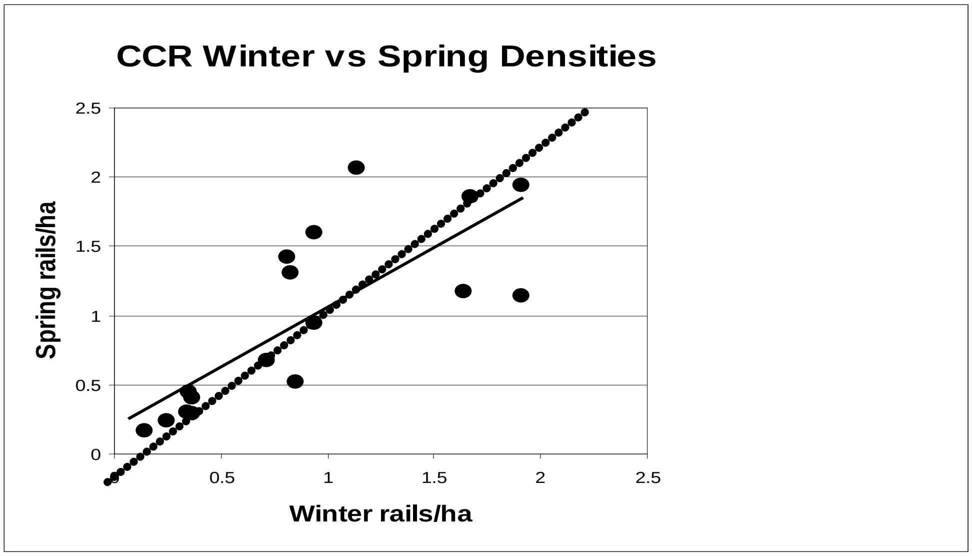

Figure F-4. Comparison of California clapper rail winter and summer densities in the same year (data from Harding *et al.* 1998). Solid line is a least-squares linear regression ($y = 0.86x + 0.20$ $r^2 = 0.60$); dotted line represents equal winter and spring densities, regression is not significantly different than 1:1.

Table F-1. Variables significantly contributing to prediction of California clapper rail occupancy (all positive contributors, overall $R^2 = 27\%$; from Foin *et al.* 1997, Table II-3).

Predictor Variable
Length of 2nd-order channels (m)
Length of 3rd-order channels (m)
Height of *Sarcocornia pacifica* in plot (cm)
Depth of channel bank overhang (cm)
Average channel depth (cm)
Surface macroinvertebrate abundance, visual scale 0-3
Cover of *Spartina foliosa* (%)

Empirical evidence from Muzzi Marsh (Marin County), the Faber (East Palo Alto), Eden Landing, LaRiviere Marsh, and elsewhere indicates that the California clapper rail populations will occupy restored tidal marshes. If it is built correctly, they will come. Once vegetation including *Spartina foliosa* and *Grindelia* was established after 5-10 years, California clapper rail populations have responded by moving in from adjacent habitats and establishing breeding populations. Densities in Muzzi Marsh and Faber Tract approach those in adjacent old tidal marshes. This response is not guaranteed; winter densities from Outer Bair Island have remained low even though the levee was accidentally breached in 1980.

Marsh restorations should aim to establish favorable combinations of vegetation cover, tidal channels, high-tide refugia, and appropriate predator control as soon as possible. Setting the trajectory towards these goals is a primary component of initial site design. In addition, the long-term trajectory of marsh development needs to be considered. These are many of the same features necessary for salt marsh harvest mouse.

We estimated the potential California clapper rail population of a given configuration of marshlands using the following elements, each discussed in more detail below:

1) Map of current and projected marshlands
2) Assignment of marsh characteristics to marshes
3) Geographic stratification
4) Assignment of ranges of California clapper rail population densities to different classes of marsh or according to specific marsh characteristics
5) Multiplication of marsh area by rail density, using fair, moderate, and high estimates
6) Mapping of potential rail population structure across proposed marshland configurations
7) Incorporation of lag times in marsh establishment/rail response

1) The EcoAtlas provides a current base map for baylands (**Table F-2**). Scenarios for restoration targets have been developed by several groups; the Goals Team, Peter Baye, and the South Bay Salt Ponds Restoration.

2) Marsh characteristics are available at several levels of resolution. The EcoAtlas divides tidal marshes into high and mid-low elevation types but this classification does not correspond to California clapper rail use of marshes. The marsh parameters in the predictive model above can be derived from aerial photography and direct measurement.

3) Geographic structure of the Bay divides the California clapper rail populations into distinct units, so regional stratification into recovery units has been undertaken. Differences between the North Bay, Suisun, and South Bay, especially salinity gradients, must be considered above and beyond the marsh-specific features.

4) **Figures F-2** and **F-3** provide the empirical data for projecting rails per hectare. These estimates can be refined by considering marsh class/vegetation, and using different densities according to predictive models based on detailed marsh characteristics (*i.e.*, **Table F-1**). However, use of percentiles may be the most effective method for establishing the range of values.

5) Multiplying Area by Density for the current and projected marshes in each geographic region will provide estimates for rail numbers. These numbers can be bracketed with "fair," "moderate," and "high" recovery results estimates according to selected percentiles. For these purposes, rail numbers will be calculated for the 60^{th} (fair), 75^{th} (moderate) and 90^{th} (good) percentiles of winter densities. Median and higher percentiles of recent population densities were used to bracket future estimated population densities because: (a) it is believed the overall recent data include substantial sampling from lower quality habitat for rails, (b) it is believed that large-scale, dedicated tidal marsh restoration efforts will result in substantially better-than-recent-average quality habitat and improved predator control, supporting densities of rails more

comparable to the higher densities reported from the 1970s (Gill 1979, Foin *et al.* 1997), and (c) higher numbers and densities of rails consistent with a recovered population are sought.

6) When these densities are mapped across the Bay, a population structure will emerge that will include numbers of discrete populations including large core populations and smaller outliers, and distances/connectivity among them. The potential sizes of demographically distinct populations form the basis for the analysis of T_e below.

7) Expected population dynamics over time are considered in this model framework, specifically lag times for marsh development and rail population expansion. In addition, the short-term impacts of predator management and *Spartina* hybrid control may also be assessed in this framework, but are not explicitly included here. The dynamic aspects of California clapper rail populations (variability through time, potential for growth or decline) are considered in the stochastic population model described below.

Example application to proposed tidal marsh restoration in South Bay

Current tidal marsh areas by reachs are presented in **Table F-2**. For illustrative purposes, the South Bay as a whole will be considered in this analysis. Goals Project target areas (Goals Project 1999) are presented in **Table F-3**.

There are approximately 900 California clapper rails in 3629 ha of habitat in the South Bay as of about 2004. The minimum proposed area of tidal marsh restoration (additional tidal marsh area) in the SBSP area is 3000 ha (50% of the Cargill purchase; L. Trulio pers. comm.); the Goals Project targets are on the order of an additional 6000 ha. At the median value of California clapper rail density (0.24 rails/ha), 3000 ha would support 720 additional rails; at the 75th percentile (0.56/ha), 1680 rails; and at 90th percentile (1.07/ha), the added area would support 3200 rails. For the Goals Project proposed restoration area (6000 ha), these numbers are approximately doubled.

The geographic distribution of restored tidal marsh complexes will create a spatial population structure that will result in some degree of demographic independence across the regions. The next section presents how California clapper rail numbers in these subpopulations can be considered in an analysis of population persistence and time to extinction.

Table F-2. Tidal Marsh Area by geographic reach (from GIS analysis of San Francisco Estuary Institute EcoAtlas data: sfei.org)

Recovery Unit	Reach Name	Hectares	Acres
San Pablo Bay:	Contra Costa West	245	605
	Napa-Sonoma	3,511	8,676
	North Marin	599	1,480
	Petaluma River	1,928	4,764
Central/South Bay:	Baumberg Area	347	857
	Berkeley	78	193
	Oakland	31	77
	Marin South	205	506
	Coyote Creek	474	1,171
	Coyote Hills	304	751
	Hayward	242	598
	Mountain View	442	1,092
	Mowry Slough	610	1,507
	Redwood City	968	2,392
	San Mateo	143	353
Suisun:	Suisun	2,835	7,005
	Contra Costa North	901	2,226
Grand Total	Grand Total	13,863	34,253

Table F-3. Goals Project (1999) south San Francisco Bay tidal marsh area goals and estimated California clapper rail population capacity based on estimated median density of 0.24 rails per hectare.

	Present (ha)	**Future (ha)**	Number of Rails	
Region	**(ca. 1998)**	**Goal**	**Present**	**Future**
South Bay	3,600	11,100	860	2,660

Stochastic Population Model: Mean Time to Extinction

The bounded random walk model of Foley (1994) provides a framework for assessing population persistence, in which the effects of population size, variability, carrying capacity, initial population size, and population trends can be examined. Each of these population factors has direct and indirect relationships to key management decisions and actions. The model can be generalized to many situations, and parameters can be estimated from time-series data when available. With additional data, the model can be expanded into a metapopulation context, in which the concept of "spreading of risk" (den Boer 1971) can be applied. This section briefly explains the theory and model and works through scenarios relevant to the California clapper rail, and is then used to establish quantitative recovery criteria—primarily the minimum area necessary for a “core” population of California clapper rail that has an acceptably long persistence time.

Because of multiplicative population growth and decline, population dynamics are best treated on logarithmic scales. A corollary of this approach is that the ratios between population sizes are more informative than absolute differences. For example, the effective difference between 100 and 200 birds is greater than the difference between 900 and 1000 birds.

The model

Full exposition of the model and application to several population persistence questions -- checkerspot butterflies at Jasper Ridge, grizzly bears in Yellowstone, wolves, and mountain lions -- are presented by Foley (1994). A key objective of the model is to estimate mean time until population extinction, T_e. Viable populations have extremely long mean time until extinction.

The population model is a bounded density-independent random walk, with population size N, and an upper bound at K (carrying capacity), and a per-capita reproductive value R_t:

1) $N_{t+1} = R_t * N_t$

Taking natural logarithms of both sides, $n_t = \ln(N_t)$, and $r_t = \ln(R_t)$, the model becomes

2) $n_{t+1} = n_t + r_t$

r_t is assumed to be a normally distributed (Gaussian) random variable, with mean r_d and variance v_r.

The mean(r_t) = r_d reflects whether the population has a net tendency to grow, or shrink - a negative r_d leads to short T_e through a deterministic trend to extinction . In general, for long (>10 year) population records, r_d is close to zero. A conservative estimate of r_d is 0: no net population growth.

The variance(r_t) = v_r, which represents the magnitude of year-to-year fluctuations, is a key variable. If v_r is low, then there is relatively little change in population size from year to year; conversely, if v_r is large, then there are considerable fluctuations in yearly population size. As a general rule, larger v_r leads to shorter T_e.

There is a maximum size K, ($\ln(K) = k$) that the population can reach, which acts as a reflecting boundary of the random walk. Extinction (N=0, or n=0) is an absorbing boundary.

The solution for T_e (mean time to extinction) for a starting number (N_0, $n_0 = \ln(N_0)$, carrying capacity k, and $r_d = 0$ is:

3) $T_e(n_0) = (2n_0/v_r)(k-n_0/2)$

If the population starts at n_0 = carrying capacity k, then the equation simplifies to:

4) $T_e(k) = k^2/v_r$

The assumption here that $r_d = 0$ (no tendency for population to grow) is a conservative one; whereas if $r_d > 0$ then the population has a tendency to grow until it hits carrying capacity. An important result is that T_e (i.e., population viability) increases as r_d gets larger. In effect, a positive r_d adds a simple form of density dependence to the model, since the population has an average net tendency to grow whenever it is below carrying capacity, and is reflected downward when it hits carrying capacity. The magnitude of r_d determines the strength or speed of the population's tendency to rebound upward after downward fluctuations. When the population starts at $n_0 = k$ and r_d is not zero, and $s=r_d/v_r$

5) $T_e(n_0) = (1/2sr_d)*[e^{2sk}(1-e^{-2sn_0})-2sn_0]$

Foley suggests that taking r_d values for the lowest ¾ of n_t values may provide an estimate of net population growth when the population is not close to a ceiling.

Interpretation of T_e (Figure 5)

The interpretation of T_e is critical to understanding the extinction process. Foley and other studies suggest that there is a constant probability of extinction each year, inversely related to T_e:

6) $p = 1/T_e$

leading to

7) $P(t) = e^{-t/Te}$

where P(t) is the probability of the population persisting from now until time t.

Equation 7 is graphed over 200 years for T_e = 100 through 2000 in **Figure F-5**. At T_e = 100, there is a 37% chance of population persistence for 100 years (conversely a 63% chance of extinction). While one might expect, given that T_e is the expected or average time until extinction, that the chance of persistence for 100 years when T_e = 100 would be 50%, this is not the case because the distribution of extinction times is skewed, with a long-right hand tail. A few populations survive for very long times, making the average time until extinction greater than the median; consequently, the majority of populations with Te = 100 actually go extinct before 100 years. For T_e = 200 there is a 61% chance of persisting 100 years, for T_e = 500, there is a 82% chance of persisting 100 years For a

95% chance of persistence over 100 years, T_e should equal 1950 years; T_e = 2000 is the upper dashed line in **Figure F-5**.

Application to California clapper rail

These equations have been programmed into a spreadsheet that calculates T_e from specified inputs (v_r, K, N_0, r_d). For application to the California clapper rail, it is assumed that K (number of rails at carrying capacity) is a function of marsh area and quality. Values of K are varied from 25 to 10,000. The model is sensitive to v_r (variance of r_t); a range from 0.05 to 0.5 has been calculated to cover the possible range of values, as well as demonstrate the sensitivity to this critical parameter

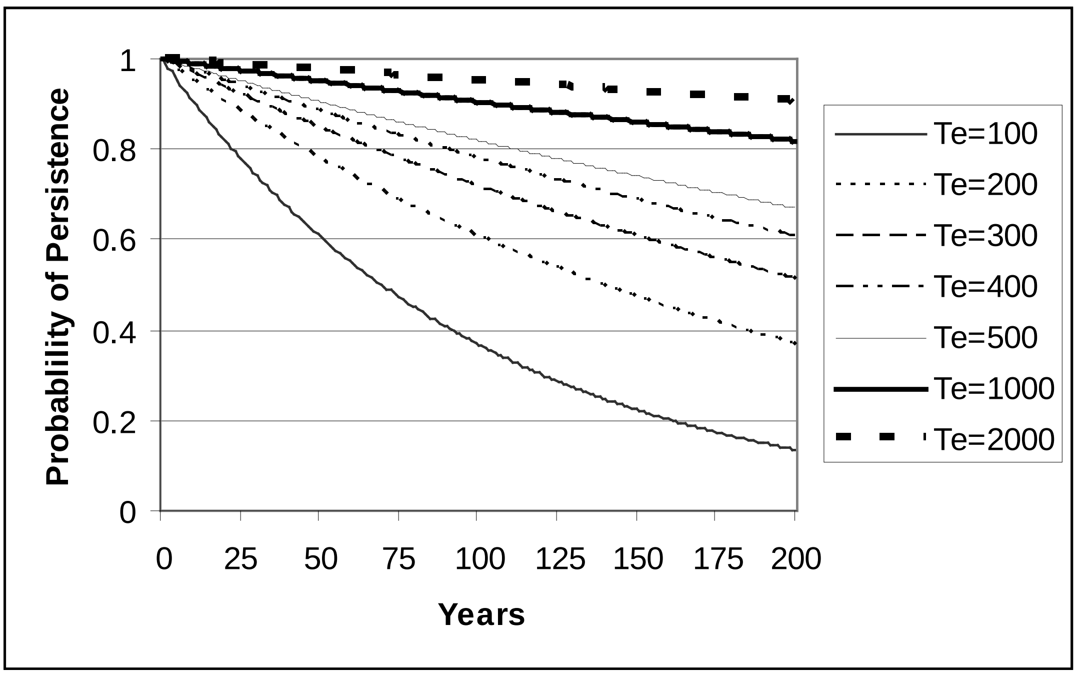

Figure F-5. Probability of persistence model. Probability of population persistence [P(t)] until time t, from Equation 7, is graphed versus t (years) for different values of mean time to extinction, T_e in years. Note that median time to extinction (time at 50% probability of persistence) is substantially less than T_e (see text).

Parameter estimation

Estimation of parameters is discussed at length by Foley (1994). Specific to California clapper rail, there are numerous estimates of rails/ha in various marshes that include time-series from which r_d can be estimated, and v_r can be estimated from numerous time series. The best current estimate of v_r = 0.26 comes from winter data in the S. Bay (**Figure F-6**). Importantly, the data are consistent with the assumption of a normally distributed variable.

Sampling error is an issue. Using raw data without consideration of sampling error leads to inflated v_r estimates, which leads to a conservative estimate of T_e (actual v_r is lower and actual T_e is higher than estimated values).

8) $v_{r(apparent)} = v_{r(true)} + v_{r(sampling)}$

Sampling variability for vocalization surveys in the North Bay is on the order of 25% (Evens and Collins 1992). If this represents a standard deviation, in the logarithmic space of the population model sampling variance translates into:

9) $\ln(1.25) = 0.223$, var $= 0.223^2 = 0.05$

Based on available information, it is believed a reasonable range for true v_r for California clapper rail is between 0.2 and 0.3. This figure may change as more data are compiled.

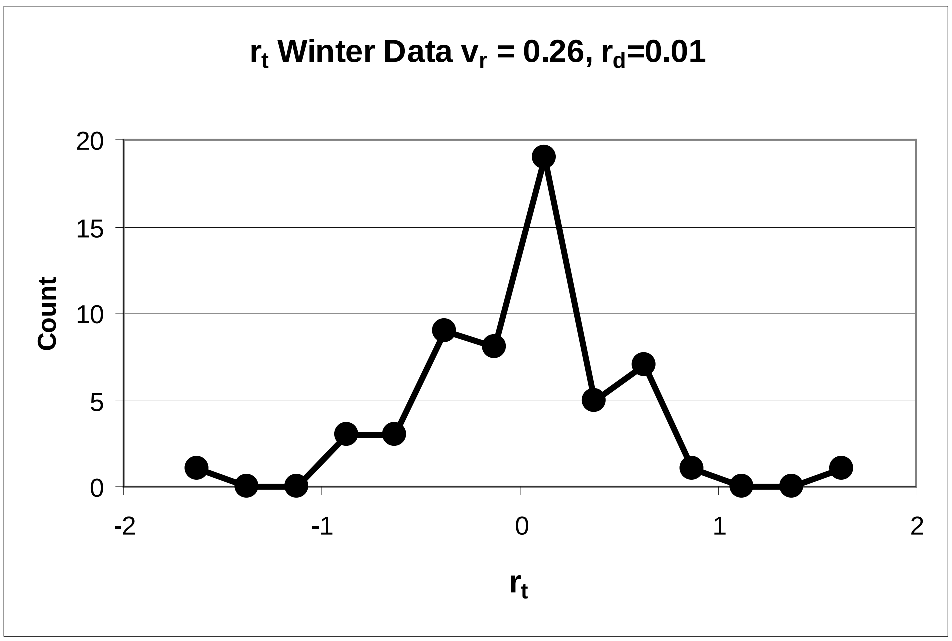

Figure F-6. Frequency distribution of California clapper rail rt (logarithmic rate of population change: see text) from J. Albertson winter data in the Palo Alto and Mowry marshes > 50 acres (20 ha) for 1989-2004.

For now, modeling will focus on isolated populations, with no immigration from (or emigration to) adjacent populations, which is a conservative (precautionary) scenario. The model can be extended to a metapopulation context, and the outline of that extension will be discussed later.

Several initial scenarios are explored to illustrate the model. These hypothetical scenarios can be adapted to fit analyses of particular existing marshes and proposed marsh restorations. Scenario 1 (**Figure F-7**) is a small initial marsh where K increases from 25 to 250 through marsh restoration ($N_0 = 25$). This approximates the small populations in remnant marshes along the Mountain View-Alviso shoreline, expanding into restored salt ponds of varying sizes up to K=250. Scenario 2 (**Figure F-8**) is a larger initial population (N_0 = 100) in marshes ranging from K = 250 to K = 2000. This scenario approximates the expansion of Bair and Greco Island populations into restored Bair Island/Ravenswood marshes, or core populations at Gallinas Creek (Marin) expanding into restored Hamilton Field marshes. The effects of a tendency for population growth (r_d > 0) are explored for Scenario 2 with N_0 = 100 and K = 250 (**Figure F-9**). Scenario 3 (**Figure F-10**) explores the effect of reintroduction size (N_0) on a K=250 marsh, and approximates a theoretical reintroduction to an isolated restored marsh or to Elkhorn Slough, Humboldt Bay, or Morro Bay.

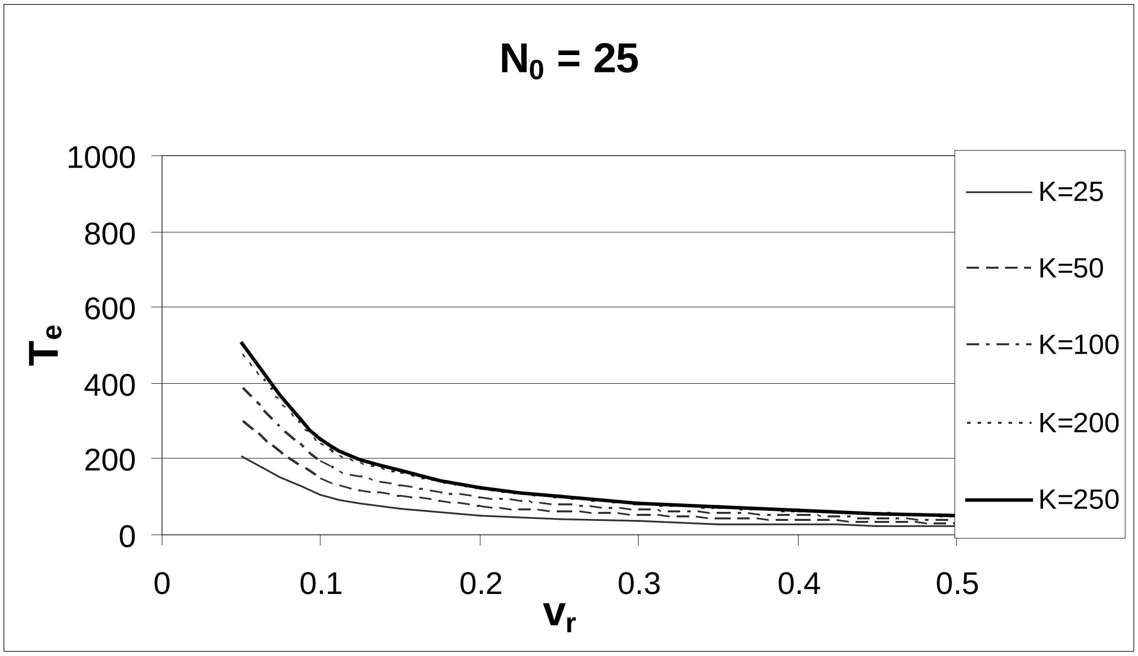

Figure F-7. Scenario 1: Smaller marshes, r_d = 0, effect of carrying capacity, K, and logarithmic population variability, v_r. Mean time to extinction, T_e, increases markedly at lower values of v_r, and increases gradually as K is increased geometrically.

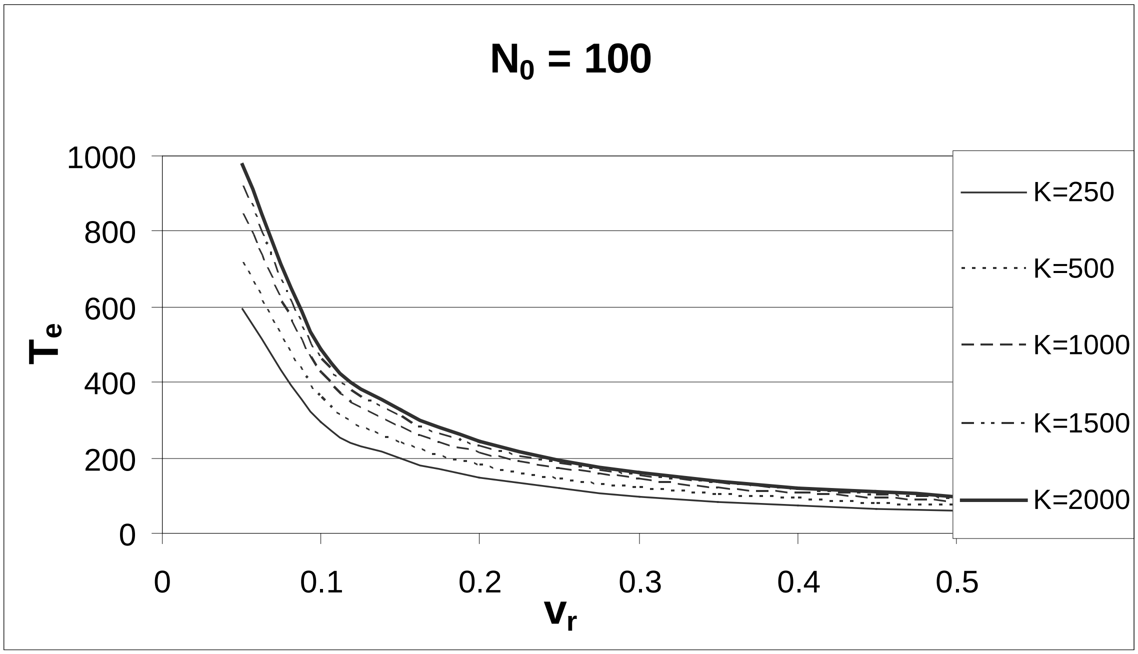

Figure F-8. Scenario 2: Larger marshes, rd = 0, effect of K and vr. The effect of vr is even more dramatic than in Figure 7; K continues to have a steady positive effect on mean time to extinction, Te.

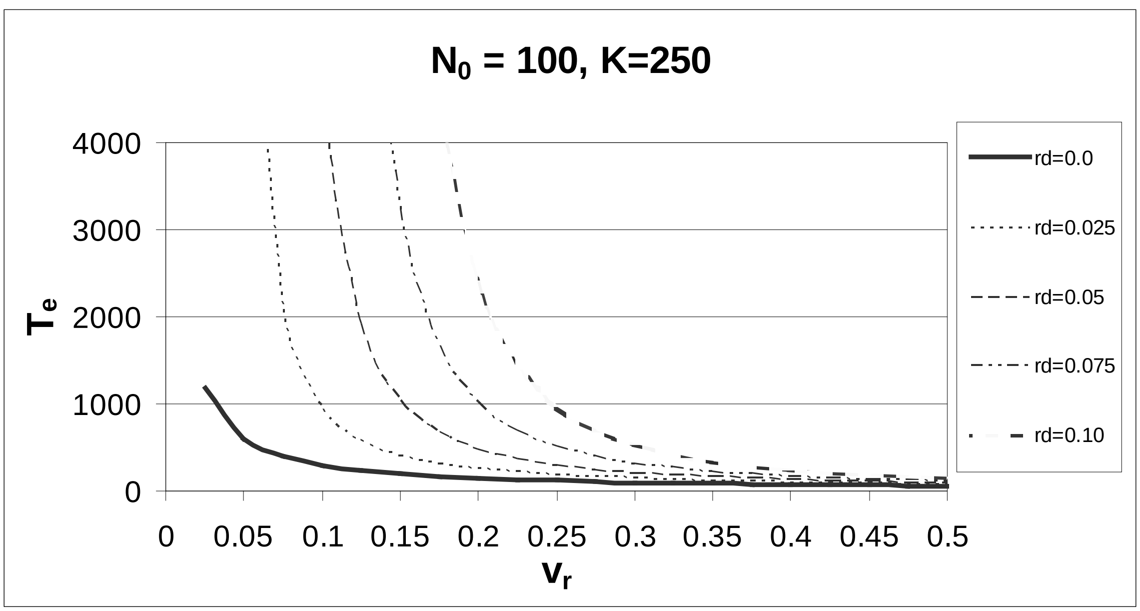

Figure F-9. Scenario 2: Larger marshes, effects of r_d and v_r. A tendency for populations to increase when below carrying capacity ($r_d > 0$) greatly increases the mean time to extinction, T_e. Values of r_d from 0.025 to 0.15 correspond to average annual growth rates when below K of 2.5% to 16.2%, respectively.

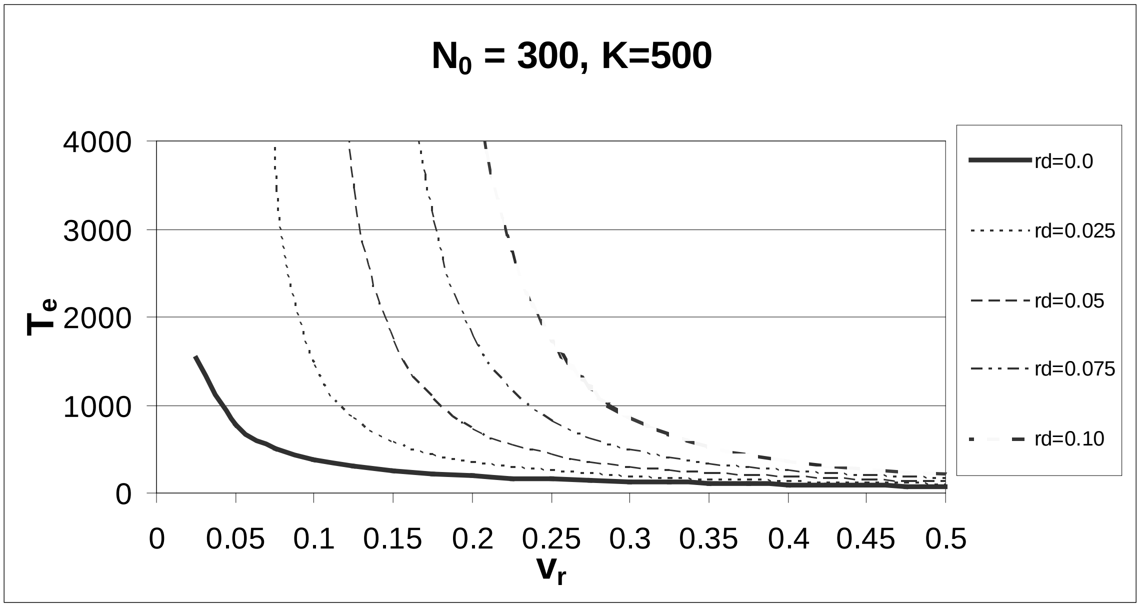

Figure F-10. Scenario for core populations, effects of r_d and v_r. Core populations can have substantial mean lifetimes if r_d can be increased and v_r decreased.

Results

For Scenario 1, Figure 7 shows the effect of 5 levels of K (individual lines) and the range of v_r (X axis) on T_e (Y axis). At $v_r = 0.25$ and K = 25, T_e = 50 years. Quadrupling K to 100 doubles T_e to 100 years; and K = 250 increases T_e to 125 years. T_e is less than 100 years for all K at $v_r = 0.3$. There is a positive effect of K on T_e throughout the range of v_r, but small marshes have a short T_e in the estimated range of v_r.

This conclusion also holds for larger marshes in Scenario 2 (Figure 8). At $v_r = 0.2$ and K = 250, T_e = 150 years, increasing to 250 years at K = 2000. At $v_r = 0.3$, T_e ranges from ~100 to 175 years depending on K.

If populations have a tendency to grow ($r_d > 0$), then T_e greatly increases (Figure 9). For N_0 = 100 and K = 250, if the average rate of increase is 10% year ($r_d = 0.095$) then at v_r = 0.2, T_e = 1250 years. Fostering conditions that encourage vigorous population recovery after downward excursions provides the strongest leverage for increasing T_e. The capacity for population growth of California clapper rails appears potentially great considering their large clutch size.

After examination of several possibilities, a core population was defined - populations considered to be central to the perpetuation and expansion of the species - as N_0 = 300 and K = 500 (**Figure F-10**). This scenario leads to T_e of >2000 years for $v_d = 0.2$, $r_d >$ 0.075 (>7.8% average annual growth when below carrying capacity).

Scenario 3 explores the impacts of initial (or reintroduction) population size into a mid-sized marsh with K = 250, using different initial N_0 ranging from 10 to 200 (**Figure F-11**). Increasing N_0 from 10 to 25 increases T_e from 100 to 125 years, but even a reintroduction of 200 only raises T_e to 150 years. This tells us that initial reintroductions do not need to be extremely large.

The last analysis (**Figure F-12**) shows the effect of K on T_e when the population starts at carrying capacity, and $r_d = 0$. Even for a population of 10,000, T_e is only ~350 years at $v_r = 0.25$, and T_e increases to 900 years at $v_r = 0.10$. This graph confirms that core populations need to be at least 500 rails in carrying capacity, and preferably 1000 or more. This analysis also suggests that the California clapper rail will remain a species at risk unless r_d can be increased and v_r reduced. Improving adult survival has previously been identified as important to reducing rail population risk (Foin *et al*. 1997). Predator control appears to be an essential strategy to increase r_d and reduce v_r, through its effect on increasing both juvenile and adult survival. Multiple populations, resulting in some hedging against the extinction risk of individual populations, will be another essential conservation strategy.

The populations modeled by this method are assumed to be demographically independent, but the model can scale to the entire rail population. Spreading of risks among subpopulations, so that asynchronous (independent) population responses occur, reduces v_r. Regional stochasticity, such as an extreme weather year (good or bad) causes correlations among population responses, tending to increase v_r. Some degree of regional correlation of population responses is the norm. An explicit spatial model of California clapper rail populations that incorporates these features and allows estimation of range-wide viability, including the ability to model particular restoration scenarios, is needed.

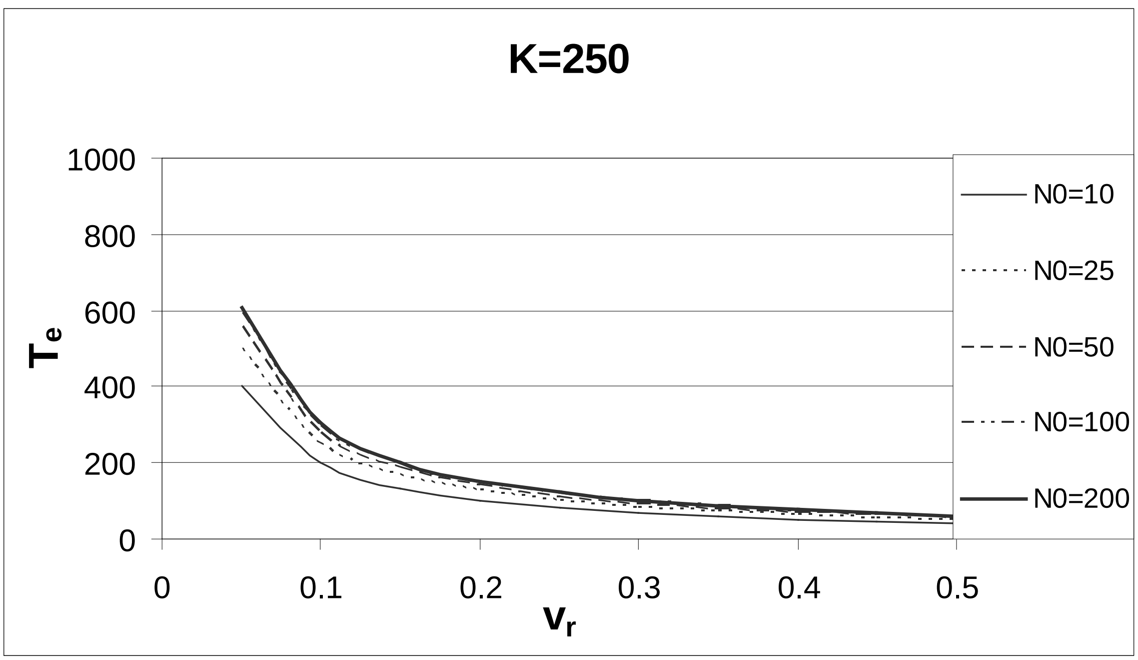

Figure F-11. Effect of initial population size in mid-sized marshes. Population persistence increases most noticeably between N_0 = 10 and 25, with diminishing benefits of larger initial sizes.

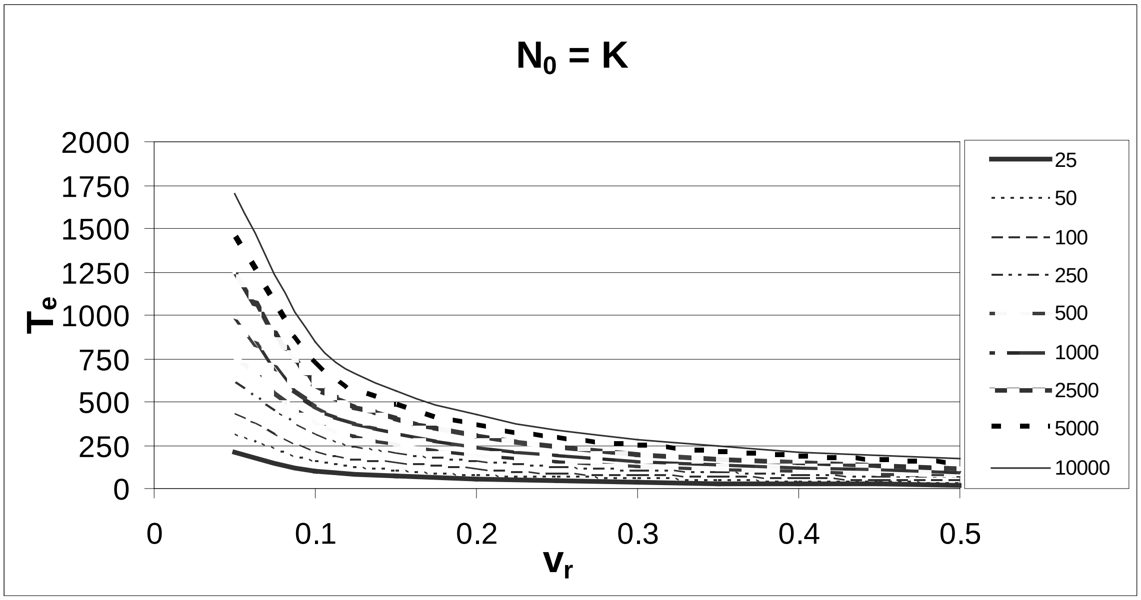

Figure F-12. Single population at N_0 = K, r_d= 0. Even for substantial carrying capacity, such as K = 1000, rail population lifetimes are fairly short ($T_e < 250$) for v_r above 0.2, and do not exceed 500 years until $v_r < 0.1$.

Summary

The above results can be summarized into the following points:

1) Small populations in small marshes have short lifetimes.
2) The largest existing California clapper rail populations have mean times to extinction (T_e) on the order of 150 to 250 years.
3) Increasing marsh size (hence rail carrying capacity, K) increases T_e, but with diminishing returns
4) Reducing v_r can substantially increase T_e for all marsh sizes. Increasing v_r over the estimated value of ~0.25 only slowly reduces T_e. Methods to reduce population fluctuation need to be explored, but possibly include creating larger contiguous habitat areas, increasing rail survival from year to year, and protecting multiple core populations with partially independent dynamics.
5) Strong leverage for increasing T_e comes from providing positive population growth, r_d, and this condition is critical to establishing populations with $T_e > 2000$ years. Regularly declining population (negative r_d), *e.g.*, due to excess predation, leads swiftly to population extinction.
6) A provisional definition of a core population is K larger than 500 rails and preferably more than 1000, with a tendency for positive population growth and low annual variability, which generates T_e in the thousands of years.
7) Even a large population (N_0=10,000, K=10,000) does not provide for long lifetimes in the absence of positive r_d unless population fluctuation (v_r) is reduced dramatically.

Management effects on population viability

Specific management actions can be translated into effects on parameters in the population persistence model. Most obvious is that expanding available habitat increases carrying capacity, K, as modeled above in Figures 7 and 8. The effects of increasing area on population fluctuations, or v_r, are less clear, but an argument can be made that larger available habitat will reduce v_r because risks from predation, flooding, and other environmental factors are spread over a larger area and the entire population will not be affected by any one factor. Reduction of predation pressure (*i.e.*, red fox control) will increase r_d, which has great leverage on increasing T_e. Importantly, a negative r_d, a likely result of high predation pressure, is a sure path to shortened T_e.

Monitoring

As marsh restoration proceeds, tracking the response of California clapper rail populations allows for assessment of success toward the ultimate recovery goals, and for adaptive management responses to local successes and failures. Surveys for California clapper rail are relatively straightforward, but can be logistically challenging and time consuming. Presence-absence can be established by call surveys during appropriate times of year, as well as visual surveys. High-tide surveys count rails when they are visible in refugia above high tide line. Breeding territories can be mapped with some precision using repeated call surveys. Demographic surveys are the most intensive, and include identification and monitoring of nests for egg hatch and chick mortality, as well as telemetry studies of adults to establish movements and mortality. Different levels of monitoring effort will be appropriate depending on the question being asked, the level of precision needed, and the scale of the study.

Levels of monitoring effort in ascending order of intensity:

1) Presence-absence: Are rails using the habitat?
2) Breeding: Are any rails breeding in the habitat?
3) Order of magnitude counts: Approximately how many rails are present in a marsh on a logarithmic scale?
4) Absolute number of breeding pairs: How many breeding pairs occupy a marsh, and how are they distributed?
5) Detailed demography: what are vital rates in the population in a particular marsh or series of marshes?

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Appendix G

Glossary of Technical Terms

accretion — growth or accumulation by deposition, usually a reference to sediment deposition

alkaline, alkali — pertaining to salts other than halite (table salt) derived from certain metals (especially calcium, magnesium) which have an basic (opposite of acid) chemical reaction

alluvial fan — a lowland deposit of sediment, formed by spreading of surface-flowing waters at or above the level of standing water. Alluvial fans are analogous with deltas, which form at or below the level of standing water

annual — in general reference, appearing each year; in reference to biological life-cycles, organisms which reproduce and die within one year

augmentation — in reference to biological population management, manipulation of a population to increase its size (number of individuals, and usually areal extent in which they are distributed locally)

backbarrier, backbarrier shoreline — the landward-facing shoreline, or back, of a barrier beach or spit, sheltered from the relatively higher wave energy that formed the barrier beach

barrier beach — a beach ridge which encloses and shelters a relatively quiet-water habitat (*lagoon*), tidal flats, or backbarrier marshes. Barrier beaches attached at one end, usually near the sand source, are called *spits*. Openings in barrier beaches that exchange tidal water are called *inlets*

beach ridge, beach — a low-relief linear deposit of coarse-grained sediments (sand, pebble, shell fragments, or organic debris) formed by waves along a shoreline at the limit of wave action or high water

benthic — existing at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers

berm — a low ridge or equivalent topographic form; often used to describe young beach ridges

bioaccumulation — the buildup of a chemical in the tissues of a living organism

biotic — relating to, produced by, or caused by living organisms

brackish — salinity that is significantly lower than seawater, intermediate between freshwater and marine salinity (marine salinity = approximately 34 parts per thousand. "Brackish" is applied to a range of salinities in soil or water that represent dilutions of ocean-strength salinity. Conventional terms in estuarine ecology, “oligohaline” (*oligo* = poor, *haline* = salt, 0.1 to 1.0 parts per thousand salinity) and “mesohaline” (meso = middle; 1.0 to 10.0 parts per thousand salinity) both fit within the more broadly defined term “brackish.” In California, “brackish” is a descriptive term for marshes with mixtures of vegetation including salt-tolerant to weakly salt tolerant species, such as tules, bulrushes, cattails, sedges, rushes, and forbs, in addition to typical salt marsh indicator plant species

calyx — as a collective unit, the sepals of a flower. Sepals lie underneath the more conspicuous petals and are usually green.

catastrophe, catastrophic — Severe rapid episodic perturbations of the environment, involving population crashes, extinctions, or large-scale physical changes that do not result in resilient, predictable rapid return to previous ecological conditions, and may result in shifts to new types of communities. Catastrophes contrast with disturbances, which may involve cyclic ecological change, and help maintain community characteristics through natural succession

colony — a spatially discrete population or subpopulation. The term is often applied to a small, peripheral, or young population

competitive exclusion — competition between species that leads to the exclusion of one from the niche

corolla — the petals of a flower, or showy unit derived from their union into a single structure such a bell-shaped, tubular, or other pollinator-guiding feature

corridor — a pathway for dispersal or movement of an organism

demography, demographic — aspects of population biology involving details of accounting and measurement of changes in births, reproductive capacity, deaths, immigration, emigration, according to organism age and developmental stages

dendritic — branching like a tree

dike, diked — large artificial berms, which are designed to obstruct movement of water, like dams. On the coast, dikes are used to exclude tidal influence from baylands. In the San Francisco Bay and Sacramento delta regions, the term *levee* is usually applied to dikes

disjunct — distribution of populations that are widely separated from a main, coherent population or cluster of populations

driftlines — lines of vegetation washed ashore and matted at the highest of high tide lines

dune slacks — brackish dune wetlands

ecotone — an ecological community that is either intermediate or continuously transitional between two other relatively well-defined community types *ecotype* — a distinct local population which is differentiated from more widespread populations by local ecological adaptations which are at least in part genetically based

edge effects — effects that enter the habitat from outside, extending from the edge inward

embayment — formation of a bay

endemic — restricted to a locality or region

escape habitat — in the context of this recovery plan, tidal refugia

estuary — a coastal embayment in which marine tidal waters with undiluted seawater mixes with freshwater discharged from terrestrial environments, producing salinity gradients (spatial trends of increasing or decreasing salt concentration, varying over time)

freshwater — water which is effectively non-saline, ranging from non-saline to "oligohaline", or very low salinity. "Freshwater" describes a range of salinities so low that physiological conditions are not harsh enough to select for a preponderance of species which are specially adapted to, or tolerant of, saline conditions. "Freshwater" contrasts with "brackish" (low salinity)

extirpated — locally extinct

fecundity — a measure of production of offspring

floret — a small, specialized flower which composes an inflorescence that looks like a single flower to pollinators

fluvial — of, relating to, or living in a stream or river

founder, founder population, founder colony — the pioneer individual or individuals of a species which establish a new population at a location which was previously unoccupied by that species when the founders first established

frass — insect excrement

geomorphology, geomorphic — the study of earth surface landforms in terrestrial, wetland, estuarine, and shallow marine environments, and the physical processes (including biotic interactions) which form them; factors pertaining to the development of landforms

gene, genetic — pertaining to hereditary factors of origin in living organisms, traits passed on from one generation (sexual or asexual) to the next. Genes are the units of hereditary information, coded in the complex DNA (deoxyribonucleic acid) of the chromosomes in nearly all living cells of an organism

genetic individual — a genetically unique and distinct product of a single fertilized egg, the product of sexual reproduction. In organisms which naturally clone themselves (vegetatively propagate, such as by rhizomes, runners, division; asexual propagation or reproduction), many apparent "individuals", either scattered or in congested, uniform patches, may represent a single genetic individual. Many plants with spreading growth forms are both clonal and sexual, and form patches of genetically uniform individuals, with each patch derived from a genetically distinct seedling. In organisms which have unitary body-structure (most higher animals), apparent individuals are typically also genetic individuals unless they develop from unfertilized eggs (asexual reproduction). In plants, a genetic individual is also know as a *genet*, to contrast with the minimum growth unit of a free-living individual plant of either a unique or cloned (copied) genet, the *ramet*

glacial, *glaciation* — pertaining to ice-ages, prolonged geologic periods of global cooling when large ice-sheets covered extensive areas of the earth's temperate and arctic regions, and high mountains. Glaciation last occurred during numerous intervals of the Pleistocene epoch, which ended about 12,000 years ago. Glaciations were associated with sea levels much lower than modern sea level, since much of the earth's water was stored in mile-thick ice sheets instead of the ocean

gland, *glandular* — in plants, a small surface structure which exudes secretions ranging from "raw" sap to physiologically processed fluids such as concentrated salts or metabolic products (resins, oils, waxes, toxins, sticky substances, etc. In animals, structures which secrete either salty fluids, organic wastes, or specialized metabolic products.

glaucous — pale green with a whitish cast

gradient — the gradual inclination, or change, of a geologic feature or characteristic, such as salinity

halophyte, halophytic — plants that typically occur in salty environments and are capable of growing and reproducing there; plants that tolerate saline soil

haustorial — having a food-absorbing outgrowth of a plant organ (as a hypha or stem)

hemiparasitic, hemiparasite — plants that are capable of establishing parasitic connections to host plants, and drawing resources (such as water, metabolites, mineral nutrients) from them to their benefit, but which do not necessarily require such connections to survive in favorable conditions

historic range — the geographic distribution of a species at or shortly before the beginning of written records of species abundance and distribution

Holocene — the "recent" geological epoch following the end of the last ice age, about 12,000 years ago, during which sea level rose from about 300 feet below its present elevation to its modern, increasing level

hybrid swarm; introgression — the entry or introduction of a gene from one gene complex into another (as by hybridization)

hydrology, hydrologic — the study of the physical properties of water movement near the earth's surface, and factors pertaining to water movement

hydroperiod — the frequency and duration of inundation or saturation of an ecosystem *hydrogoemorphic* — involving the interdisciplinary science that focuses on the interaction and linkage of hydrologic processes with landforms or earth materials and the interaction of geomorphic processes with surface and subsurface water in temporal and spatial dimensions

hypersaline — pertaining to salt concentrations significantly higher than marine salinity of about 34 parts per thousand, usually associated with evaporative concentration of brine

impoundments — a body of water formed by damming

inbreeding — sexual reproduction among closely related individuals

inbreeding depression — loss of viability (vigor, adaptability, ability to survive in the environment) and/or fecundity (production of offspring) associated with sexual reproduction among closely related individuals

inflorescence — any defined branch system of flowers

inlets — incompletely closed barrier beaches

intergrades — to merge gradually one with another through a continuous series of intermediate forms

invasive — reproducing or otherwise spreading rapidly and in large numbers in a habitat, often becoming dominant to the detriment other (usually native) species

lagoon — a wave-sheltered, semi-enclosed shallow water body derived from a tidal source such as a bay or ocean coastline. Natural lagoons are often related to *barrier beaches* with either inlet constrictions to tidal flows (*e.g.*, Bolinas Lagoon), or partial to complete restriction of tidal flows (Rodeo Lagoon, Abbotts Lagoon), with intermittent tidal influence from storms or breaches in tidal barriers. In California, natural lagoons usually occur near the heads of bays, or the mouths of coastal drainages and streams where beach ridges form. *Tidal lagoons* associated with terrestrial drainages may include tidal mudflats, sandflats, channels, subtidal open water, or mixtures of these, are essentially small estuaries. *Artificial lagoons*, such as salt ponds (salterns, solar salt evaporation ponds, sabkahs) or managed waterfowl ponds, are formed by man-made dikes rather than barrier beaches.

Lepidopteran — of the order of insects (Lepidoptera) including moths and butterflies

levee — in natural stream or marsh systems, a levee is a low ridge or berm of sediment deposited by stream flows over bank edges, which reinforces the confinement of flows in the channel, and restricts drainage of water from adjacent marsh plains or floodplains back into channels. In artificial systems, levees are synonymous with dikes.

MHHW — average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch

MHW — average of all the high water heights observed over the National Tidal Datum Epoch

MSL — arithmetic mean of hourly heights observed over the National Tidal Datum Epoch

MLW — average of all the low water heights observed over the National Tidal Datum Epoch

MLLW — average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch

marsh island — a marsh which is surrounded by open water or open, unvegetated tidal flats, lacking direct connections or bridges to terrestrial habitats

marsh plain (*tidal marsh plain*) — the relatively flat expanse of tidal marsh which forms near the upper limit of regular monthly tidal elevation. On the California coast, marsh plains in areas sheltered from waves are usually close to the elevation of mean higher high water.

metapopulation — a theoretical approach describing structural and dynamic relationships among multiple populations, involving the extinction and recolonization of the populations

microtidal — a tidal environment which has a relatively small or restricted vertical tidal range. Globally, "microtidal" may refer to tidal environments up to 2 meters (over 6 feet) in vertical range (daily rise and fall), but in the context of California estuaries, "microtidal" refers to portions of estuaries or embayments with occluded tidal circulation and minimal, damped vertical tidal range (less than about 30 centimeters [1 foot] daily rise and fall). "Muted tidal" or "muted marsh" is a term applied to wetlands with tidal range significantly restricted by dikes and tidegates San Francisco Bay.

mitigation — Actions which address an adverse environmental impact or influence by either (1) avoiding the impact (redirecting it or stopping its cause); (2) reducing or minimizing the magnitude, scope, or intensity of the impact; or (3) compensating for the impact by replacing or substituting for the [natural] resource, or ecological functions, which are impaired, suspended, or eliminated.

mudflat — unvegetated, water-deposited flats of fine sediment (mud: silt to clay) which are almost always wet. Mudflats in an estuary are usually types of tidal flats, but when non-tidal waterbodies such as ponds or lagoons (such as salt ponds or duck ponds) dry or draw down, they may expose nontidal pond-bottom mudflats.

non-native — in a practical sense, any plant population which established after dispersal by human conveyance (deliberate or accidental) in historic times (following European contact or settlement), and was not present in the flora during the time indigenous people occupied the land exclusively.

null zone — zone of no current and highest sediment deposition *overwash* — overtopping of beaches, spits, or coastal dunes by extreme high tides; in California, usually associated with periods of erosion under storm conditions in California. See also *washover*.

pan — (usually as *salt pan*) Pans are relatively flat-bedded localized wetland areas which are unvegetated, and concentrate either hypersaline brine or salt crusts by evaporation. Pans range from marsh depressions ("tidal marsh ponds" which are usually ponded and flooded only by spring high tides, storm surges, stream flood discharges, or rainfall only) to relatively higher flats or gently sloping fans which are only occasionally and briefly flooded ("high salt pans"), and are often playa-like plains. Pans at tidal marsh edges also can grade into seasonal wetlands influenced by freshwater drainages, seeps, and springs.

pappus — an appendage or tuft of appendages that crowns the ovary or fruit in various seed plants and functions in dispersal of the fruit

perennial — plants that live three or more years

peripheral — on or near an edge or constituting an outer boundary

phylogenetic — based on relationships between species over evolutionary time

plastid — organelles that are the site of manufacture and storage of important chemical compounds used by the cell

Pleistocene — the geologic epoch of the Quaternary era in which multiple glaciations (ice ages) occurred. The Pleistocene epoch ended about 12,000 years ago, and was followed by the Holocene, the "recent" geologic epoch in which sea level rose to its modern position.

polydactyly — the condition of having more than the normal number of fingers or toes

population — in the ecological context, a population is a group of potentially reproducing individuals within a species which are geographically or ecologically segregated to a significant degree from other populations. Populations may be interpreted at different spatial scales. "Distinct populations" usually refer to those with significant contrasts in genetic characters, or those with well-defined geographic or ecological boundaries. This is not to be confused with "distinct vertebrate population segment," which is a distinction specifically defined by policy (61 FR 4722).

refugium (plural- refugia) — an area providing protection to a species from a threat or threats

reintroduction — the re-establishment of a species to an area in which it had been extirpated. Reintroduction may refer either to habitat within the vicinity of a past population, or within the approximate historic range of a species. The geographic precision of "reintroduction" varies with factors such as its historic pattern of distribution, the rigor of data on historic localities, and mechanisms and patterns of dispersal. The term contrasts with "introduction", which refers to artificial establishment of a species in novel habitat, or locations distinctly outside its known historic range (*e.g.*, dispersed by humans across strong natural geographic or ecological barriers; see also *non-native*).

resilience — their ability of populations to recover naturally following disturbances or catastrophes

rhizomes — somewhat elongate usually horizontal subterranean plant stems that are often thickened by deposits of reserve food material, producing shoots above and roots below, and distinguished from a true root in possessing buds, nodes, and usually scalelike leaves

riparian — pertaining to small drainages,creeks, streams or rivers; usually refers to the vegetation or habitat along the banks of these, and in California the term most often applies to woody vegetation (shrubs and trees)

rosette — a dense circle of leaves near ground level growing from an unexpanded stem tip near ground level

salinity — saltiness, the concentration of dissolved salts in sediment or water

salinity gradient — the shift towards increasing or decreasing salt concentration with distance and direction

salt pans — unvegetated, poorly drained flats or depressions which can concentrate salts through evaporation; intermittently ponded saline habitats

scalds — shallow, summer-dry salt pans largely devoid of vegetation

scarification — cutting the seed coat using abrasion, thermal stress, or chemicals to encourage germination

scarps — a line of cliffs produced by faulting or erosion

seasonal wetland — wetlands which have waterlogged soils, flooded or inundated condions only around the annual rainfall season (in California, winter or spring), but becoming either well-drained or desiccated in arid rainless seasons. They contrast with perennial wetlands, which have at least waterlogged soils most of the year.

sediment — particles of rock, mineral, shell fragments, or debris which are eroded, transported, and deposited by moving water, waves, or wind. Sediments are also classified by particle size (texture). The smallest (finest) mineral particles are *clays*, which remain suspended in water for relatively long periods of time, and tend to stick to each other when left undisturbed. *Clay* sediments have very small pore spaces, and are relatively impermeable to moving water. *Sand* is made of rock, mineral, or shell fragments which stick together very weakly, and are quite permeable to water because of the large pore spaces between sand particles. *Silt* particles are small enough to remain suspended as cloudiness (turbidity) in water, or dust in air, and have some cohesion (stickiness, plastic texture when wet), but are large enough to settle in quiet water and be relatively permeable to water. *Pebbles* and larger *cobbles* are large particles which cannot be moved by normal storm winds, and require high-velocity currents or energetic waves to be transported.

seed bank — the dormant viable seeds in the soil. Persistent natural soil seed banks have viable seeds which can maintain latent, dormant populations for very long periods of time even though growing plants may be absent, or apparently extirpated.

seed banking — the deliberate conservation practice of collecting and storing seeds artificially

shell hash — finely eroded shell fragments

silt — see *sediment*

slough — in California, a large tidal creek or former tidal creek (channel segments peristing after tidal connections have been blocked). *Slough system* refers to tidal creek networks.

spits — barrier beaches attached at one end, usually near the sand source

stamen — the stalked flower structure which supports a sac (anther) containing pollen; in popular understanding, the "male" part of a flower.

stewardship — in the context of this recovery plan, stewardship refers to the involvement of interested citizens (professional or amateur conservationists) or local community groups in the practical management, protection, and observation of natural area reserves. Stewardship contrasts with conservation management conducted solely by government agencies and professionals working under their direction.

style — the stalked structure at the summit of the floral axis which is a conduit for the growth of pollen tubes, connecting the pollen-receptive stigma surface with the ovary (chamber bearing ovules, the unfertilized seed precursors)

stigma — the tip of the carpel (popularly understood as the "female" flower part) which traps pollen and provides a medium for germination of pollen grains

subpopulation — a subdivision or subordinate group (subunit) within a population. Subpopulations may include discrete colonies, local concentrations within large, loosely defined populations, or local breeding neighborhoods which are not geographically distinct.

subsaline— moderately saline

subshrub— woody only at the base

subsidence— depression of ground surface elevation below sea level

surge, storm surge - the additional rise in sea level above a predicted astronomic tide, due to meteorologic influences, such as wind-generated waves (wave "set-up", or piling up of water) low barometric pressure, and onshore winds.

synchronous — happening, existing, or arising at precisely the same time *taxon, taxonomic* — taxonomic unit, whether named or not: *i.e*. a population, or group of populations of organisms which are usually inferred to be phylogenetically related and which have characters in common which differentiate the unit (*e.g.* a geographic population, a genus, a family, an order) from other such units

teratogenesis — prenatal toxicity characterized by structural or functional defects in the developing embryo or fetus

tidal datums — standard elevations defined by certain phases of the tide and used as references to measure local water levels

tidal marsh — a wetland found along coasts and estuaries which is vegetated with emergent (above-water), nonwoody vegetation, mostly grass-like plants or broadleaf plants (forbs). The flooding characteristics of such marshes are determined by the tidal movement of the adjacent estuary or ocean.

tidal prism — the volume of tidewater in flux between successive high and low tides

tide, tides, tidal — changes in sea level due to the gravitational pull of the moon and sun generating a long, slow wave, the *astronomic* (= star-influenced) *tide*. This true *tidal wave*, the moving bulge in sea level associated with astronomic tides, is not the same as the popular concept of a "tidal wave" caused by earthquakes, properly called a *tsunami*. The vertical rise and fall of the tide is known as the *tidal range*, which may be expressed the average difference in sea level over a given period of time, such as a day, month, or longer periods. *Microtidal* environments (applied to coasts, embayments, or estuaries) refer to tidelands and waterbodies with relatively small tidal ranges; *mesotidal*, intermediate tidal range; and *macrotidal* refers to large tides. *Flood tides* are rising tides; *ebb tides* are falling tides. *Spring tides* are not the tides in spring months, but the tides with greatest tidal range of the year, caused by alignment and reinforcement of the gravitational influence of the sun and moon. *Neap tides* are the weakest tides of the year (smallest tidal range), caused by antagonistic alignment of the gravitational pull of the sun and moon. The "high tide line" usually refers to the position (indicated by watermarks such as driftlines or erosional edges) of the highest tide within a time period of reference, usually a year in ecological contexts.

transgression, transgressive — in the context of coastal shorelines, transgression refers to the landward movement or migration of a shoreline. Shoreline transgression is associated with either coastal erosion, sea level rise, or both. In the context of coastal marshes, transgression also refers to the landward migration of the edges of tidal marshes, as low-lying landforms are gradually "drowned", or subjected to tidal influence, where they had previously been above tidal influence.

trophic — of or relating to nutrition

type locality — original location at which a species is identified

uplands — terrestrial environments free from tidal flooding *vernalization* — the acquisition of the competence to flower in the spring by exposure to the prolonged cold of winter

vernal pool, vernal swale, vernal marsh — in California, vernal pools refer to a particular class of seasonal wetlands in isolated drainages with very shallow soil root zones that become strongly desiccated in summer, but are inundated (ponded) in winter or early spring. They typically are dominated by annual plants, and often have soil layers which are restrictive to subsurface water movement. The term "vernal" means spring, and refers to the often showy, ornamental displays of colorful annual flowers which appear as the pools dry up. They are also known as winter pools or hogwallows. Vernal swales are similar and related features which are shallow drainages (often terminating in pools) with very slowly flowing water during periods of high rainfall. Vernal marshes (or lakes) refer to very extensive shallow winter-ponded areas which are mostly desiccated in summer, but include a substantial proportion of summer-dormant perennial marsh vegetation.

viable — capable of existence and development as an independent unit

washover — alluvial fans or terraces of sandy sediments formed by tidal surges (extreme high tides) forming gently sloping gradients on overwashed beach ridges, spits, or coastal dunes. Washovers naturally include gradual ecotones between salt or brackish marsh and beach or dune communities on barrier beaches. Sometimes used synonomously with overwash, the process of flooding and deposition.

wrack — marine vegetation, especially seaweed, cast ashore in masses

Appendix H

Summary of Major Public Comments and Service Responses on the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*

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* = Asterisk represents comments submitted by peer reviewers of *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*.

1. Grouped comments

a.) Climate-change/Sea level rise

1.) **Comment:* Twelve commenters stated that considerably more area should be included within the recovery unit boundaries in order to ensure that sufficient acreage of high tidal marsh and upland refugia remains to support rails and mice and to ensure their recovery as sea level rises. These commenters suggested that actions that enable upland movement of tidal marsh should receive the highest priority rating and that these actions should be integrated throughout the TMRP text. They strongly felt that recovery unit boundaries should capture wetland transgression areas (former marshes, moist grasslands, and upland areas that would allow wetlands to move inland). One commenter stated that the attempt to restore tidal marsh to the deeply subsided areas such as those in the southern part of San Francisco Bay, even though adequate sediment may not be available in sufficient amounts to accomplish restoration, would seem to merit low priority.

Response: The Service agrees that conservation of undeveloped lowlands bordering occupied or suitable endangered species habitats in tidal marshes must be an essential high priority to adapt high marsh-dependent species to accelerated sea level rise Therefore, criteria for all 5 covered species (under Factor E) specifies that 'High marsh/upland transition lands, when and wherever possible, must be preserved or created as part of new marsh restoration efforts and managed to provide opportunity for landward migration of species in response to sea level rise.' In addition, nearly all actions under Action 2.2.2 were re-written to include ecotone restoration with the tidal restoration recommendation. Finally, Action 1.2 also relates to preservation/restoration of ecotonal habitat.

In the Draft document, the recovery unit boundary was based on the historic 100-year flood line. To more accurately reflect most recent estimates of anticipated sea level rise, revisions to the recovery unit boundaries have been made. Using data associated with the medium to medium-high emissions scenario described by Heberger *et al*. (2009), which predicts 1.0 to 1.4 m (3.3 ft to 4.6 ft) of sea level rise by 2100, the extent of sea level rise by 2100 has been overlaid, in light blue masking, on restoration maps. The decision was then made to make the landward extent of sea level rise the new recovery unit boundary, thereby shifting the boundary landward when compared to that in the Draft document. Areas occupied by hard development were excluded, however, from this new boundary. This revised recovery unit boundary better reflects geographic boundaries important to tidal marsh recovery during higher sea levels, as it would incorporate opportunities for landward transgression of habitat and species.

This revised focus places an increased emphasis on preservation of high marsh ecotone and low, gently sloping, undeveloped areas adjacent to existing marshes, in the few locations where they exist. This revised emphasis reduces the reliance on subsided baylands that hold low potential as future habitat. Also, text has been revised under the recovery actions specific to the rail to clarify that lands considered suitable habitat should anticipate future sea level rise.

2.) *Comment*: Ten commenters suggested that the draft recovery plan include an expanded discussion of the effects of climate change, especially in regard to sea level rise, on tidal marsh habitats and species. They suggested citing updated predictive models and using the best available science to describe sea level rise as a central threat (versus a primary threat) to the long-term survival of tidal marshes; to consider in a quantitative fashion how high rates of sea level rise may affect available habitat, specific species, and associated recovery goals; and to develop recovery strategies with a focus on the central threat of sea level rise. One commenter thought it might be best to address changing science in regard to climate change through an addendum to the recovery plan and another wanted it stated explicitly in the text that climate change effects are time-delayed, long-lasting, and largely irreversible. One commenter said the *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (TMRP) needs to develop and consistently apply an updated, unified, simple, robust, and integrated conceptual model of the effects of accelerated sea level rise on tidal marsh ecosystems and listed species.

Response: The Service has made every effort to remain informed about the rapidly changing science of climate change and resulting sea level rise. Climate change was described in the Draft document as a primary threat, falling under Factor E Threats to California's Tidal Marsh Ecosystems in the Introduction. However, the recovery plan has been revised to incorporate estimates from the latest sea level rise and marsh accretion models (which have been uniformly adopted by the majority of resource agencies) to place greater emphasis on sea level rise as a central threat, and to discuss in more detail, the anticipated effects to the ecosystem and tidal marsh species, to the extent they are known.

Text has been revised by adding language about specific effects of anticipated increased salinity at the plant community level. However, in most cases, little is known about species-specific effects, therefore, no text has been revised in that regard. Recovery strategies were developed incorporating the current models for anticipated sea level rise. The U.S. Fish and Wildlife Service (Service) is aware that due to sea level rise, land currently meeting the tidal marsh acreage criterion will likely differ from what meets this criterion in the future. Text has also been added to discuss the characteristics of climate change effects, such as storm surge intensity, which have the most damaging implications to tidal marsh recovery. It should be noted that recovery plans may be revised after their publication. Should future scientific study change our knowledge of how sea level rise will affect California tidal marshes, it may become necessary to amend this TMRP.

Finally, development of a conceptual model to predict effects of sea level rise, as one commenter suggested, is outside the scope of recovery planning at this point in the recovery planning process. However, it is appropriate to add such a model as a Priority 1 recovery action, therefore the text has been revised accordingly.

3.) *Comment*: Three commenters noted that the plan should discuss in more detail the anticipated effects of sea level rise on, specifically, rising salinity in the marsh and the shift in the salinity gradient. They urged a more complete discussion of the projected effects of those salinity changes on tidal marsh ecosystems.

Response: Text has been added to emphasize anticipated climate-driven changes related to salinity. Also, text has been revised to incorporate effects of those salinity changes, to the extent we know them.

4.) *Comment:* One commenter recommended adding the following regional recovery strategy: 'Create mid/high marsh and refugia habitat to replace marsh and refugia that will be lost to rising sea level.' This reviewer also suggested ensuring undeveloped baylands and uplands adjacent to the Bay are included within the Recovery boundary in order to identify opportunities for restoration/recreation of these habitats, and to encourage acquisition and restoration efforts on these lands.

Response: This action was not added to the Stepdown Narrative (stepped down recovery strategy) because it is already recommended via Actions 2.2.2.1 through 2.2.2.9 (now Actions 2.2.2.1 through 2.2.2.7). The restoration maps have been revised by moving the recovery unit boundary landward, thereby accommodating a larger potential area within which restoration to bayland habitats should occur.

5.) *Comment:* Two commenters suggested that because sediment accumulation is critical for marsh stability especially in the face of sea level rise, the TMRP should encourage the use of dredged material from the Bay as part of a regional sediment management strategy.

Response: Text has been revised, under Regional Recovery Strategies, to encourage the beneficial re-use of dredge material.

6.) **Comment:* The TMRP's conclusion that it "remains uncertain whether accretion will keep pace with accelerated sea level rise and other climate-related effects; California's tidal marshes may either rise with rising sea level, or erode or drown" should be revisited.

Response: The text has been revised. Though language regarding Orr *et al*.'s (2003) study was retained, text was added to mention the later work by Callaway *et al*. (2007) which makes marsh loss the more likely scenario than marshes accreting sediment at a sufficient pace.

7.) *Comment:* To illustrate how species distributions and future sea level rise scenarios could be displayed in a map, one commenter created maps that highlight remaining open space, including agricultural and grazing lands that can provide refuge from sea level rise, which should be made a top priority for acquisition, protection, and management.

Response: The Service appreciates the development of these maps and has used them to revise the restoration maps. Specifically, they were used to reshape or add mapping units (polygons).

8.) *Comment:* One commenter stated that each of the five ecosystem-level strategies should more explicitly include goals specific to reducing climate change threats to listed species.

Response: General climate change text was added to the first and last ecosystem-level strategy. Recommending specific climate-change related actions is not appropriate at this tier of strategy discussion.

9.) *Comment:* One commenter stated that the Regional-level and Species-level Recovery Strategies do not include sufficient guidance on place-based and species-specific recovery actions to reduce climate change threats.

Response: No revision has been made. Under our *Interim Endangered and Threatened Species Recovery Planning Guidance* (NMFS and USFWS 2010), a Recovery Strategy is intended to give an overview of the approach to the recovery efforts for the species; site-specific actions are presented in the Stepdown Narrative. No specific suggestions were made by commenter.

10.) *Comment:* One commenter stated that recovery plans for species threatened by climate change should recommend reductions in greenhouse gas emissions as a matter of urgency.

Response: No text has been added recommending reductions in greenhouse gas emissions because the scale of the greenhouse gas emissions problem and its control is beyond the scope of this recovery plan. However, the Service is moving aggressively to address the challenges of climate change. We have a draft Strategic Plan for Climate Change that focuses on adaption, mitigation, and engagement with partners to seek solutions to the challenges to fish and wildlife. Created in concert with the strategic plan is a five year action plan that outlines tasks that the Service will pursue to address climate change. One way the Service is already taking action is through the creation of the Landscape Conservation Cooperatives (LCCs) which are management-science partnerships that inform integrated resource-management actions addressing climate change and other stressors within and across landscapes.

11.) *Comment:* One commenter stated that future projected increases in salinity due to decreased freshwater inflow in spring (Knowles and Cayan 2002) and sea-level rise (N. Knowles, unpublished data) suggest that salinity reduction measures may be needed to retain species associated with brackish and fresh conditions.

Response: No text has been revised. It is most likely that, in the face of sea level rise and the resulting increase in salinity, the boundary between brackish and fresh water environments will move landward, assuming there is land available to accommodate this change. Should artificial reduction of salinity be found necessary, the Suisun Marsh Salinity Control Gates could potentially serve that purpose.

12.) *Comment*: One commenter stated that maintenance of all existing tidal marshes listed under the Species-level Recovery Strategies may not be possible under high rates of sea level rise. They suggest that some prioritization based on marsh sustainability potential under sea level rise may be needed (see PRBO tool with preliminary results for review: data.prbo.org/apps/sfbslr).

Response: Text has been revised to add "… must be protected and/or enhanced, *at least in the short-term*, include…". Though some or all of these marshes could be too low to support marsh habitat in the long-term, they will be important to preserve for the species in the short-term.

13.) **Comment:* One commenter suggested that Action 4.4.7 (former Action 4.2.3.7), "Study the effects of global warming/climate change and resulting sea level rise on tidal marsh ecosystems" be elevated in the task hierarchy and priority level, and it should be linked to essential, related tasks such as habitat restoration, management, and population viability that will play out in the 21st century rather than the 20th century.

Response: This action has been changed to Priority 1.

14.) *Comment:* One commenter suggested that the strategies section of the TMRP should include exploring options for reconnecting flood control channels with marsh flood plains to increase the amount of sediment reaching the tidal marsh.

Response: The text has been revised to encourage the reconnection of flood control channels with flood plains to increase sediment delivery to restoring marshes.

15.) *Comment:* One commenter suggested that the TMRP should evaluate the potential to maintain brackish marsh habitat in the estuary by ensuring adequate freshwater inflow through implementation of regulations. They stated that if the Suisun Marsh is expected to convert to primarily salt marsh rather than brackish marsh over the next several decades, the TMRP should discuss how to address the loss of brackish/freshwater wetlands.

Response: No text has been revised. There is a great deal of uncertainty in regard to the degree to which, and at what time scale, shifting salinity will affect plants. Also, it is not within the purview of the recovery plan to implement regulations regarding freshwater inflow, especially when the focus on this document is preservation of habitats and species of saline environments.

16.) *Comment:* One commenter suggested that when reviewing a proposed development project adjacent to a recovery unit and within the predicted sea level rise inundation area, the Service should require the project developer to complete a sea level rise assessment so the issues related to sea level rise adaptive management plans for that area may be identified.

Response: The Service does not have the authority to establish such regulatory requirements (*i.e*., such as requiring proposed projects to conduct sea level rise assessments), however, sea level rise may be included in the effects analysis occurring as part of section 7 endangered species consultation or HCP development, as appropriate.

17.) *Comment:* One commenter suggested that when existing structures that are barriers to the migration of distinct populations of listed species are adapted due to sea level rise, consideration be given to incorporating a corridor between separated populations of listed species.

Response: Text was revised to add that planning for sea level rise should take into consideration corridors between separated populations of covered species.

b.) Map revisions

Mapping Comments- Suisun Marsh

1.) *Comment*: One commenter suggested that Figure 11 and 12 underrepresents salt marsh harvest mouse habitat in Suisun Marsh. The commenter stated that the map only shows the 2,500 acres of salt marsh harvest mouse habitat and multi-species conservation areas in the Marsh and suggested we use the triennial vegetation survey study map to determine suitable habitat throughout the marsh.

Response: No revision has been made. Figure II-12 strictly shows known distribution of the species, based on occurrences recorded in the California Natural Diversity Database and is not meant to represent suitable habitat.

2.) *Comment*: One commenter noted that in Suisun, the recovery unit boundary follows the five foot elevation line, yet the mapping of these boundaries should follow the strategies cited above and outlined in Section III of the TMRP.

Response: The five foot elevation line was not specifically used to determine the recovery unit boundary in Suisun. The Recovery Unit line was delineated primarily using the 100 yr flood line, but was revised during this finalization to account for projected seas level rise and to exclude areas now occupied by hard development.

Mapping Comments- North Bay

3.) *Comment*: Several commenters made suggestions to change designation of existing tidal marsh or future habitat designation or ownership in the areas of Gallinas Creek, Corte Madera Creek, Corte Madera Ecological Reserve, Bothin Marsh, Petaluma River, Bahia, Black John Slough, Bel Marin Keys, Canalways, Sears Point Restoration Project, Highway 37, Richardson's Bay, San Rafael Airport, McInnis County Park, and St. Vincent/Silviera Ranch. Also, some commenters thought the recovery unit line should move landward to incorporate more areas for future marsh transgression in the San Pablo Bay Recovery Unit and encouraged the protection of small discontinuous pocket marshes or narrow strip marshes, which may function as corridors.

Response: The shift in the recovery unit boundary landward, as described above, resulted in many areas mentioned being incorporated into the recovery unit. Where possible, the Service has added polygons that extend into low, adjacent uplands in the San Pablo Bay Recovery Unit (and plan-wide), though some may be too small to view, due to scale of the maps. This should not be interpreted as indicating that an area is unimportant for tidal species. Also, new polygons designating potential future restoration have been identified in the San Pablo Bay Recovery Unit. The suggested revisions to these areas in the North Bay have been made, with the exception of those requested in the following comments:

4.) *Comment*: One commenter was concerned that a pie-shaped parcel north of Hamilton Airfield appears to be shown as tidal marsh on the maps, but is currently not a marsh.

Response: The area in question is shown as recommended future tidal restoration, not as existing tidal marsh, therefore no revisions have been made.

5.) *Comment*: The same commenter stated that the recovery unit boundary should be extended west in the area of Miller Creek so that it ends at Highway 101.

Response: Map revisions have been made to extend the recovery unit line and habitat designations to the west for the area in question. However, due to inappropriate elevations relative to sea levels, they were not extended to Highway 101.

6.) *Comment*: The same commenter stated that a 20 acre parcel at the mouth of San Rafael canal should have been shown as existing tidal marsh.

Response: No revision has been made. This parcel was already shown as existing marsh, however, due to its small size, the symbology was not clear. The new, solid yellow masking for existing marsh is more visible.

7.) *Comment*: The same commenter stated concern that several small marshes or areas in need of restoration near Tiburon and Sausalito were not identified on the maps.

Response: Figure III-15 was not revised in response to this comment because it could not be determined where previously unidentified habitat exists in the areas in question.

8.) *Comment*: The same commenter stated that other important areas in Marin County are not noted in the text. Canalways' (marshland in San Rafael) protection would create a continuous band of habitat. Tiscornia Marsh and several adjacent parcels could be restored to provide a more continuous corridor along the Bay.

Response: The bulleted list of areas under the Central/South San Francisco Bay Recovery Unit section was not meant to be exhaustive so the text has not been revised. Revisions to Figure III-13, however, have been made. Pocket and fringing marshes have been designated as existing marsh on the maps, where discernible, and new polygons designating potential future restoration have been identified in the area, as well.

Mapping Comments- East Bay

9.) *Comment*: Several commenters made suggestions to change the recovery unit boundary in the East Bay in places such as the interpretive center north of the San Mateo bridge and the Oakland International Airport.

Response: The suggested revisions to these areas in the East Bay have been made, with the exception of the sites discussed directly below.

10.) **Comment*: One commenter stated that, in Figure III-20, "potential *Suaeda californica* restoration" is designated broadly over actual and potential habitat areas, yet equal or superior comparable habitats in the East Bay, such as Brooks Island (Richmond) beaches, which are fully protected reserves within historic range and contain highly suitable habitat, lie outside the recovery unit boundary.
Response: Figure III-20 has been revised to remove labels showing where potential *Suaeda californica* reintroduction could occur. We agree that many other comparable sites exist, however, all of them cannot possibly be shown without cluttering the maps. Also, reintroduction sites for other species in the TMRP have not been shown.

11.) *Comment*: One commenter was concerned that Arrowhead Marsh, in Oakland, did not seem to be indicated as critical habitat for clapper rails although they are found there.

Response: Existing marsh is indicated at Arrowhead marsh on Figure III-17. Critical habitat designation is an important, but separate process from recovery planning for listed species. An area is designated critical habitat only after the Service publishes a proposed rule in the Federal Register and then receives and considers public comments on the proposal. The final rule, including the boundaries of the critical habitat, is also published in the Federal Register.

Critical habitat has not been designated for the California clapper rail. Although not a substitute for critical habitat designation, some revisions have been made to the maps to better reflect areas of most importance to achieve recovery of the species.

12.) *Comment*: One commenter stated that the area between Coyote Hills and the salt ponds to the west of them should be designated "Future ecotone restoration."

Response: Due to the steep topography, we did not feel that designation of the area west of Coyote Hills as "future ecotone restoration" was appropriate. Other, gently sloping, more appropriate areas for gradual transition of habitat have been identified.

13.) *Comment*: One commenter was concerned that Figure II-6 incorrectly indicates that Oakland International Airport's south field is extirpated *Suaeda californica* habitat. They state that the airport's south field was open water until filling commenced in 1955.

Response: The *Suaeda californica* occurrence data accessed through California Department of Fish and Game's California Natural Diversity Database had low precision in this case, therefore a large area is demarcated within which the actual occurrence was located. It is likely that this particular occurrence was located in the landward portion of the hatched polygon shown, not the South Field where only open water existed.

Mapping Comments- South Bay

14.) *Comment:* Eight commenters stated the following concerns regarding identification of future tidal restoration areas near Redwood City: The TMRP points to restoration efforts already underway on former Cargill salt ponds in San Pablo Bay and at outer Bair Island. Although we commend the Service for including the 1,433+ acres of salt ponds in Redwood City within the recovery unit boundary, given the importance of creating a non-fragmented habitat… and because of the obvious capacity for these salt ponds to be restored to tidal marsh and to contribute to the recovery of key species of concern, including the western snowy plover and the California clapper rail… it seems logical and essential to identify the Cargill salt works in Redwood City as a location for either future or potential tidal restoration… we are dismayed that no recovery actions have been proposed for the area or priority designation assigned… Undeveloped, gently sloping terrestrial lowlands bordering the estuary and the least subsided baylands should be top priorities for conservation given the necessity of protecting transition areas for the landward migration of species as sea levels rise… The Redwood City salt ponds should be recommended for tidal restoration because: 1) of the TMRP stated criteria and priorities 2) findings of the Habitat Goals Report (1999), 3) findings of the Feasibility Report (Siegel), 4) it is feasible, per the fact that 436 acres of on-site restoration is currently proposed by the owners of the salt ponds as part of their development proposal, 5) the Napa Plant Site, similar to the Redwood City salt ponds in size and past use, is currently being restored to active tidal marsh, and 6) The United States Congress has already taken legislative action in identifying these salt ponds as a priority for future expansion of the Don Edwards National Wildlife Refuge.

Response: Maps have been revised by adding a designation of "Potential Future Tidal Restoration." The new category applies to lands within the newly overlaid sea level rise boundary, which are appropriate for tidal restoration, but which have constraints preventing near or medium term restoration efforts. The Redwood City salt ponds, on **Figure III-20** are an example of one place that holds this new habitat designation.

15.) *Comment*: One private landowner commented that reference to their lands should be removed from the maps. They felt it was unfair to call out their lands by name. Also, they requested no addition of their lands to the maps.

Response: We retained reference to certain landowners on the legend of the maps due to their juxtaposition to associated tidal marsh habitats and the distribution of their lands throughout the planning area. This includes other private landowners, such as mitigation banks, land trusts, and water districts. They appear by name in the legend of the maps as well. As aerial imagery was used as a background to the maps, all lands appear on the maps, however, only lands which could play important roles in recovery of the tidal marsh ecosystem have overlaid habitat designations. These lands fall into the following categories, based on existing constraints to restoration: Existing Tidal Marsh, Near-term Tidal Restoration, Likely Future Tidal Restoration, Potential Future Tidal Restoration, and Future Ecotone Restoration. In this case, based on comments received during the public comment period, the exclusion of the commenter's lands from any habitat designation was found to be biologically unjustifiable. Consequently, the commenters lands (along with property of other private landowners) were overlaid with a habitat designation called "Potential Future Tidal Restoration." This designation applies to lands within the overlaid sea level rise boundary, which are appropriate for tidal restoration, but which have constraints (such as pending development proposals, unwilling sellers, or environmental or engineering constraints) preventing near or medium term restoration efforts. We recognize throughout the plan that the implementation of the recommendations of this recovery plan are voluntary and that designation of lands in the maps does not obligate the landowner in any way.

16.) *Comment*: Several commenters suggested changes to the recovery unit boundary, ownership boundaries near Cargill's Newark and Redwood City salt ponds and the Service's refuge near Newark, Figures III-20 through III-24, Alviso, and the Patterson Ranch lands west of Ardenwood Blvd.

Response: Though the correct ownership boundaries for the San Francisco National Wildlife Refuge were depicted, overlapping of the ownership, recovery unit and marsh parcels lines was confusing. Every effort has been made to make the maps clearer. The suggested revisions to these areas in the North Bay have been made, with the exception of the sites discussed directly below.

17.) *Comment*: One commenter stated that Figure III-25 should be corrected to accurately show the location of Least Tern Island and to include the existing salt marsh harvest mouse preserve within the Recovery Unit.

Response: Though some maps have been revised to add labels for place names, only critical features are labeled on the maps in order to maintain clarity.

18.) *Comment*: One commenter stated that the map of wetlands just west of Gold Street and adjacent to Highway 237 is in error, as that is where Hoxie dump created an enormous hill on which to place office buildings. They added that a sliver of mitigation wetlands is adjacent to Highway 237, but Hoxie development lies between it and southerly end of Pond A8, next to Guadalupe River.

Response: The exact location that the commenter references could not be determined, therefore, a revision was not made. Also, the suggested revision would likely have been at such a small scale as to be negligible to the reader.

19.) *Comment*: One commenter stated that in Figure III-24, the Fremont-Coyote tract has no recovery designation. They also state that the Fremont General Plan identifies these lands as "wetland-lowland transition" habitat.

Response: Due to this parcel's location in relation to Coyote Hills, Highway 84, and nearby urbanization, it was determined that it held minimal restoration potential, therefore, no revision was made.

Mapping Comments- General

20.) **Comment*: Commenters requested that Figures I-1, II-1, II-2, III-13, F-2 and F-3 be enlarged, improved for better clarity, or have a label edited or added.

Response: Those figures have been improved. However, Fig. F-2 and F-3 have not undergone revision because the commenter's intent is not clear. Also, Figure I-1 has been revised in several aspects, including the addition of middle marsh. However, no representation of relative frequency of species distribution across the marsh has been added, as the commenter requested, as this figure was meant to be a very simple representation of species distribution in a marsh.

21.) *Comment*: One commenter stated that the TMRP maps should include a zone specifically for high marsh and ecotone protection and restoration areas that indicates high priority for protection, restoration, and acquisition equivalent to Zone 1. Currently unclassified areas in the footprint of the TMRP that would provide wetland transgression and high marsh ecotone should be assigned this high priority designation.

Response: While text and maps (via the shift in recovery unit boundary) have been revised to place stronger emphasis on preservation of high marsh and ecotone areas next to existing marshes that may accommodate habitat in the face of rising sea levels, no new designation has been shown on the maps. A habitat designation for areas which may be appropriate for ecotone restoration already exists on the maps.

22.) *Comment*: Please place the word "voluntary" in the document title and on each map.

Response: The text has been revised in the section directly preceeding the restoration maps to add "Participation by private landowners in recovery plan implementation is entirely voluntary." Individual maps have not been revised to add this statement as they should not be de-coupled from the introductory paragraphs to the maps. Text has also been revised under Recovery Plan Preparation to add the voluntary caveat.

23.) *Comment*: One commenter stated that the Segment maps in Section III of the TMRP should be expanded to include species distributions and future sea level rise scenarios.

Response: The maps have been revised to reflect the medium to medium-high emissions scenario described by Heberger et al. (2009). The extent of sea level rise under this scenario became the new recovery unit boundary, with the exception that areas under hard development were excluded. Species distribution was not added to the segment (restoration) maps because this would have made them unnecessarily complicated. Species distributions are shown in the figures of Section II.

24.) *Comment*: One commenter expressed that the importance of small pocket marshes and narrow strip marshes be considered during conservation efforts.

Response: Though narrow bands of tidal marsh, in some cases, may be extremely vital in the short-term in providing connectivity between populations, they are also extremely vulnerable due to their relative inability to buffer listed species from threats such as predation, human disturbance, pollution, and inundation due to sea level rise. While the preservation of such small patches of habitat is important in the short-term, the TMRP focuses, in the long-term, on preservation and restoration of larger (deeper) swaths of tidal marsh habitat.

25.) *Comment*: Several commenters provided information on Liquefaction Susceptibility Map of South Bay, Salt Marsh Harvest Mouse Capture Locations and Barriers to Movement, San Jose/Santa Clara Water Treatment Plant EIR Figure 4-8 Endangered Species in Baylands, U.S. Corps of Engineers Study Area Map of Coyote Creek, Coyote Creek Reach I Salt Marsh Harvest Mouse Habitat Management Area, and Coyote Creek Reach 2, in regard to how it might affect restoration or species recovery in the future.

Response: The Service appreciates this information and these resources were used to improve the final document.

c.) Zone discrepancies

1.) **Comment*: Many commenters expressed confusion about zone designations. Many commenters disagreed with the assignment of zone status in various locations based on their personal opinion of conservation value or were confused by the fact that some lands had no designation whatsoever. Also, several commenters thought the zone designation only applied to lands not currently in conservation ownership, when in fact, it referred to the relative importance of continuing to protect in perpetuity currently protected lands. Some commenters, in addition to disputing a particular zone status, suggested that 1) Important Bird Areas with a Z1 designation should have restrictions in place to prevent aircraft from flying below a certain altitude that might affect bird flight, 2) that development proposals near Z1 or Z2 areas should demonstrate zero net increase in light pollution, and 3) that development proposals near Z1 or Z2 areas should demonstrate zero decrease in local pH.

Response: Because the designation of zones (on maps), as distinct from priorities (in actions) caused significant confusion to commenters, for the final recovery plan boundaries, “zones” have been removed from the maps. Instead, we have focused on identification of additional opportunities for protection or restoration, revisions to boundaries of areas already identified, and the accurate designation of all of these as Existing Tidal Marsh, Near-term Tidal Restoration, Likely Future Tidal Restoration, Potential Future Tidal Restoration, and Future Ecotone Restoration. Identification of specific areas to target for protection/restoration/management will be made strategically with the objective of meeting stated recovery criteria and will be guided by the stakeholder group on the recovery implementation team.

Even if zone designations were retained in the Final recovery plan, no revision to impose additional restrictions would have occurred. It is not within the scope of recovery plans to establish regulatory requirements (*i.e.*, such as restricting aircraft flight, requiring zero net increase in light pollution, or reduction in local pH), however, these concepts may be explored through section 7 endangered species consultation or HCP development, as appropriate.

2.) **Comment:* One commenter suggested that distinction between Priorities and Zones should be more clearly described.

Response: Priorities refer to the actions themselves and have specific formal definitions: Priority 1 actions that must be taken to prevent extinction or to prevent a species from declining irreversibly; Priority 2 actions that must be taken to prevent a significant decline in the species population/habitat quality or in some other significant negative impact short of extinction; and, Priority 3 all other actions necessary to provide for full recovery of the species (NMFS and USFWS 2010). As mentioned above, for the final recovery plan, "zones" have been removed from the maps.

3.) *Comment:* One commenter suggested restructuring the zone designations such that the highest zone status would be assigned to high marsh and ecotone areas. They suggested this be accomplished by adding an additional zone designation.

Response: Instead of adding an additional designation which would further complicate the maps, text and maps (via the revised recovery unit boundary) have been revised with an increased emphasis on the importance of restoring and preserving high marsh (vs. low marsh), ecotone, and otherwise adjacent gently sloping undeveloped uplands. As mentioned above, for the final recovery plan, "zones" have been removed from the maps.

d.) Salt marsh harvest mouse criteria

1.) *Comment:* One commenter suggested that sub-criterion B for the salt marsh harvest mouse be reworded to specify "sufficiently deep pickleweed plains *and* sufficiently deep high marsh zones". The same commenter suggested clarifying the salt marsh harvest mouse downlisting criteria in regard to required capture efficiency.

Response: In both regards text has been revised.

2.) **Comment:* One commenter suggested an increase in the minimum VHA acreages, depending on the final habitat mosaic ratio of South Bay Salt Pond managed ponds to restored tidal marsh.

Response: The Service feels that the VHA minimum acreages are appropriate and reachable, regardless of which South Bay Salt Pond habitat mosaic ratio comes to fruition.

3.) *Comment:* One commenter asked why the target acreage is so low for salt marsh harvest mouse in Corte Madera, China Camp to Petaluma and Petaluma River marshes since other tidal marshes along the Petaluma River comprise at least several hundred acres.

Response: Though the total target acreage may already exist in some marsh complexes, the TMRP criteria calls for the acreage to be contiguous, high quality tidal marsh habitat with well-developed channel systems and high tide refugia/escape cover at the high marsh/upland transition and inner-marsh. Though most marsh complexes within the San Pablo Recovery unit already do or could support 1,000 acres with these habitat characteristics, the decision was made that, due to constraints on restorable land, habitat at the Corte Madera marsh complex (renamed China Camp to Richardson's Bay for the final TMRP) could only provide 400 acres with these characteristics. This criterion would likely be met at Corte Madera Marsh.

4.) *Comment:* One commenter inquired as to why the 'viable habitat area' terminology is used for salt marsh harvest mouse, but not clapper rail.

Response: VHAs are smaller units within the larger marsh complexes where we expect to have mice (and rails). While the "marsh complex" units apply to both rails and mice, "VHA"s were developed for use in the mouse recovery criteria due to the mouse's smaller home range and distinct sampling methodology.

5.) *Comment:* One commenter suggested other areas along Denverton Slough be included in a VHA within the Nurse Slough/Denverton Marsh Complex.

Response: The Bradmoor Island- Little Honker Bay VHA has been revised to include all areas along Denverton Slough.

6.) *Comment:* One commenter suggested that VHA descriptions should be written so surveyors can locate the boundaries of each VHA.

Response: VHAs were purposely described without rigid boundaries. VHAs are required (for down/delisting) to occur in a general region, but have the flexibility to flow over into surrounding geographic areas, should the habitat be suitable. It is not as important exactly where populations occur, as long as the supporting habitat is of high quality and can sustain those populations in the long-term. Surveyors should survey accordingly, based on suitable habitat.

e.) California clapper rail criteria

1.) *Comment:* Two commenters needed clarification on what is meant by "large geographic area" in the context of rail habitat.

Response: The intention with requiring a 'spread over a large geographic area' was to ensure that large tracts of marsh are not restored/protected in only one area, thus leaving the population at risk to extirpation from stochastic events. Instead, populations should be found throughout the entire geographic range, with corridors throughout, to enable the maximum genetic exchange. In other words, the populations should not be isolated, but should be well-connected. Text was revised to clarify this intent.

2.) *Comment:* One commenter felt that the recovery criteria relating to mercury concentrations in rail eggs is too vague and should specify whether that threshold is for any egg measured or as a mean or median value. And if so, whether there is a minimum sample size and geographic region.

Response: This recovery criterion was revised to specify that the mean mercury concentration of all eggs sampled within a marsh complex must fall below 0.2 µg/g (fresh wet weight) for five consecutive years. No minimum sample size has been established. Only fail to hatch eggs will be sampled; sampling will occur opportunistically as fail to hatch eggs are available. However, we do not know for certain what proportion of the rail population can sustain developmental abnormalities and still have a self-sustaining population. As stated in the TMRP itself though, recovery criteria are our best assessment at this times of what needs to be completed so that the species may be downlisted or delisted (*i.e*., meeting the definition of threatened but not the definition of endangered or meeting neither the definition of threaten nor the definition of endangered, respectively). If rail numbers rebound to a sufficient level due to achieving other recovery criteria, it is possible that a status review may indicate that downlisting or delisting is warranted although not all recovery criteria are met (*i.e*., mean mercury concentrations may be allowed to reach 0.2 µg/g (fresh wet weight) within a marsh complex). Conversely, it is possible that the recovery criteria could be met and a status review may indicate that downlisting or delisting is nonetheless *not* warranted (*i.e*., mean mercury concentration must fall below an even *lower* threshold within a marsh complex).

3.) *Comment:* Several commenters had concerns about the criterion relating to control of *Lepidium latifolium*. The commenters wondered if the criterion for maintenance of *Lepidium latifolium* at 10 percent cover was for the presence of *Lepidium* on the marsh plain only or adjacent uplands as well. Also, they wondered where and how the boundaries of its presence are determined when calculating the 10 percent threshold and over what time period. Finally, one commenter stated that keeping *Lepidium latifolium* to a level of 10 percent will be extremely difficult due to restrictions of herbicide use in tidal areas.

Response: Text in regard to this criterion has been revised. The 10 percent threshold applies to areas down-gradient from the high marsh/upland transition zone, including areas of higher ground within the marsh plain. The Service feels that the 10 percent ceiling on *Lepidium latifolium* in tidal areas is an ambitious, but attainable goal, through proper permitting.

4.) *Comment:* One commenter suggested that dogs and cats can directly kill rails in additional to simply disturbing rail habitat.

Response: Text of Factor A/7 has been revised to reflect that domestic animals can also predate, not just disturb habitat of, clapper rails. “Dogs” was changed to “domestic animals”.

5.) *Comment:* One commenter stated they would like to see a discussion of habitat in Marin County included in the Criterion A/1 portion of the clapper rail criterion, specifically at Corte Madera and Gallinas Creeks and marshes in San Rafael and Mill Valley/Richardsons Bay.

Response: Though Corte Madera Creek was previously mentioned by name already in Criterion A/1, the marsh complex was renamed to “San Rafael Creek to Richardsons Bay” to better encapsulate Marin County habitat from China Camp south to the Golden Gate Bridge. The intent of the section on Recovery Criteria is not to discuss habitat at length. Background information on this geographic area can be found in section I, Introduction and in the regional-level recovery strategies for San Pablo Bay.

6.) *Comment:* One commenter felt that the clapper rail criteria numbers in San Pablo Bay and Central Bay for both downlisting and delisting seemed low.

Response: No revision has been made in recovery criteria, as the Service, in consultation with clapper rail species experts, feels the numbers chosen are appropriate. We used the best available scientific data, including Dr. Stuart Weiss’ work on probability of rail population persistence and input from various rail experts, to develop the recovery criteria. However, we acknowledge that this work is not comprehensive. Therefore, we have added, as a recovery action, the development of a formal population viability analysis for the California clapper rail (Action 4.2.6.1), during which long-term variables will be considered to the extent possible. It may be determined at a later date that this information indicates that recovery criteria should be revised.

7.) *Comment:* One commenter suggested the downlisting criteria should include quantitative, time-specific targets for the acquisition, creation, and management of high marsh/upland transition lands sufficient to allow landward species migration and reduce climate change threats. They further stated that delisting criteria should require that specified target levels of high marsh/upland transition lands have been acquired or created; that these transition lands are supporting the landward migration of listed species and are sufficient to support viable populations over a range of sea level rise scenarios and over a sufficiently protective timeframe (*i.e.*, 100 years). Also, they felt that the recovery criteria should also include targets for water management practices that protect listed species from changes in salinity.

Response: Both downlisting and delisting criteria have been revised to add a criterion relating to creation or preservation of high marsh/upland transition lands as they pertain to landward migration of species. Though too little is known at a marsh-specific scale about the timeframe for sea level rise to put a quantitative, time-specific target on this criterion, many of these questions are topics of research recommended in the Stepdown Narrative in the document.

8.) *Comment:* One commenter was concerned that no downlisting or delisting criterion was proposed that would require a stable or growing population on average, either for a recovery unit or for the estuary as a whole.

Response: No text has been revised. Factor E of the clapper rail delisting and downlisting criteria specifies that regional target numbers must be achieved as an average over a 10 year period. Avian experts consulted on this aspect of the recovery criteria felt that this requirement provided assurance that survival will span typical year-to-year fluctuations and at least one wet and one dry season. However, reaching these goals will require sustained population growth for a number of years.

9.) *Comment:* One commenter suggested that incorporating a focus on reproductive and mortality rates into the recovery criteria would help focus the recovery strategy on steps that lower mortality rates, of juveniles and adults, and/or increase reproductive rates.

Response: Several of the current criteria relate to mortality of rails: A/7 and C. Down/Delisting criterion A/7 requires site-specific management plans for most public lands in the San Francisco Bay to reduce recreation-based disturbance to tidal marsh species. Down/Delisting criterion C requires a predator management plan at all appropriate sites and predator monitoring such that predation pressure on rails falls below a level at which it negatively affects long-term population persistence. Both of these criteria address the lowering of mortality rates. Neither an age-structured model of population growth nor life history tables have been done for California clapper rail. Because of this, we are not able to specify target reproductive rates. However, we have revised the text by specifying under Action 4.2.6.1 (former Action 4.2.1.2.5.1) that an age-structured model for population growth should be developed.

10.) **Comment:* Two commenters had concerns with the downlisting and delisting criteria for Suisun Bay Area and with the delisting criteria for Tomales Bay. They stated that rail population levels of 100, 200 and 32, respectively, would be prone to extinction. One commenter stated that attaining the 60^{th} percentile of current density may not be sufficient to ensure that the rail is no longer in danger of extinction, neither is there a basis for the assertion that attaining the 75^{th}

percentile, in terms of density, renders the rail no longer likely to become endangered in the foreseeable future. Therefore, several commenters recommend a population viability analysis as a recovery action. They state that this analysis would project the likelihood of population expansion or contraction, including the possibility of extinction or decline in numbers below specified levels. Another commenter similarly suggested that the long-term predictions of the model used to develop recovery criteria are not credible; they are based on a snapshot of existing habitat distribution and structure and do not account for habitat changes due to magnitude of sea level rise or the rate of sea level rise.

Response: The populations in the Suisun Bay Area and at Tomales Bay would not constitute core populations, but rather small satellite populations which would serve to indicate that enough California clapper rails exist within core populations to result in dispersing of juveniles. Much uncertainty exists in regard to the effects of future sea level rise on tidal habitats and how to model rail population persistence using sea level rise as a variable. We used the best available scientific data, including Dr. Stuart Weiss' work on probability of rail population persistence and input from various rail experts, to develop the recovery criteria. However, we acknowledge that this work is not comprehensive. Therefore, we have added, as a recovery action, the development of a formal population viability analysis for the California clapper rail (Action 4.2.6.1), during which long-term variables will be considered to the extent possible. It may be determined at a later date that this information indicates that recovery criteria should be revised. Also, Action 4.4.7 (former Action 4.2.3.7) calls for studying the effects of global warming/climate change and resulting sea level rise on tidal marsh ecosystems, including effects on the rail.

11.) *Comment:* One commenter suggested that the presence of an average of 100 and 200 rails in Suisun Bay over a 10 year period, as downlisting and delisting criteria, respectively, is a lofty goal, since there are no records of their numbers ever being this high in this region, except possibly in the early 1990s. They felt the model in Appendix F clearly didn't fit Suisun Bay, since *Spartina* is not present there and suggested using target numbers for rails in a format similar to that used for plants. For example, 'Downlisting criteria for *Cirsium hydrophilum var. hydrophilum*: Number of plants (median, minimum, *etc.*)'. The same comment above is applicable for delisting criteria.

Response: It is widely recognized that conditions in Suisun Bay will never produce optimal habitat for the California clapper rail, however, the Suisun Marsh population is an important satellite population to the larger population in the greater San Francisco Bay estuary. Supporting more rails in Suisun Marsh (via restoration of more tidal marsh) with demographic connectivity to the larger San Francisco Bay meta-population is important to ameliorate the risk of extinction of the rail. The target of 100 individuals was developed with input from various rail experts. As mentioned above, we have added specific language to Action 4.2.6.1. recommending a formal rail population viability analysis. The results of that analysis may inform future revisions to existing criteria. No revision to text has been made at this time.

12.) *Comment:* One commenter felt that just because densities on average were observed to be lower in San Pablo Bay than in San Francisco Bay, a lower value should not have been used in calculating target numbers for that unit. They stated that such an approach cannot be justified in terms of population persistence or avoidance of extinction. They acknowledged that there may be important differences between habitat suitability in Suisun Bay versus San Francisco Bay, such that Suisun marshes may never be able to support the numbers of rails seen in San Francisco Bay, but maintain that there are no over-riding habitat differences between San Pablo Bay and San Francisco Bay to justify the use of a lower criterion for the former.

Response: The California clapper rail criteria have been revised in regard to minimum required acreage per marsh complex and target number of individuals per recovery unit. The Service feels there are important differences between the habitats of San Pablo Bay and San Francisco Bay in salinity and resultant vegetation, therefore, a lower density has been used in the former (as was done in the draft) to calculate minimum required acreage. However, we did revise the minimum acreage in the Central/South San Francisco Bay recovery unit due to a minor math error (correct value is 1,111 acres per marsh complex, not 1,250 acres) but have retained the 90^{th} percentile of observed winter population densities to calculate the acreage. Therefore, minimum habitat acreage (under Factor A of de- and downlisting criteria) in the Central/South San Francisco Bay recovery unit has decreased slightly. Target numbers of individuals (under Factor E/1 of the de- and downlisting criteria) has been revised, as well. While the downlisting target numbers have not changed (calculated at the 60^{th} percentile of observed winter population densities), the target numbers required for delisting have been revised to reflect the 90^{th} percentile of observed winter population densities. Therefore, target numbers (to accomplish delisting) have increased in all recovery units. In Suisun and Tomales Bay, a target density and minimum acreage have been agreed upon by species experts, as observed winter population densities were not available.

13.) *Comment:* One commenter stated that the current status of “core” population areas was unclear.

Response: Though PRBO Conservation Science and others have conducted significant surveys of tidal marsh bird species in recent years, not all core population areas have specifically been surveyed such that an accurate status could be given to each in the TMRP. Species status surveys are one of five major elements of the recovery strategy. Specific details of survey needs are, therefore, spelled out in the Stepdown Narrative.

14.) *Comment:* One commenter suggested it is not clear that controlling invasive *Spartina* will benefit clapper rail populations and that it may be one of the few options for trapping sediment and building marsh elevations rapidly in the face of sea level rise. Therefore, they felt its removal should not be a criterion for downlisting.

Response: The text has been revised to reflect our current knowledge that removal of invasive *Spartina* does negatively impact the California clapper rail and that its removal must consider the protection of nearby rail populations. Also, the recovery criterion in question that specifically mentioned invasive *Spartina* control was revised to state "Control of future invasive plant infestations, while minimizing effects to clapper rails…".

15.) *Comment:* One commenter disagreed that the California Coastal Conservancy defined success of the *Spartina* eradication as no net increase beyond 2001 levels. They stated that the "goal" has always been eradication of all identified invasive *Spartina* and they suggested we change the language to read: 'Control of extant *Spartina alterniflora* and its hybrids and implementation of a system for its early detection. The definition of control success shall be equivalent to that developed by the California Coastal Conservancy's Invasive Spartina Project: eradication of all identified invasive *Spartina* within the San Francisco Bay Area'.

Response: Recovery criteria previously relating to invasive *Spartina* (A/6 for the rail and A/5 for the mouse) has been revised to state "Control of future invasive plant infestations, while minimizing effects to clapper rail, and implementation of a system for their early detection".

f.) Critical Habitat

1.) **Comment:* Four commenters expressed concern that no explanation was offered in the recovery plan as to why critical habitat was not identified. They stated that if critical habitat is not delineated, the maps in the document will be even more important in making determinations as to which lands are critical to recovery of the listed species and to include sufficient areas within the boundaries to allow tidal marshes and refugia/ecotones to migrate landward.

Response: Critical habitat designation is an important, but separate process from recovery planning for listed species. An area is designated critical habitat only after the Service publishes a proposed rule in the Federal Register and then receives and considers public comments on the proposal. The final rule, including the boundaries of the critical habitat, is also published in the Federal Register.

Critical habitat has not been designated for the California clapper rail, salt marsh harvest mouse, or *Suaeda californica*. Although not a substitute for critical habitat designation, some revisions have been made to the maps to better reflect areas of most importance to achieve recovery of those species. As stated in the species accounts, critical habitat *has* been designated for *Chloropyron molle ssp. molle* and *Cirsium hydrophilum* var. *hydrophilum* (FR 72(70):18517-18553) and maps in this recovery plan are consistent with that rule.

2.) **Comment:* One commenter suggested that the recovery plan should include geographically explicit, corrected maps that are consistent with the recovery strategies and Stepdown Narratives, and that indicate where lands that are essential to the recovery of the listed species are located in both occupied and future needed habitat locations.

Response: The recovery unit and restoration maps are consistent with the recovery strategies and Stepdown Narrative and acreage criteria and necessary qualitative characteristics are specific. Although specific lands are recommended for restoration on the maps, recovery plans involve voluntary participation, so the TMRP does not require specific parcels be acquired and/or restored to reach recovery. The TMRP must retain some flexibility in regard to acquisition and management.

g.) Suisun Marsh salinity control

1.) *Comment:* One commenter wondered if there is actual documentation that improvements in waterfowl management in Suisun resulted in 'large-scale conversion of pickleweed'.

Response: The text has been revised to remove the words "large-scale".

2.) *Comment:* One commenter suggested that the statement that the Suisun Marsh Salinity Control Gates (SMSCG) "maintain low summer and fall salinities in portions of the marsh" is inaccurate. They stated that the SMSCG is only permitted to be operated October through May, and then only when salinity levels would otherwise be higher than the variable monthly salinity standards.

Response: The text was revised to reflect the accurate seasonal operation of the SMSCG.

3.) *Comment:* One commenter requested clarification on the phrase 'widespread effects' in the statement 'Operations of the salinity control gate has a widespread effect on water and soil salinity, raises water levels in the marsh, and reduces tidal range and circulation'. They also requested we cite the source and field data to support these assumptions.

Response: The text has been revised to state that operation of the "…gates has the *potential* to cause widespread effects on water and soil salinity…".

4.) *Comment:* One commenter suggested a complete revision to the entire section to describe more fully the operation of the SMSCG, salinity standards, deficiency standards, and conditions that trigger higher salinities during drought conditions.

Response: No text has been revised. A complete explanation of operations of the SMSCG is beyond the scope of this document, but is discussed on the following website: www.water.ca.gov/suisun/facilities.cfm. Reference to this website has been added to the text. We have limited our discussion of the SMSCG gates operation to how artificially variable salinities may alter natural vegetative community structure, thereby affecting habitat for the rail and mouse.

5.) *Comment:* One commenter stated that the Suisun Marsh channel water salinity standards (October to May) are not "artificially low or stable".

Response: No text has been revised. Though the salinity standards were revised in western Suisun Marsh to better reflect natural salinity variation, the gates function to maintain salinity at levels in eastern Suisun lower than they would naturally be, for purposes of waterfowl marsh management and to mitigate for the Central Valley water projects.

6.) *Comment:* One commenter suggested that if we expect successful implementation of the TMRP, the document's impact on the adjacent landowners must be addressed.

Response: The text has been revised to state that any change in operations of the salinity control gates should consider impacts to neighboring lands.

7.) *Comment:* One commenter wished to 1) dispute our statement that the SMSCG does not operate in spring, 2) clarify to us that the SMSCG is "operated to mitigate the impacts of the water projects" and 3) inform us that the Department of Water Resources data for the SMSCG shows very limited operation of the SMSCG after its initial set-up and salmon studies.

Response: All three associated statements in the text have been revised to clarify these facts.

h.) *Spartina* control

1.) *Comment*: One commenter each has requested that 1) we clarify the type of vegetation each marsh zone supports, 2) we state that over-aggressive control of invasive/hybrid *Spartina* can have deleterious consequences for tidal marsh birds and that it does have a potentially useful ability to expedite marsh accretion, 3) we clarify that *S. alterniflora* x. *folisosa* hybrids are the main threat, not *S. alterniflora*, and 4) we update the sections of the document dealing with invasive *Spartina.*

Response: The text has been revised to 1) clarify the type of vegetation each marsh zone supports and 2) reflect our current knowledge that removal of invasive *Spartina* does negatively impact the California clapper rail, that its removal must consider the protection of nearby rail and other bird populations, and to suggest research on the hybrid's use in expediting marsh accretion through controlled growth. Also, text has been revised to 3) clarify throughout the document that the main threat is the hybrid, not *S. alterniflora* itself, and 4) update sections of the document dealing with invasive *Spartina.* First, text was revised to include lessons learned from the recent invasive *Spartina* treatment project. Also, a new approach is presented in the recovery plan on how to deal with future infestations of the species and very recent studies are discussed which explore replacing the disappearing structure of invasive *Spartina* with artificial habitat. Finally, the Stepdown Narrative has been revised to include several research items related to the study of *Spartina* and its marsh accreting properties. The text was also revised under the *Spartina* control-related actions to reflect the likelihood that some level of hybridization between *Spartina alterniflora* and *Spartina foliosa* may be determined to be acceptable and that success criteria may change.

2.) *Comment:* One commenter disagreed that hybrid *Spartina* is the dominant plant of Cogswell Marsh and Oro Loma Marsh and suggested we cite updated information about the Invasive *Spartina* treatment success.

Response: The text has been revised to remove the statement that invasive *Spartina* is the dominant plant at Cogswell marsh. Also, text has been revised to reflect the most recent information about reductions in invasive *Spartina*.

3.) *Comment:* One commenter suggested giving a higher priority to the following Actions (4.2.1.2.6.3, 4.2.3.2, 4.2.3.5 and to add tasks under Action 4.2.4.2).

Response: The priorities for Actions 4.2.7.2 and 4.4.2 (former Actions 4.2.1.2.6.3 and 4.2.3.2) were changed from 2 to 1. Given our policy regarding assignment of priority numbers (NMFS and USFWS 2010), we determined that upgrading action 4.4.5 (former Action 4.2.3.5) is not justified. Also, additional tasks suggested under comments for Action 4.5.2 (former Action 4.2.4.2) appear to already fall under Action 4.5.2.2 (former Action 4.2.4.2.2).

4.) **Comment:* One commenter suggested the document should emphasize thresholds for eradication of hybrid *Spartina* within its limited range in the Estuary and California. For widespread invasive plant species that may not be eradicated (like *L. latifolium*), objectives and tasks should focus on keeping uninvaded and minimally invaded portions of the estuary cleared of populations, local impact reduction in previously invaded habitats with endangered species, and exclusion in new (restored) habitats.

Response: As more information becomes available about the extent and effects of plant invasions (and their control) on the covered species, additional actions for elimination or control of those invasives may be developed, likely by the Recovery Implementation Team. Regional recovery strategies currently already specify the focus suggested above, therefore, no text has been revised.

5.) *Comment:* All tasks, including that for invasive *Spartina* control, need to be very specific about how and when and to what extent each task will be managed in order to achieve the goals of the TMRP.

Response: We have included the greatest specificity possible in the recovery criteria and actions.

6.) *Comment:* One commenter stated that UC Davis is not necessarily the only lab able to do genetic testing on *Spartina* and that The State Coastal Conservancy, through the *Invasive Spartina Project*, is working to refine genetic testing methods to identify invasive *Spartina*.

Response: Action 4.3.9 (former Action 4.2.2.9) has been reworded to state "Continue to refine genetic analysis to verify pure *Spartina foliosa* stands in San Francisco Bay.'

7.) *Comment:* One commenter stated that The State Coastal Conservancy, working closely with the Service, coordinates and is the primary funder of the *Invasive Spartina Project* and would appreciate being referenced, by the addition of 'State Coastal Conservancy's' before '*Invasive Spartina Project'*.

Response: The text has been revised to acknowledge the State Coastal Conservancy.

i.) Local land use ordinances

1.) *Comment:* One commenter encouraged the Service to include in its implementation plan, working with regional agencies that regulate bay fill and water quality to allow work to occur for projects sponsored by local jurisdictions.

Response: The text has been revised to state that coordination with agencies will be necessary.

2.) *Comment:* One commenter suggested the expansion of regulations to address the purposeful damage to wetlands that is sometimes performed in anticipation of future development as a way of removing wetland characteristics.

Response: The Service acknowledges that these activities may take place. Change of regulations and/or recommendations to do so are outside the scope of the recovery planning process.

3.) *Comment:* One commenter suggested that the document should encourage local ordinances to prohibit not only establishment and maintenance of feral cat colonies but to prohibit cats from roaming freely. This commenter also inquired as to the definition of a cat proof fence.

Response: The text under regional recovery strategies for San Francisco Estuary and in the Stepdown Narrative has been revised to read that "Local governments should be encouraged to prohibit feeding of feral or otherwise free-roaming cats within their boundaries, illicit feeding stations should be located and removed, and homeowners adjacent to tidal marshlands should be notified that cat trapping may be conducted to protect endangered species." The text has been revised to remove reference to cat-proof fencing.

4.) **Comment:* One commenter stated that the recovery plan fails to identify the widespread and extensive conversion of low-intensity agriculture (hayfields and pasture) in lowlands bordering the diked baylands of the northern estuary (primarily San Pablo Bay) during the first decade of the 21st century, which occurred with no County or State regulation or environmental assessment.

Response: No text has been revised. However, conversion of low-intensity agriculture to vineyards near the marshes of San Pablo Bay is discussed both in the section titled *Historical tidal marsh loss and degradation around the San Francisco Bay Estuary* and in the species account for *Chloropyron molle* ssp. *molle*.

5.) *Comment:* One commenter stated that the document does not consider local land use plans.

Response: The recommendations made in the recovery plan are not designed to supersede local land use plans. The document's scope is narrower and specifically related to the recovery of the covered threatened and endangered species.

6.) *Comment:* One commenter stated that the Marin County Board of Supervisors authorized a watershed program that actively seeks local, state and federal partners to fund integrated approaches to flood management and habitat restoration. The commenter vowed that the Department of Public Works (DPW) staff involved in the Program will be sure to work closely with Service staff to develop projects consistent with the goals identified in the recovery plan.

Response: The Service looks forward to partnering with DPW staff on projects consistent with the goals of the recovery plan.

7.) *Comment:* One commenter noted that many recovery plan projects will also require Army Corps of Engineers permits. They stated that the Army Corps of

Engineers Permit Program Regulation 33 Code of Federal Regulations Park 332, *Compensatory Mitigation for Losses of Aquatic Resources* at section 332.3 (b) states that 'Compensatory mitigation projects should not be located where they will increase risks to aviation by attracting wildlife to areas where aircraft-wildlife strikes may occur (*e.g*., near airports).

Response: Many tidal marsh recovery implementation projects will not involve mitigation. For those that involve mitigation, the proper permitting process will be followed, including appropriate siting. Specific restoration techniques would be identified by the Recovery Implementation Team working groups. As stated above, if tidal restoration has the potential to affect existing facilities, such as airports, ways to eliminate or reduce those effects will be evaluated as site-specific restoration plans are proposed.

j.) Restoration and bird strikes

1.) *Comment:* One commenter stated that promoting wildlife habitat adjacent to Oakland International Airport (OAK) can attract various animals including birds, leading to increased potential for aircraft strikes. The commenter encouraged the Service to consider FAA's Advisory Circular 150/5200-33B. According to this Circular, a Wildlife Hazard Assessment should be completed for any Tidal Marsh Recovery Plan habitat creation or enhancement project within 5 miles of OAK.

Response: The Service has reviewed FAA's Advisory Circular 150/5200-33B and understands that plans for projects which may attract hazardous wildlife within 5 miles of OAK must be reviewed by OAK. The Service does not foresee attraction of California clapper rail to areas within 5 miles of OAK as being a concern for aircraft strikes. The California clapper rail, in particular, flies very low to the ground.

2.) *Comment:* The same commenter suggested that the recovery plan, Section III regarding San Francisco Bay Estuary, identify what recovery plan actions within the various areas of the San Francisco Bay Estuary would be within 5 miles of an existing airport and therefore require a Wildlife Hazard Assessment prior to possible implementation. This commenter named the public use or federal airports that exist within the recovery unit boundary on **Figures III-7, III-10, III-12, III-16, III-17, III-19, III-21,** and **III-26**.

Response: It is not possible to pin point specific parcels needing to be restored to prevent the extinction of the rail or other covered species, however general regions around the Bay can be, and are, identified for these actions. The maps have been developed to illustrate one vision of the tidal habitat mosaic around the Bay. More specific restoration techniques may well be identified by the future Recovery Implementation Team working groups. If tidal restoration has the potential to affect existing facilities, such as airports, ways to eliminate or reduce those effects will be evaluated as site-specific restoration plans are proposed and all applicable regulations will be complied with.

k.) Habitat for salt marsh harvest mouse in Suisun Marsh

1.) **Comment:* Three commenters suggested that we place more emphasis on the importance of *Schoenoplectus americanus* (especially) and *Bolboschoenus maritimus* and other mature brackish marsh vegetation to the salt marsh harvest mouse, especially in Suisun Marsh. Commenters noted that in recent studies, just as many salt marsh harvest mice were found in areas of mixed-wetland vegetation, especially in areas of mature thatch accumulation, as in areas dominated by pickleweed in Suisun Marsh. Also, commenters suggested citing the HT Harvey 2007 report regarding 2006 trapping in South Bay that showed mature *Schoenoplectus robustus* (alkali bulrush) is used by the salt marsh harvest mouse.

Response: Text has been revised to describe the significant numbers of salt marsh harvest mice supported by primarily mature stands of *Schoenoplectus americanus* with deep masses of thatch within them in Suisun Marsh (Sustaista *et al*. 2012) and also in mature and heavily thatch-filled *S. robustus* in the South San Francisco Bay (HT Harvey 2007). Also, text was clarified throughout the document regarding the common factors of occupied salt marsh harvest mouse habitat, whether tidal or diked, being depth of marsh, density of vegetation, as well as size and continuity of cover.

2.) **Comment*: Three commenters were concerned that we were too dismissive of the permanence of salt marsh harvest mouse populations in Suisun Marsh. Two commenters questioned the statement that populations were dependent upon 'opportunistic colonization of unstable *Sarcocornia'*, stating that this statement conflicts with CDFG and CDWR data showing that in most areas, *Sarcocornia* persists for many years. One commenter disagreed with the statement 'Unstable, unmanaged flooding or poorly managed diked *Sarcocornia* marshes, however, are highly vulnerable to catastrophic flooding and extirpation'. They stated that *Sarcocornia* is one of the most stable vegetation types in Suisun Marsh, that populations recover quickly from flood and fire events, and that the referenced statement denigrates the value of Suisun managed wetlands to the species.

Response: The text has been revised to delete the statement 'opportunistic colonization of unstable *Sarcocornia'* and to clarify that the managed marshes have quite stable populations of the plant. The second referenced sentence has been revised to read: "Unmanaged or poorly managed diked *Sarcocornia* marshes, however, can be unstable and highly vulnerable to catastrophic flooding and local extirpation." Text has been revised throughout the plan to reflect the stability of these populations. However, it is also stated that, though at times diked marshes have supported larger numbers of salt marsh harvest mice than fully tidal marsh in the short-term, diked marshes are no substitute for the latter due to lack of sustainability.

3.) *Comment:* One commenter asked us to define "deep subsidence". The commenter states that soil subsidence began when these areas were originally diked and used for agricultural practices but since that time, wetland conservation has kept these areas wet most of the year and subsidence has been minimized.

Response: Text was revised to clarify that diked marshes are "sometimes unstable" and that recent wetland conservation practices in Suisun Marsh have kept the areas wet for most of the year, thereby minimizing subsidence.

4.) *Comment:* Two commenters disagreed with the statement that there has been "large-scale conversion of *Salicornia* to seasonal waterfowl habitat through improvements in Suisun Marsh duck clubs." They state that the Service approved the DFG triennial vegetation survey methods and periodically review survey results and that this claim has never been verified.

Response: This section of the TMRP also pertains to historic reasons for decline. Wetland conservation practices, although beneficial to the ecosystem, are relatively recent in Suisun Marsh. However, text has been revised to remove the words "large-scale".

5.) *Comment:* One commenter suggested that the sentence "Other habitats used by salt marsh harvest mice in the Mouse Conservation Areas are not, to date, being assessed for vegetation change" is inaccurate. The commenter added that the vegetation at the mouse conservation areas is monitored every three years with the marsh-wide vegetation survey for changes as well as during each survey period.

Response: The text has been revised to remove the last sentence in the paragraph.

6.) *Comment:* Two commenters noted that studies conducted jointly by CDFG and CDWR have shown that salt marsh harvest mice move at least 100 meters from tidal wetland edges (Sustaita, *et. al.* 2010). One of these commenters also noted that the distribution map for salt marsh harvest mouse only shows areas where mice have been trapped, not where habitat occurs.

Response: No text or maps have been revised because the distribution maps are designed only to show species distribution, not suitable habitat. The restoration maps show, among other things, existing marsh habitat. However, text has been revised to reflect findings of this recent study.

7.) *Comment:* One commenter suggested that vegetation in the Suisun Marsh rarely contains pure stands of *Sarcocornia*. The commenter wrote: "As defined in the Suisun Ecological Working Group, the high marsh can be defined as the area from approximately mean higher high water to extreme high water. Middle

Marsh is defined as the region from approximately mean high water to mean higher high water. The low marsh occurs from approximately the mean lower high water to mean high water."

Response: We agree with the commenter that Suisun Marsh rarely contains pure stands of *Sarcocornia*. **Figure I-1** was revised to show the location of middle marsh, and definitions of tidal zones were added to the caption.

8.) *Comment:* One commenter wrote that California's survey efforts from 2002 to 2005 in Suisun Marsh documented large numbers of salt marsh harvest mice in the Conservation Areas, but this was not due to any management or habitat shift other than by Mother Nature. The commenter states that conducting of surveys in areas other than *Sarcocornia* was more likely why mouse numbers showed an increase.

Response: The text was reworded so as not to imply that the increase was due to any management shift.

9.) *Comment:* One commenter noted that the Salt Marsh Harvest Mouse Conservation Areas are referred to as "Mouse Preserves" and that these 2,500 acres set aside for salt marsh harvest mice. The commenter stated that these areas are not preserves because game can still be managed and hunted within them.

Response: The text has been revised to replace the term "preserve" with "Conservation Areas".

10.) *Comment:* One commenter stated that recent research has refuted the Suisun Ecological Workgroup conclusion that 'adverse water management…in Suisun has contributed to the decline of the species' and that the salt marsh harvest mouse is doing quite well today.

Response: Though conditions are better for salt marsh harvest mice in Suisun Marsh now than they were at the time of listing, based on the 2010 five year review for the species, the salt marsh harvest mouse continues to meet the definition of endangered (Service 2010). Also, as stated in the Suisun Marsh Management, Preservation and Restoration Plan (October 2010), the "conversion of tidal wetlands as a result of diking resulted in a loss of habitat for many species, including those now listed as threatened or endangered" (salt marsh harvest mice). As Page 131 of the TMRP addresses not only current and future threats, but reasons for decline, the existing language is appropriate.

11.) **Comment:* One commenter asked whether the statement that says the Service will accept muted tidal marshes in the Grizzly Island marsh complex means that the Service or state agencies will maintain and manage those muted diked marshes in perpetuity?

Response: Due to the significant number of salt marsh harvest mice supported by diked wetlands in Suisun and the low likelihood of restoring those areas successfully to tidal marsh without severe reductions in salt marsh harvest mouse numbers, we have determined that diked marshes in public/conservation ownership may be relied upon to reach recovery criteria acreages. Similar to predator management, management of diked wetlands is meant to be ongoing, at least until species numbers rebound significantly. According to the Antideficiency Act, federal employees are prohibited from involving the government in any obligation to pay money before funds have been appropriated for that purpose, unless otherwise allowed by law. 31 U.S.C. § 1341(a)(1)(B). However, we will continue to work with our partners to protect species and habitat where and when necessary.

12.) **Comment:* One commenter expressed concern that the statement "Transition from diked wetlands to restored or enhanced tidal marsh habitat, where feasible" merely recites recovery plan text discussing background justification, without specifying what actions to take or even consider. They state this is not a useful task unless it cites at least conceptual restoration actions and guidelines and when and where to apply them.

Response: General restoration guidelines are already provided in the supporting language under Action 2.2.3.3. More detailed guidelines are not appropriate in the recovery plan, but are suited to future discussions of the Recovery Implementation Team.

13.) *Comment:* In regard to the statement: 'The implementation of this program should establish 2,500 acres of preferred salt marsh harvest mouse habitat (California Department of Fish and Game *in litt.* 2000)', under Species-level Recovery Strategies, one commenter suggested that 'should establish' should be replaced by 'has established'.

Response: The text has been revised accordingly.

14.) **Comment:* One commenter suggested identifying the marsh edge in the southeastern portion of Rush Ranch to receive "extra" protection from potential grazing and other large mammal intrusion, because it is the area where Hays found the largest numbers of Suisun shrews ever trapped.

Response: The referenced text has been revised.

l.) Appendices

1.) **Comment*: Several commenters had editorial comments about the Appendices. Those comments suggested we clarify 1) that it is the upper half of the middle marsh zone that is affected by higher high tides, 2) that all 161 animals captured by Hays in 1990 were Suisun shrews, 3) that "high marsh" should be used instead of "tidal refugia", 4) egg laying and fledging timeframes for western snowy plover, 5) that tidewater goby have not been extirpated from Elkhorn Slough, and 6) that the brackish water snail also exists in Elkhorn Slough. Also, commenters suggested we change acres to hectares in **Table F-3**.

Response: All of these suggested revisions have been made to the document.

2.) **Comment:* One commenter wished to designate as highest priority in the Suisun shrew conservation strategy, the protection, restoration, expansion and improvement of the mid marsh- high marsh ecotone, the high marsh and wherever possible, the high marsh-grassland ecotone. The basis for the top priority, they commented, was that the area is of high importance at the Rush Ranch site where Hays trapped Suisun shrews. They noted that allowing grazing at that site and the destruction of the grassland-high marsh ecotone that would result would be devastating and likely result in the loss of that population.

Response: The text has been revised in this section on shrews to make protection, restoration and expansion of the mentioned marsh zones the number 1 action. Also, under the action dealing with project impacts, text has been added to specify that grazing impacts at Rush Ranch should be assessed and remediated.

3.) *Comment:* One commenter suggested the deletion of the following sentence: "Approximately 600 hectares (1,400 acres) of crystallizer beds near Redwood City are no longer in salt production and provide an opportunity to significantly increase western snowy plover habitat… as well as providing habitat for the California least tern, and many shorebirds, and some rare insect species." The commenter states that the location is still harvesting salt and that citing this property is particularly inappropriate given the lack of context. They also state that Cargill (the landowner and commenter) has sold and donated 40,000 acres for habitat preservation, thereby providing ample publicly-owned acreage on which to create habitat for plover.

Response: The text has been revised to remove this paragraph from Appendix C and to update text here in regard to recently proposed revised critical habitat for the western snowy plover.

4.) *Comment:* One commenter suggested removing the following two paragraphs on page 71 of Appendix C: The paragraph beginning with "A potential conflict exists between tidal marsh ecosystem recovery goals and maintenance of post-fledge foraging and roosting in diked habitats in the South Bay…" and the paragraph beginning with "Increases in potential nesting habitat should be achieved by converting extensive industrial salt crystallizer beds to wide, playa-like salt pan habitats...".

Response: The paragraphs have not been removed but the text has been revised to clarify that these measures should occur only where lands are available via willing landowners. Also, text has been revised to replace "should" with "could" in the sentence referring to “nesting habitat *could* be achieved by converting extensive industrial salt crystallizer beds to wide, playa-like salt pan habitats”.

5.) *Comment:* One commenter suggested the Service develop conservation goals or targets for other tidal marsh bird species of concern, such as California black rail, salt marsh common yellowthroat, and the three tidal marsh species of song sparrow. They state that though their status is summarized in Appendix C, conservation goals have not been incorporated into the TMRP itself.

Response: Recovery criteria are only developed for federally listed species, not species of concern. However, nearly all regional recovery strategies and recovery actions benefit the tidal marsh ecosystem as a whole, including the species of concern mentioned by the commenter. In this way, the federally listed California clapper rail serves as an umbrella species under which other species of concern are benefitted.

6.) *Comment:* One commenter suggested that text and maps be revised to include updated information on California black rail, common yellowthroat, and the three tidal marsh song sparrows. Also, it was suggested that the same be done for the western snowy plover distribution map.

Response: Distribution maps for all species have been revised to reflect updated distribution. Also, species accounts for the common yellowthroat and song sparrows (Volume II) have been updated with current information. The species account for the California black rail has been updated using Spautz and Nur 2002.

7.) *Comment:* One commenter noted that it is unclear what is meant by “subpopulations may migrate or not”, in Appendix C. On the coast, some of the breeding birds at each site are resident year round while some depart for the winter. Each site contains year round residents, birds present only during the breeding season, and birds present only during winter. Most birds migrate from inland sites for the winter but a few may also overwinter in the Central Valley.

Response: The text has been revised to remove the sentence.

8.) *Comment:* One commenter noted that, in Appendix C, the list of shorebirds includes some very uncommon species and is missing several common to abundant species, some of which also breed in the Bay.

Response: No text has been revised. Appendix C is meant to be applicable background for *sensitive* species of the tidal marsh. It is not meant to be an inventory of common species that occur there.

9.) *Comment:* One commenter noted that, in Appendix F, factors that may influence population growth rate itself were not considered in the analysis, only the variance in instantaneous growth. They noted that variance in instantaneous growth is hard to specifically manage for. Also, they state that the analysis in Appendix F did not consider population exchange, on which dispersal between semi-isolated populations will have a large effect.

Response: The model reflected in Appendix F was the best available to us at the time of writing. For the final document, we have added a recovery action to conduct a population viability analysis on the California clapper rail. We specify that this should be an age-structured population model with an emphasis on necessary connectivity and should project the likelihood of population expansion or contraction, including the possibility of extinction or decline in number below specified levels.

10.) **Comment:* One commenter expressed concern that the Southern sea otter species of concern treatment was eliminated from Appendix C. They state that it is cited as a species of concern inconsistently for areas at the northern end of its range, but not Morro Bay where it also occurs.

Response: No text has been revised. The Regional Species Planning Checklists are meant to be general lists of all species that may be affected by restoration/recovery efforts. Appendix C includes more detailed background on those species more likely to be affected by restoration/ recovery efforts. Not all species found in the former will be found in the latter. Southern sea otter was not included in Appendix C because, unlike that of some other marine mammals, sea otter prey does not use tidal marsh habitat.

11.) **Comment:* One commenter suggested that the Service explain in the document why they have failed to propose listing of tidal marsh shrews, which do not appear to be sustained by the diked pickleweed marshes in Suisun Marsh that sustain the largest sub-regional populations of the listed salt marsh harvest mouse.

Response: No text has been revised. The TMRP is a large, comprehensive recovery planning document covering five federally listed species. It is outside the scope of the TMRP to elaborate on why a sensitive species has not been listed. Listing is a formal process, separate from recovery, which requires a species status assessment, including a threats analysis. Without conducting that assessment and analysis, the Service cannot conclude if a species should be proposed for listing. To consider a species for listing, either a petition must be submitted to the Service requesting the action (and presenting data) or the Service may internally initiate the listing process through the candidate assessment process. The latter route requires sufficient in-house knowledge of the species status and then must be prioritized amongst existing workload.

12.) **Comment:* One commenter stated that there is no argument or evidence presented to justify the assumption that recovery actions proposed for other listed species in San Pablo Bay or Suisun Marsh would overlap with viable founder populations of tidal marsh shrews.

Response: No text has been revised. In Appendix C, under Conservation Strategy for the tidal marsh shrews, it is stated that "Acquisition and management for wildlife in the San Francisco Bay Estuary has presumably provided incidental benefits to conservation of tidal marsh shrews, particularly in the extensive tidal marsh areas owned by the State Lands Commission, California Department of Fish and Game, and the San Francisco Bay National Wildlife Refuge Complex." That section goes on to explain how specifically, tidal marsh restoration conducted for the benefit of salt marsh harvest mouse is likely to benefit the tidal marsh shrews, but that diked marsh management likely would not. In addition to restoration of tidal marsh, preservation of high marsh/ upland ecotone and amelioration of contaminant and predation issues in Suisun Marsh and San Pablo Bay is certain to benefit tidal marsh shrews.

13.) **Comment:* One commenter suggested that the integration of the recovery plans for the western snowy plover and the TMRP should be reviewed in context of recent, apparently progressive declines in snowy plover breeding success along the maritime Pacific Coast range of this subspecies, relative to recent declining trends in San Francisco Bay breeding success.

Response: Snowy plover numbers can fluctuate significantly from year to year. We have made every effort to update the TMRP using the most recent survey data.

14.) **Comment:* One commenter suggested that the TMRP should identify the need to develop broad sub-regional and site-specific habitat management or restoration strategies to reconcile essential and geographically compressed recovery needs of western snowy plovers and tidal marsh species.

Response: No text has been revised, as this task would fall under the purview of the Recovery Implementation Team in coordination with the Service.

m.) Specific Actions

1.) *Comment:* One commenter suggested adding the following information to the Implementation Schedule for Action 2.2.2.5. "Action Duration: TBD, Responsible Parties: Elkhorn Slough Tidal Wetland Project, an initiative of the Elkhorn Slough National Estuary Research Reserve, Cost estimate: TBD, Comments: Further planning required to identify appropriate strategy". Also, they suggested adding the following information to the Implementation Schedule for Action 2.2.2.6. "Action Duration: TBD, Responsible Parties: Elkhorn Slough Tidal Wetland Project, an initiative of the Elkhorn Slough National Estuary Research Reserve, Cost estimate: TBD, Comments: Further planning, engineering, and regulatory compliance required".

Response: The text has been revised to add the requested language to Action 2.2.2.5. No text has been added to Action 2.2.2.6 because that action does not specifically target Elkhorn Slough Tidal Wetland Project or the Elkhorn Slough National Estuary Research Reserve.

2.) **Comment*: One commenter suggested the following revisions to actions in the document. 1) Action 2.1.10.2. Include the mouse and the Suisun shrew as well as the common yellowthroat, 2) in Action 3.1.2.7., reference that Hays developed an excellent shrew trap (Hays 1998), 3) replace the term "tidal cycle" with "tidal range" or "tidal circulation", and 4) regarding Action 2.1.6.1., clarify whether we intended to state that "Salinity and flow manipulations via the Montezuma salinity control gates should be evaluated in light of possible consequences for populations of *Chloropyron molle* ssp. *molle*", not *C. hydrophilum* var. *hydrophilum*.

Response: For parts 1 through 3 noted above, the revision was made. For part 4, text was revised to add "and *Cirsium hydrophilum* var. *hydrophilum"*. Management of the salinity control gates could potentially affect both this species and *C. mollis* ssp. *mollis* (now *Chloropyron molle* ssp. *molle).*

3.) **Comment*: One commenter wondered if the determination of desirable population sizes for long term persistence of salt marsh harvest mouse (in Action 4.2.1.2.6.1 [now Action 4.2.7.1]) is possible.

Response: Action 4.2.1.2.6.1 (now Action 4.2.7.1) was added to the Stepdown Narrative because a good population viability analysis would help us learn more about the population dynamics of the salt marsh harvest mouse. Surveys for salt marsh harvest mice are labor intensive and it would therefore be difficult to assess progress toward target population levels determined through a PVA, nonetheless, it was added as a recovery action to give us an idea of the magnitude of progress toward the goal.

4.) *Comment:* One commenter proposed that the interdisciplinary review panel mentioned in Action 2.2.1 be removed from the plan as there are currently many regulatory agencies (including San Francisco Bay Joint Venture) providing oversight and review, eliminating the need for this redundant process.

Response: Supporting text under Action 2.2.1 has been revised to add "ensure the coordination of restoration design review, whether via creation of a new panel or via formal incorporation of design review into existing regulatory oversight." The Recovery Implementation Team may determine that the San Francisco Bay Joint Venture could serve as such a panel.

5.) *Comment:* Six recovery actions from the TMRP are mentioned as ones that relate to current work being conducted by the South Bay Salt Pond (SBSP) Restoration Project.

Response: The Stepdown Narrative text has been revised to acknowledge the beginning of this work by the SBSP Restoration Project.

6.) *Comment:* One commenter suggested giving a *lower* priority to Action 4.2.7.3 (former Action 4.2.1.2.6.4) and Action 4.5.2.4 (former Action 4.2.4.2.3).

Response: The TMRP has been revised by lowering priorities for these two actions by one rank each and by adding a new priority 1 Action 4.5.2.5 for studying acceptable contaminant levels in biosentinels.

7.) *Comment:* One commenter suggested that, in Action 1.2.1, fee title acquisition should be the highest priority because conservation easements often cost almost as much as fee title ownership and require even more management oversight with less controls.

Response: The intent, in writing the acquisition-related actions, was to allow the maximum amount of flexibility in funding mechanisms and to instead focus on the management of lands.

8.) *Comment:* One commenter suggested adding several sites to those recommended for acquisition in Action 1.2.1 in the Central/South San Francisco Bay and San Pablo Bay Recovery Units.

Response: No revision has been made. Areas named under Action 1.2.1 are the marsh complexes that correspond to the recovery criteria. They encompass all areas where acquisition and protection of specific parcels may occur.

9.) *Comment:* One commenter suggested that federal sources of funding for monitoring and research on lands owned by entities that do not have funding for these studies should be encouraged in Action 2.1.

Response: Though finalization of the TMRP does not include allocation of associated funding, the Recovery Division of the Sacramento Fish and Wildlife Office within the Service has a small amount of annual funding available to implement recovery projects. In addition, the Recovery Division can help leverage funds and otherwise assist partners in pursuing other federal and non-federal funding.

10.) **Comment*: One commenter suggested several parts of the document be re-written to add more detail. The commenter stated that the Service is charged with providing "site-specific management actions as may be necessary" and that this conflicts with programmatic actions, future committees or review teams, etc. which are generally too vague to be useful. For example, the commenter stated that "Work with [organizations, agencies]…" should be a means of achieving a task, not a type of task itself. As another example, they state that "Develop a web-based clearinghouse…" is also a purely programmatic action that has no explicitly defined substantive outcome for survival or recovery of endangered species, or explicit linkage to other recovery tasks that do so. It is not clear to the commenter why a "clearinghouse" would merit a priority 2 status if it is not expressly related to site-specific recovery actions. Also, the commenter wished to have more definition behind the actions "Manage tidal marsh habitat" and "develop and implement habitat management plans" and for the document to include actions capable of implementation with reasonable time and geographic specifications. Also, this commenter wished to see detailed guidelines for establishing ecotones (Action 2.2.2.7).

Response: The TMRP provides site-specific actions. However, where there is a lack of knowledge (*i.e.*, about severity of threat, habitat use, movement, rate of accretion with and without anticipated sea level rise, etc.) actions are necessarily written more broadly. In regard to biological research actions, in most cases, linkages to species benefit are already made. In several cases, the actions which the commenter identifies as too vague are broken down beneath the general action into more detailed actions.

The Service considers continued coordination among agencies necessary for recovery, therefore, we have not removed those associated actions from the Stepdown Narrative. A web-based clearinghouse for information on the rapidly changing science of climate change as it applies to restoration would be very helpful in informing real-time conservation decisions. However, the priority of this action has been changed to 3.

"Manage tidal marsh habitat" (Action 2.1) and "develop and implement habitat management plans" (Action 2.1.4) are part of the Stepdown Narrative framework and are meant to organize the recovery strategy. Specific recovery actions are stepped down from there (*e.g*., "Work with state and local agencies that manage land to manage habitat…" [Action 2.1.1.2]). While there are certainly benefits to identifying even more specific actions in the Stepdown Narrative, where possible, writing these actions using general terms allows greatest flexibility in its effective implementation (*i.e*., if predation impacts shift in location).

The TMRP, under the section which discusses restoration (under ecosystem strategies) explains that accepted standard for successful tidal marsh restoration is constantly changing. It goes on to recommend the use of the Bay Institute's 2004 document entitled *Design Guidelines for Tidal Wetland Restoration in San Francisco Bay*— the best available science—but states that it may be replaced with a better document during the life of the TMRP. Without specific knowledge of each restoration site, the TMRP is unable to give specific design parameters, so no revision has been made in that regard.

11.) **Comment:* One commenter suggested that the actions "Create tidal marsh" (page 292)… and "Restore…high quality tidal marsh habitat" need to be explicitly and exclusively aimed at restoration of suitable, defensible endangered species subhabitats of tidal marshes, principally high marsh and associated sub-habitats.

Response: The Service feels that appropriate emphasis has already been placed on describing the desired quality of restored habitats, therefore, no revision has been made.

12.) *Comment:* One commenter suggested we use results of Liu *et al*. (2009) as a basis for development of a robust and informative monitoring program (Action 3.1.1).

Response: The text has been revised to state that Liu *et al*. 2009 should be used as a basis for a robust monitoring plan.

13.) *Comment:* Two commenters suggested adding various research tasks, including research on tidal marsh species other than California clapper rail. They suggest Actions 4.2.3 and 4.2.4 be expanded to include additional research into environmental/habitat (4.2.3) and threats (4.2.4). In particular, they suggest research on importance of specific plant species on tidal marsh birds (rails and others) and the role of channel structure (sinuosity, width of channels). Research is needed on impacts of predation on population persistence and the factors that can reduce predation rates.

Response: The text has been revised in the Stepdown Narrative to add detail to Action 4.4.6, in regard to channel structure. It is not clear what the commenter specifically meant by "research into the importance of specific plant species on tidal marsh birds." Therefore, that action was not added to the Stepdown Narrative. The rail species account in the draft plan had a comprehensive section on predation impacts, so that text has not been revised, however, text under Action 4.5.4.3 has been added to specify that additional research should be conducted on determining tidal marsh bird life stages most sensitive to predation and on determining management activities most appropriate to reduce the rate of predation. Research conducted under revised Action 4.2.6.1 (rail PVA) would consider the impact of predation on population persistence.

14.) *Comment:* One commenter noted that Section IV currently has very few actions that are tied explicitly to reducing climate change threats and these are lower priority (1.2.2, 1.2.3, 4.2.3.2, and 4.2.3.7). They suggest that the Stepdown Narrative should list more comprehensive, high priority actions for ameliorating climate change threats to listed species.

Response: The text has been revised to upgrade Action 1.2.2 to Priority 1. Action 1.2.3 was not upgraded in priority because most areas where undeveloped, suitable *Suaeda californica* habitat exists, are already in conservation ownership. Text was revised to upgrade Actions 4.3.2.2 and 4.2.3.7 to Priority 1. No specific additional actions dealing with climate change were recommended by the commenter. The Service feels that climate-related recovery action needs are well represented in the Stepdown Narrative.

15.) **Comment:* One commenter suggested that the task "Reverse current trend of tidal marsh loss in Elkhorn Slough…" does not address whether it is physically feasible to accomplish this goal and it does not specify a threshold for erosion reversal that would result in gains of suitable California clapper rail habitat.

Response: The text has been revised to recommend full implementation of the current planning effort in Elkhorn Slough (Tidal Wetland Project), which explores the most feasible options for restoration. The threshold for erosion reversal in Elkhorn Slough which could result in California clapper rail habitat should be illuminated through this planning process and is not appropriate to hypothesize here.

16.) *Comment:* One commenter noted that at the Don Edwards Wildlife Refuge, red-tailed hawks, white-tailed kites, kestrels, and northern harriers have been perching on the telephone and utility lines that run through the marshes. They suggested that these lines should either be undergrounded or moved away from the marshes to protect the endangered species and other creatures found in the marshes.

Response: No text has been revised. Action 2.1.8.2.2 (formerly 2.1.9.2.1) calls for the development and implementation of management plans for lands adjacent to the Bay Trail and other public access areas to reduce human-related disturbance to species and habitat. Supporting text specifically mentions that the Refuge should work with PG&E to remove avian predator nests from their electrical towers.

17.) *Comment:* One commenter suggested the TMRP include updated site-specific recovery actions to reconcile the needs of other species with those targeted within this plan to avoid conflicts.

Response: Considerable effort went into ensuring that development of the TMRP goals and actions did not conflict with recovery planning and general conservation efforts for other species in the Bay.

n.) Recovery Implementation Team

1.) *Comment*: Five commenters (California Native Plant Society, Coastal Conservancy, Association of Bay Area Governments, private citizen for US Corps of Engineers, Mid-peninsula Regional Open Space District) requested participation on the future Recovery Implementation Team.

Response: The Service appreciates the commenter's enthusiasm and interest in tidal marsh recovery. When a Recovery Implementation Team is developed in association with this recovery plan, those entities will be considered for participation on the Team.

2.) *Comment:* One commenter stated that the TMRP does not explain or cite the authority of the Recovery Implementation Team (RIT), criteria, or qualifications for eligibility, or the scientific independence of the RIT, although it does explain the scope of its review, and it does not expressly include independent scientific critical peer review functions. They state that the TMRP cannot properly defer necessary updates, or defer substantive, site-specific actions, to the programmatic activity of a RIT or other advisory bodies.

Response: No text has been revised. Per Service guidance (NMFS and USFWS 2010), the Service possesses considerable flexibility in identifying and selecting team members appropriate to serve on a recovery, or recovery implementation teams. The Service retains the right to select members of the RIT that would best serve the recovery of the ecosystem. It is appropriate for some site-specific recovery actions, especially in regard to tidal restoration and research that must occur sequentially, to be deferred to the RIT.

3.) *Comment:* The Recovery Implementation Team (RIT) would necessarily have to operate longer than 5 years (page 323) to have any meaningful, substantive outcome. The charter of the RIT and its reporting to the Service should ensure its scientific independence from agency policy; the recovery task should make this independence and transparency of its recommendations explicit so it is not merely "an outlet of….public outreach education" (page 193), but a valid scientific peer review and advisory panel.

Response: Per Service Guidance (NMFS and USFWS 2010), recovery teams and recovery implementation teams may be convened to assist and advise the Service on a variety of aspects related to the development and implementation of an endangered species' recovery plan. The recovery team serves in an advisory capacity to the Service. Though we cannot predict exactly how long the RIT will be active, as this will be dependent on the pace at which recovery of this ecosystem will occur, we anticipate that it will be active more than 5 years. Details for the RIT will be in the Terms of Reference developed by the Service at a future date.

o.) Recognition of Efforts

1.) *Comment*: One commenter requested the mention of the South Bay Salt Pond Restoration Project under recovery strategies for the salt marsh harvest mouse.

Response: The text has been revised to accommodate these wishes.

2.) *Comment*: One private landowner requested acknowledgement of their sale and donation of land which contributed toward recovery of tidal marsh species and specifically requested language be added which states that the focus in this document has more emphasis on restoration and management and less on acquisition compared to the 1984 California clapper rail and salt marsh harvest mouse recovery plan. They recommended that more emphasis should be put on describing the great strides that have been made in conservation to date and should specify restoration strategies, opportunities, priorities, timelines and funding sources for habitat restoration on the public lands that have increased so much in the last 15 years.

Response: The text has been revised in several places (Introduction, Tidal Marsh Conservation, Restoration, and Management and Recovery Strategies, California clapper rail) to acknowledge sale and donation of lands. Text has also been revised to reflect that, though acquisition is still recommended in some locations, there is an increased focus on restoration in the current recovery plan, as compared to the focus on acquisition in the 1984 recovery plan. Also, conservation efforts to date are described in the Tidal Marsh Conservation, Restoration and Management section of the recovery plan. Finally, restoration strategies, opportunities, priorities, and timelines for existing public lands are described under the Ecosystem Strategies, Regional Strategies, Restoration Maps, Stepdown Narrative and Implementation Schedule sections of the recovery plan. Recovery Plans do not identify specific funding sources.

3.) *Comment:* One environmental group requested acknowledgement that their organization purchased, or acquired through donation, 1,027 acres of tidal marsh and adjacent upland habitats, and has done considerable restoration on those lands.

Response: The Service acknowledges the substantial work this organization has accomplished in preserving and restoring habitat along the San Francisco and San Pablo Bays. Though highly valuable, the projects listed in the commenter's letter were not added to the text, with the exception of one large project, as the bulleted list therein was intended to focus on only the largest restorations by acreage.

4.) **Comment:* One commenter requested the specific acknowledgement of three individuals that wrote portions of the early drafts of the recovery plan.

Response: The Service agrees and text has been revised to acknowledge these individuals.

5.) *Comment:* One commenter requested acknowledgement of the California Coastal Conservancy and asks that the largest tidal marsh restoration to date in the San Francisco Bay receive more attention. Also, they suggested that the section on restoration status of the Napa Marsh be updated.

Response: The text has been revised under "Tidal Marsh Conservation, Restoration and Management" to add more detail in regard to the significance of the South Bay Salt Pond Restoration Project to ecosystem recovery. Also text regarding the status of Napa Marsh has been updated.

p.) Editorial

1.) **Comment:* Several commenters had various editorial comments which identified typographical or other simple errors such as missing spaces, incorrect spelling, suggestions to use the more common of two places names for the same location, italicize glossary words only at first use per chapter, changes in taxonomic names, corrections to implementation dates for restoration projects, correction of description of marsh zones in **Figure I-1**, erroneous designation as a site of “international” importance instead of “hemispheric” importance, clarification of the species of bulrush present in Suisun Marsh versus the South Bay, addition of plant species to the list of plant associates of *Spartina foliosa*, revision to salt marsh harvest mouse versus western harvest mouse traits in **Table II-5**, addition of species to **Table III-8**, clarification that rails are found along all of Gallinas Creek (not just the southern area), addition of an oil spill erroneously left off the list, addition of Marin Audubon Society (MAS) and Sonoma Land Trust to Appendix D and MAS to the Implementation Schedule List of Responsible Parties, removal of old man tiger beetle from one of two places on the same table, and addition of BREACH II and IRWM projects to list of current conservation projects.

Response: The text has been revised to correct these errors in accordance with the associated comments.

2.) **Comment:* One commenter noted that some of the restoration maps have been duplicated and some have been omitted.

Response: A few copies of the Draft TMRP were inadvertently printed with duplicate and/or missing maps. We immediately replaced those copies with complete copies of the Draft TMRP and apologize for any inconvenience.

3.) *Comment:* One commenter suggested that the ‘may’ in the sentence about sea level rise being a serious factor be changed to ‘will’ (page 278).

Response: The text has been revised.

4.) *Comment:* One commenter suggested adding ‘Suisun Marsh’ to the statement that ‘densities may be very low outside of the Highway 37 and Mare Island Marshes…’ on page 127.

Response: The text has been revised.

5.) *Comment:* One commenter stated that the Villablanca and Brown research was conducted only on salt marsh harvest mice from Suisun; it has not been shown that tail length has the same level of importance throughout the range of the species. Also, the commenter points out that the results of that study showed salt marsh harvest mice and western harvest mice are not hybridizing, so they suggested changing 'Results of the study indicate that the two species are not likely hybridizing…' To 'Results of the study showed that the two species are not hybridizing.'

Response: The text has been revised to specify 'in Suisun' on the first issue and the word 'likely' has been removed regarding the second issue.

6.) *Comment:* One commenter noted that it is factually incorrect to describe the entire Redwood City salt pond site as 'crystallizer beds.' They state that the Redwood City salt ponds 'consist of pickle ponds, crystallizers, bittern desalting ponds, bittern storage ponds, and wash ponds' and the site should be described as salt ponds.

Response: This comment recommends a change to text within the *Recovery Plan for the Pacific Coast Population of Western Snowy Plover*, not the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. If a revision/update is made to the former plan in the future, text in that plan will be revised appropriately to clarify that not all ponds within the Redwood City salt pond area are crystallizer ponds.

7.) *Comment:* One commenter stated that the description of the Suisun Marsh Plan (Page 50) is accurate, but the 2,500 acres of conservation area is not. They state that only the original 1,000 acres of conservation area were designated specifically for salt marsh harvest mice. The additional 1,500 acres were approved by the Service as conservation area for multi-species benefit. They go on to state that the current description of 'major intake for marsh water supplies from Grizzly Bay…major marsh channels' was never implemented and the anticipated effects and redistribution of water has never occurred.

Response: The text has been revised to clarify that the latter 1,500 acres was for multi-species benefit. Also, the text has been revised to state that the change in intake has not occurred.

8.) *Comment:* One commenter felt that the terminology for 'deep' vs. 'shallow' marshes is confusing (given the connotation of water depth) and that it would make more sense to refer to 'wide' and 'narrow' marshes.

Response: Given the orientation of the Bay to adjacent marshes, the Service believes the term "deep" is more appropriate here. However, we agree that for some readers not familiar with marsh habitat, this may be confusing. Therefore, we have added text in the first page of the Introduction, defining the term.

9.) *Comment:* One commenter did not feel that the cover photo represents the tidal marsh ecosystem. They felt that the photo shows habitat that is degraded, marginally suitable or unsuitable habitat for most of the species featured in the plan and only shows dredge spoil side-casting covered by invasive non-native iceplant, acid-sulfate barren spots, and coyote brush. The commenter felt that photos of either target ecosystem structure, or suitable target habitat, or species themselves, would be more appropriate.

Response: The cover photo has been edited to cut out the majority of non-native vegetation that existed in the foreground. The remainder of the photo shows high quality pickleweed marsh.

10.) *Comment:* One commenter stated that the drawing labeled "salt marsh harvest mouse" on page 123 represents a naked tail with a broad base, small ears relative to head length, and body:head allometry that more closely matches a Norway rat than a salt marsh harvest mouse or western harvest mouse. Additionally, they noted that the photograph labeled "Suisun thistle" on page 54 shows a colony of bull thistle and the photo and drawing of soft and salt marsh bird's beaks bear only marginal resemblance to their intended subjects. They recommended that all the drawings and inaccurate photos be replaced by accurate and representative photos verified by species experts.

Response: The photos of Suisun thistle and soft bird's beak have been replaced by original line drawings done in house by the Service. For the salt marsh harvest mouse, we retained the same line drawing used in the draft due to unavailability of additional authorized artwork.

q.) Non-listed sensitive species

1.) *Comment:* One commenter stressed the importance of preserving the southeast corner of the Rush Ranch property, as it holds one of the only sizable populations of Suisun shrew. The commenter offered that Hays and Lidicker (2000) identified the need to exclude grazing from grasslands adjacent to marshes.

Response: The text has been revised to reference the Hays and Lidicker study and to add investigation of grazing impacts to the list of shrew conservation measures.

2.) *Comment:* One commenter with long-term experience in trapping rodents in Suisun Marsh stated that none of their trappers have captured a salt marsh wandering shrew in decades. They stated that perhaps none still exist, but that a deeper and more complex high mash zone along tidal marshes would help.

Response: The text has been revised.

3.) *Comment*: One commenter expressed concern that alteration of tidal regimen of any of the salt ponds should not confuse anadromous salmon and steelhead from accessing appropriate river systems of origin, either Guadalupe River or Coyote Creek, by creating attraction flows that divert them to ponds when entering or exiting their spawning grounds. They stated that restoration of anadromous fish populations in the South Bay should be top priority for all agencies.

Response: The text under salmon and steelhead in Volume II of the document has been revised to add this cautionary language.

4.) *Comment*: One commenter wished to state that black rails, too, will benefit from refugia, not just clapper rails.

Response: The text has been revised to state that black rails will benefit as well.

5.) *Comment*: One commenter stated that the highlighted species of concern should be re-evaluated to ensure the recovery actions proposed in the TMRP are sufficient to prevent them from sliding into extinction.

Response: No text has been revised. This recovery plan focuses on the five listed species, but it does identify specific actions for several non-listed species where those needs are known. Volume I (Introduction) of the TMRP briefly discusses associated species and refers readers to Appendix C (Volume II) which provides pertinent background on these species. In addition, the Regional Recovery Strategies fold in conservation needs and strategies for both listed and non-listed tidal marsh and tidal-marsh associated species.

6.) **Comment:* One commenter stated that in view of (1) the rarity of other inland populations which have uncertain taxonomic relationships with the coastal populations and type locality, and (2) severe threats to the only known population in the type locality, the Service should propose listing of *Cicuta bolanderi* (water-hemlock; or the Pacific Coast population segment of the invalidated combination of *C. maculate* ssp. *bolanderi*).

Response: The TMRP is a large, comprehensive recovery planning document covering five federally listed species and is not an appropriate place for the Service to discuss listing actions. Listing is a formal process, separate from recovery, which requires a species status assessment, including a threats analysis. Without conducting that assessment and analysis, the Service cannot conclude if a species should be proposed for listing. To consider a species for listing, either a petition must be submitted to the Service requesting the action (and presenting data) or the Service may internally initiate the listing process through the candidate conservation process. The latter route requires sufficient in-house knowledge of the species status and then must be prioritized amongst existing workload. It is outside the scope of the TMRP to initiate a listing action.

7.) **Comment:* One commenter stated there is no argument or evidence presented in the conservation strategy or threat analysis to justify the assumption that recovery actions proposed for other listed species would overlap with *Castilleja ambigua* ssp. *humboldtiensis* (Humboldt Bay owl's clover). The same commenter expressed concern that the unique Point Pinole population is endangered by marsh erosion and sea level rise affecting the sole known locality. They suggested the Service propose listing this population segment and verify whether it is a distinct taxon.

Response: The section on regional recovery strategies for Humboldt Bay and the North Coast specifically recommends eradication of Chilean cordgrass in Humboldt Bay and other strategies that benefit non-listed species of the North Coast. The text has been revised, however, to specifically recommend eradication of this invasive under Action 2.1.7.1.1. As mentioned above, it is outside the scope of the TMRP to initiate a listing action.

8.) **Comment:* One commenter noted that the taxonomy discussion of salt marsh bird's beaks in Appendix C should reflect the recent revisions by Tank *et al*. 2009 cited in the species account treatment of taxonomy in the recovery plan. They also noted that salt marsh bird's beak is associated with *Lasthenia glabrata* ssp. *coulteri*, a rare species that should be treated as a species of concern naturally aligned with its recovery actions.

Response: Appendix C, under the salt marsh bird's beaks, has been revised to add the taxonomy discussion cited in Volume I of the TMRP. Also, text has been revised in the species account of *Cordylanthus maritimus* ssp. *maritimus* (now *Chloropyron maritimum* ssp. *maritimum*) to include *Lasthenia glabrata* ssp. *coulteri* as an associated species.

9.)

**Comment:* One commenter stated that the South San Francisco Bay range of *Puccinellia nutkaensis* is heavily invaded by the decumbent, creeping European seaside goosegrass, *P. maritima*. Also, they stated that many reported occurrences of *P. grandis* may be the previously unrecognized European congener of *P. grandis*, if distinct from its north Pacific allied taxon *P. nutkaensis*, and should therefore be treated as a species of concern.

Response: Due to the taxonomic uncertainty regarding these taxa as to whether or not they are a sensitive entity, *P. grandis* has not been added to the species of concern.

10.) **Comment:* One commenter noted that they detected *Polygonum marinense* (Marin knotweed) in 2010 as far east as Rush Ranch, Suisun Marsh and that its original endemic rare status is obsolete as it spreads and behaves like a low-level non-native invasive species, which it may well be. Unless new evidence suggests otherwise, the commenter suggested that this plant be eliminated as a species of concern and conservation attention should be reallocated to more deserving taxa.

Response: Due to the newly reported occurrence of this species throughout a much wider range than previously known, we have removed this species from the section on species of concern.

11.) *Comment:* The same commenter stated that, to protect the marshes and the species of concern, great care should be taken to locate trails and viewing platforms to create the least disturbance possible in the marshes.

Response: The Service has and will continue to participate in, planning efforts by local municipalities to ensure that trail and viewing platform design plans take into consideration endangered and sensitive tidal marsh species and their habitats.

2. General Comments

1.) *Comment:* One commenter emphasized that Petaluma Marsh is considered one of the largest intact tidal marshes in the region and will clearly remain important in species recovery. In order to keep this and other existing tidal marshes viable as habitat, they suggested that the TMRP make specific management recommendations in addition to the broad programmatic tasks currently identified in the plan.

Response: Specific management recommendations in and near Petaluma Marsh are currently described in the Regional Recovery Strategies for San Pablo Bay and a portion of the recovery criteria for the California clapper rail and salt marsh harvest mouse specifically pertain to the Petaluma populations of these species.

2.) **Comment:* One commenter attached a portion of a chapter on China Camp to give some idea of the situation and problems at China Camp.

Response: The text has been revised in the species account for the salt marsh harvest mouse to describe the unique character of the China Camp area as a transition between its northern and southern subspecies.

3.) **Comment:* One commenter has several minor comments regarding salt marsh harvest mouse population distribution, life history/ecology or habitat characteristics/ecosystem in the species account. For example, the commenter stated specifically that *Grindelia* occurs both above and below the line between high and mid marsh.

Response: The text has been revised in each case in response to the comments.

4.) **Comment:* One commenter stated that the salt marsh harvest mouse criteria concerning viable habitat areas should say "… or deeper, have a high marsh transition zone and have excellent escape cover both in the middle and high marsh zones", instead of saying "…some degree of high marsh transition zone".

Response: The text has been revised to add suggested language.

5.) **Comment:* One commenter, recommended deleting "…these ecotones, the transitional areas between habitats…" from the ecosystem recovery strategies because it is confusing and the section reads well without it. The same commenter requested clarification, in the same section, of whether the Service is saying it is more important to provide high marsh habitat where the adjacent mid marsh is shallow.

Response: The text has been revised by deletion of the first sentence and by clarification of the second.

6.) **Comment:* One commenter thought it would be almost impossible to eradicate *Lepidium latifolium* (perennial pepperweed) completely from tidal semi-brackish to brackish marshes and urged the Service to recommend research on the matter before recommending complete eradication.

Response: The Service agrees with this statement. No revision was made. We do not recommend eradication. We recommend reduction to 10 percent cover per marsh.

7.) **Comment:* One commenter provided a draft of a paper on fragmentation (Shellhammer, H. and R. Duke. 2010), which gives a case and data for the likelihood of a narrow tidal marsh becoming a barrier rather than a corridor. The commenter felt the paper should inform Action 4.2.1.2.6.2.

Response: The text has been revised to cite this paper, in preparation. Specifics are given (in the salt marsh harvest mouse species account) for the width at which a marsh becomes a seeming filter or barrier. Text was added to encourage development of high marsh zones that are at least 50 meters in width. Also, action 4.2.1.2.6.2 has been deleted, considering the studies described in the attached draft paper.

8.) **Comment:* One commenter suggested the document address eradication of iceplant *(Carpobrotus edulis*, not *C. chilensis*) in the Napa marshes since they have not found the mice to use it and monocultures of iceplant crowd out all other species of plants.

Response: Iceplant control in Napa marshes was already mentioned under Action 2.1.6.1.3, however, text has been revised (in the species account for salt marsh harvest mouse and in the regional strategies for San Pablo Bay) to add brief discussion of the *Carpobrotus edulis* invasion in Napa marshes.

9.) **Comment:* One commenter stated that, in the salt marsh harvest mouse recovery strategy, pickleweed should not be referred to as a high marsh plant.

Response: The text has been revised.

10.) *Comment:* One commenter requested acknowledgement of a reverse trend of habitat conversion from brackish to salt marsh (net 77 ac since 1989), even given freshwater discharges of Santa Clara Water Pollution Control Plant.

Response: The text has been revised.

11.) *Comment:* One commenter requested we correct the inaccurate statement that wastewater discharges are low in salinity due to state and federal water quality laws.

Response: The sentence has been reworded to state that discharges are low in salinity because they are entirely composed of freshwater discharged from homes and businesses. Also, the paragraph was revised to acknowledge the reverse trend of conversion to salt marsh, resulting in 77 net acres.

12.) *Comment:* One commenter requested a re-wording to language describing freshwater discharge being a constraint to tidal restoration, given that recent trend has been conversion from brackish to tidal.

Response: The paragraph has been reworded to state that discharges do not present the constraint they did previous to 2006 and that constraints will be related to fluctuations in rainfall and delta outflows.

13.) *Comment:* One commenter requested that the Service temper the concept in the statement "Any shoreline trails considered essential and low-impact should be routed well away from high tide edge and high tide refugial habitat", by taking into account the size of the wetland areas adjacent to public access routes. They state that large wetlands such as Oro Loma or Cogswell marsh provide many upland edges that are not close to the Bay Trail and that these refugial areas in combination with the provision of seasonal alternative routes can provide wildlife the necessary buffer and allow the Bay Trail to be located along the Bay.

Response: While the Service acknowledges the value of seasonal alternative routes and that placing the Bay Trail along the Bay reduces the impact to refugia at the high tide/upland interface, refugia within the marsh plain itself is of higher quality, in part due to relative absence of predators. Placing the Bay Trail along the Bay reduces the value of this habitat. Text has been added (in regional recovery strategies for the San Francisco Estuary) that routing trails away from high tide edge and high tide refugia is especially important at small marshes or those with little refugia within the marsh plain itself.

14.) *Comment:* One commenter stated their strong belief that the existing levees at the bayward edge of marshes such as Oro Loma and Cogswell Marshes create muted tidal wetlands that support a wide variety of wildlife, as well as create an essential shoreline setting for the Bay Trail and requested that Service recognize value of this use of levees.

Response: No revision has been made. Though it is true that muted wetlands provide some degree of wildlife value, they are not the ideal habitat for the covered species. Dikes require maintenance in perpetuity, create predator highways and steep dikes provide little to no high marsh refugia for small mammals or birds.

15.) *Comment:* One commenter requested that the Service eliminate the proposed 'Future Tidal Restoration' of Oro Loma Marsh which was successfully restored as a muted tidal wetland with a wide variety of habitat and species.

Response: The map has been revised to show Oro Loma as existing marsh.

16.) *Comment:* One commenter requested that the Service recognize the value of activities like hiking and bird watching by making it a priority of the Plan to incorporate these human activities into the restoration process along with interpretive signage and education programs.

Response: The goal of the TMRP is to lay out strategies for reducing threats to covered species to the extent that they can be safely removed from listed status. The Service has coordinated with various local agencies with recreation-based missions on the development of their regional management/operations plans to best accommodate the needs of sensitive species. However, it is not the goal of the TMRP to lay out recreation goals for the San Francisco (SF) Bay.

17.) *Comment:* One commenter, in regard to the statement in the TRMP that 'engineering can be overdone', wished to remind us that the South Bay Salt Pond Restoration Project will require some level of engineering for every phase of construction.

Response: The Service acknowledges the emphasis SBSP Restoration Project puts on designing site-specific solutions to ultimately produce a self-sustaining and resilient ecosystem and realizes the value of proper engineering plans.

18.) *Comment:* One commenter suggested that providing wildlife-oriented public access and recreation is one of the three goals of their project, and that they look forward to working collaboratively with the Service to make sure that this is achieved in an effective manner.

Response: The Service recognizes and appreciates the value of public education, involvement and support. Actions listed under section 5.3 of the TMRP's Stepdown Narrative describe ways we believe the public could best garner public support in recovery of the covered species. We also acknowledge the long-term benefit to the ecosystem in providing thoughtfully designed and well managed recreational trails to the public.

19.) *Comment:* One commenter, though wholeheartedly supporting the need for broad transition zones, is concerned about the regulatory approvals that may be required (to construct broad transition zones) depending on the source, quality, and quantity of materials available… as well as the issue of placing fill material in existing wetlands to create broad upland areas.

Response: The restoration of ecotone habitat will undoubtedly require varying levels of engineering and permitting effort depending on site-specific details. The Service is committed to working collaboratively with local and other regulatory agencies on permitting issues so that Bay resources are protected while improving habitat for the covered species.

20.) *Comment:* One commenter stated that it would be helpful to restoration planners, practitioners, and land managers if the Service used the TMRP to more fully discuss our position on the appropriate mix of habitats. However, the specific mention of the related Environmental Impact Statement/Report and adaptive management program in the draft plan leads them to believe, despite any potential future critical habitat designations, that their approach to restoration for the SBSP Restoration Project is consistent with the TMRP, as currently written.

Response: The restoration of Bay habitats, including the salt ponds, will undoubtedly entail ecological trade-offs. As explained in the text, the TMRP maps reflect only one vision by which recovery goals for the covered species may be met. In fact, various habitat mix scenarios could result in recovery of the listed species. Though specific parcels are recommended for tidal restoration or other actions on the maps, requiring this to meet species recovery does not enable the flexibility of ecosystem restoration that is necessary with such a dynamic system and ignores the fact that *where* tidal restoration occurs is less important than *how* it occurs (maximum acreage with deep middle marsh and deep, gently sloping high marsh complete with intermarsh and upland refugia) and how it is *managed* in regard to predator management, invasive plant species, etc. Future critical habitat designations for the western snowy plover will consider the TMRP as well as other regional planning efforts, such as the SBSP Restoration Project. The Service believes that western snowy plover recovery goals can be met, even given the tidal marsh acreage recovery criteria described in the TMRP and under the SBSP Restoration Project scenario involving minimum ponded habitat acreage.

21.) *Comment:* One commenter was concerned that the language on page 49 and pages 234-235 overemphasizes one of the three pond complexes in the South Bay Salt Pond Restoration Project footprint.

Response: The text has been revised to better describe the project.

22.) *Comment:* One commenter had several questions regarding the standardization of monitoring techniques, mainly in regard to how it will be implemented. The commenter wondered if the commenter's own monitoring program would be subject to review by the Recovery Implementation Team. Furthermore, the commenter wondered who would develop these standardized techniques, whether all tidal wetland restoration projects would be subject to these standards, and how this would affect their current monitoring program. The commenter was also concerned that the TMRP states that salt marsh harvest mouse monitoring protocols have been developed in conjunction with the SBSP Restoration Project, but was not aware of any such coordination.

Response: In October and November 2006, the Service did coordinate on salt marsh harvest mouse monitoring protocols with the SBSP Restoration Team, via HT Harvey/SBSP. Discussions involved HT Harvey's development of defensible salt marsh harvest mouse monitoring protocols for SBSP Restoration Project areas and were associated with their section 7 consultations.

That said, it is not the intent of the Service to mandate, via the TMRP, the methodology that all surveyors must use to survey tidal marsh species. Neither the SBSP Restoration Project nor other restoration efforts will be "subject to review" by the RIT.

23.) *Comment:* One commenter stated that it would be helpful to property owners, planners and decision-makers, and organizations and individuals who advocate for the protection of clapper rail habitat to have a fact sheet or guidance document from the Service that addresses the nature (slope, types of vegetation, etc.) of the high tide refugia habitat needed by the rails.

Response: A discussion of what comprises quality high tide refugia habitat is included in Chapter III of the TMRP, under Ecosystem-level strategies. Also, as discussed in the TMRP, in 2004, The Bay Institute published *Design Guidelines for Tidal Wetland Restoration in San Francisco Bay*, an excellent discussion of objectives, constraints, design guidelines, and recommendations central to most tidal marsh restoration projects.

24.) *Comment:* One commenter asked the basis for the statement that Oro Loma is an example of a site where "engineering of tidal restoration can be overdone, require corrective measures, develop slowly, or develop mostly habitats or vegetation other than those originally planned".

Response: Oro Loma marsh was listed as an example because this restored salt pond developed mostly habitat other than that originally planned. This marsh has one of the largest infestations of *Spartina alterniflora* hybrids in the eastern Central Bay, and is adjacent to several other large infestations including sites along the San Leandro/ Hayward shoreline.

25.) *Comment:* One commenter asked the meaning of "re-engineered tidegates."

Response: The term "re-engineered tidegates" refers to tidegates that have been modified to either increase or decrease the amount of tidal flows entering a system. In this case, the gates were modified to minimize floodwaters and hasten flood drainage, thereby encouraging development of a partially (or muted) tidal marsh. The term has been added to the glossary.

26.) *Comment:* One commenter noted that the TMRP states that Radio Beach is one of four sites considered highly feasible for reintroduction of *Suaeda californica* in one to three years. The landowner 1) wonders if there are other of their properties considered for reintroduction and 2) is concerned with encumbering any of their properties by encouraging establishment of an endangered species and asked to be contacted regarding any potential plans to experiment with introducing *Suaeda californica* to Radio Beach.

Response: The only property owned by this landowner that is currently identified for investigation into *Suaeda californica* introduction projects is Radio Beach. Also, any consideration of establishment of a plant population on private property would certainly begin with a high level of coordination with the landowner and proceed only with their full consent to partnering with the Service in rare plant reintroductions and recovery of native biological diversity in restored San Francisco Bay wetland habitats.

It should be reiterated that private landowners can make important contributions toward recovery of *Suaeda californica* while avoiding excessive planning complexity, cost, delay, and controversy. Also, due to preliminary site screening, under most agreements for reintroduction, current recreation and maintenance activities would not be considered to adversely affect *Suaeda californica* and the Service agrees that there will be no additional land use restrictions or permitting requirements imposed *for current activities* upon the landowner as a result of *Suaeda californica* reintroduction. In return, the landowner managing the reintroduction site agrees to reasonably minimize any potential effects to *Suaeda californica* caused by routine, ongoing recreational or maintenance activities occurring as a part of landowner operations.

27.) *Comment:* One commenter suggested we quantify the current status of endangered tidal marsh species in the Executive Summary and include a table in the document that describes the listing date, significant progress to downlist and/or delist these species, acreages of current public land holdings, and cost for restoration per marsh.

Response: To the extent that it is known, much of this information has already been provided. A brief status report is given for each species in the Executive Summary. Restoration costs per recovery unit are included in the Implementation Schedule. It is infeasible to include a table with information as described by the commenter for each species. In many cases, that information is not known. For instance, even in using the best available science, data are lacking, such as the presence and density of salt marsh harvest mice in specific marshes and whether recently restored marshes are serving as suitable habitat and will allow for expansion of populations. It is one goal of the recovery plan to bring attention to the need for such information. Also, “current public land holdings” cannot uniformly be counted toward target acreage goals due to variability in management.

The Service purposely strove to illustrate the difference between general conservation strategies and specific action recommendations by separating the ecosystem strategies (and subsequent tiered regional and species-specific strategies) from the Stepdown Narrative, which contains specific (to the extent feasible) recommendations, complete with time and cost estimates.

28.) *Comment:* One commenter suggested we declare in the TMRP that restoration is the primary funding priority. They also recommended that funding plans be summarized and then broken down into categories and prioritized so the public can see exactly how public funds are planned to be spent.

Response: Text has been revised in several places to clarify that funding restoration and management is the priority, as opposed to the focus on acquisition in the 1984 recovery plan. The development of a recovery plan does not come with specifically dedicated funding, though technical assistance is offered to pursue the several avenues of competitive grant programs that exist at U.S. Fish and Wildlife Service. Instead, the TMRP is meant to help our private and public recovery partners leverage funds within their own jurisdictions/organizations.

29.) *Comment:* One commenter suggested we improve cost estimates by completing a full cost analysis. They suggest that where costs are unknown, we acknowledge this and give an estimate range so that the final cost estimates are not misleading.

Response: Costs estimates in the TMRP were carefully developed through consultation with species and restoration experts. This entailed gathering several estimates for the same work and arriving at an average estimate or a range of estimates. Though some costs have been revised for the final recovery plan, there are still actions that lack cost estimates because there are too many unknown variables to arrive at an accurate estimate. These action costs are noted as TBD (to be determined) in the implementation table. Oftentimes, preliminary actions must be accomplished before a detailed action description can be developed. Text in the Executive Summary (Estimated Cost of Recovery), however, has been revised to add “plus costs that are unable to be determined at this time.” Cost estimates on a planning document of this size are inherently rough. However, we used the best information available to arrive at reasonable estimates, where possible.

30.) *Comment:* One commenter expressed concern that a considerable part of the budget is directed to regulatory enforcement. They suggested that regulatory actions be budgeted under Section 7 and Section 10, and should not be allowed to divert needed financial resources from recovery actions.

Response: The Service must assign a cost for all recovery actions in a recovery plan. The particular actions dealing with regulatory implementation (*e.g.*, continuance of coordination with federal, state and local agencies on habitat protection) are already occurring (as are several other actions), are not funded with recovery funds, and thus do not use funds that could otherwise support recovery actions.

31.) *Comment:* One commenter suggested we consider restoring White Slough to exemplify a model tidal marsh, in an accessible public nature viewing area as part of the TMRP.

Response: In **Figure III-10**, the White Slough area is already depicted as existing tidal marsh habitat that should be protected and maintained.

32.) *Comment:* One commenter urged that the TMRP provide more specific information about the attributes of the refuge areas needed by the clapper rails and harvest mice to assure they can effectively use these areas as cover from predators during high tides.

Response: The general attributes of marshes most important to these species are already described within their respective species accounts and ecosystem recovery strategy section. In addition, we refer readers to *Design Guidelines for Tidal Wetlands Restoration in San Francisco Bay.* Further recommendations for ameliorating predation problems would necessitate site-specific analysis which is not within the scope of this recovery plan.

33.) *Comment:* One commenter noted that establishing an outreach program will be an important step in gaining public understanding and support for protecting listed species and that this information should be distributed to property owners, persons designing high tide refugia habitat, planners and planning commissioners.

Response: Outreach and education is an important element of the recovery strategies described in the recovery plan (Action 5.2), including outreach to the groups mentioned. No revision to the text was made.

34.) *Comment:* One commenter urged that all remaining undeveloped baylands must be protected.

Response: In the TMRP, specific areas were targeted for recommended restoration and/or protection, with special attention paid to undeveloped, gently sloping areas adjacent to existing marsh. While the protection of *all* undeveloped lands might be useful in meeting goals of other planning efforts, we have placed highest priority on areas that could provide the best current or future habitat in meeting acreage goals related to recovery of the listed species in the TMRP.

35.) *Comment:* One commenter asked why the ecotonal habitats list from the Bay Goals report (2000) compiled by Glen Holstein wasn't used.

Response: Though Glen Holstein's report is a comprehensive compilation of ecotonal plant communities throughout California, several of which occur within environs of San Francisco Bay, the list described in the TMRP is more representative of what occurs today in ecotonal habitats of San Francisco Bay, which is the focus of the TMRP.

36.) *Comment:* One commenter asked what constitutes a 'population survey'?

Response: In this context "population survey" simply means a survey of the number of individuals in each population. This sentence was meant to convey that less survey data in general are available for the northern subspecies than the southern subspecies, even taking into account the annual monitoring in Suisun by CDFG.

37.) *Comment:* One commenter expressed concern with the 50 year time frame for the recovery plan, particularly in view of the limited areas identified on the maps and the length of time it has taken for this update to be available. They stated that while updates are anticipated every five years, they are not comfortable that they will actually take place as scheduled.

Response: We are unclear whether the commenter recommends a shorter or a longer time frame for the recovery plan. The 50 year time frame was selected in light of the anticipated time frame needed to achieve mature functioning marsh habitat, reduce or eliminate non-native plant communities, observe a long-term result from predator management control efforts, etc. Separate from the recovery plan itself, five year reviews are anticipated roughly every five years for most species and we strive to complete them within that timeframe.

38.) *Comment:* One commenter suggested it would be useful for the TMRP to provide a summary of the status of the listed species and of their population trends over at least a 10-year period.

Response: Though this information would be useful to provide in the TMRP, it is not available for most of the covered species.

39.) *Comment:* One commenter stated that California clapper rails have been found in tidal marsh along San Antonio Creek near Neils Island, but they expect they are also present in the 2,000 acre historic Petaluma Marsh.

Response: No revision has been made, as we consider the section on San Pablo Bay distribution of the species currently reflects this knowledge.

40.) *Comment:* One commenter suggested the discussion on page 98 should also note populations found at Bahia marshes, which were expanded in 2008 by Marin Audubon Society.

Response: The text has been revised to add that rails have been found at Bahia.

41.) *Comment:* One commenter thought the language referencing 'diked salt marshes south of Black John Slough' sounds like it is the Bahia marshes, but that these are no longer diked, as of 2008.

Response: The text has been revised by deleting the sentence regarding Black John Slough.

42.) *Comment:* One commenter suggested surveys of salt marsh harvest mouse are needed in North Bay marshes, since to their knowledge, there have been no surveys done in Marin County marshes for many years.

Response: No revision has been made. The TMRP, in Action 3.1.2.6 recommends that monitoring for salt marsh harvest mice be conducted rangewide, but focused on the 33 viable habitat areas, some of which are located in the North Bay.

43.) *Comment:* One commenter stated that the terms "refugia", "transition zone", and "ecotone" are generally used to refer to the same upland band adjacent to tidal marshes and on which the rail and salt marsh harvest mouse depend for protective cover during high tides. The commenter suggested the terms be used uniformly in the TMRP and that a distinction should be made between refugia habitat and buffers.

Response: The text has been revised to clarify terms.

44.) *Comment:* One commenter suggested that increased disturbance from recreational access, humans, and dogs, should 1) be described broadly in order to be able to cover yet-unidentified recreational uses and 2) also include free-roaming cats, bikers, and other such uses.

Response: Revision has been made under ecosystem recovery strategies to reflect the need to account for impacts/strategies related to yet-unidentified recreational activities. Free-roaming (feral) cats and disturbance from bikers are already mentioned as threats under Factor A, so no further revision was made.

45.) *Comment:* One commenter stated that 1) the reference to feral cats should be changed to free-roaming cats and 2) recreational boating uses, including kayaking, and other recreational non-motorized boats and sail crafts can directly impact habitat and listed species when they access the water.

Response: The text has been revised to read "feral or otherwise free-roaming cats" and to include all water sports.

46.) *Comment:* One commenter requested the addition of the following strategy to the Ecosystem Strategies section: 'The Service and DFG shall comment more actively during environmental review process on projects having the potential to impact tidal marshes and/or high tide refugia and buffer areas.'

Response: No revision has been made, as this activity is already represented. It would fall under Action 1.3 which recommends the strengthening of regulatory and legal protections by improving coordination with federal, state and local regulatory authorities.

47.) *Comment:* One commenter requested the addition of the following strategy to the Ecosystem Strategies section: 'The Service shall develop and distribute materials to educate government planners, officials, public and private property owners about habitat needs for California clapper rail and salt marsh harvest mouse.'

Response: No revision has been made, as this activity is already represented in Actions 5.3.2 and 5.3.3 which recommend 1) developing, maintaining and distributing updated information and educational material related to recovery and conservation of species covered in the TMRP and 2) coordination with local news media to promote public interest in the recovery and conservation of species covered in the TMRP, respectively.

48.) *Comment:* One commenter agreed that public participation is vital not only with private landowners but with non-profits which can attract volunteers to work to improve habitats, outreach to the public by distributing educational materials to educate decision-makers and the public about the habitat needs of the listed species, and why and how to ensure their survival.

Response: The Service agrees that these actions, which fall under Action 5.3.2, are important to implementation of the TMRP.

49.) *Comment:* One commenter suggested encouraging the restoration of smaller marshes as well as larger.

Response: The intent of the TMRP is to stress the importance of preserving and restoring tidal marsh with an emphasis on those parcels that contribute the most conservation benefit: large parcels of high quality marsh with low degree of threats to the covered species. Under Ecosystem Strategies, we explain that restoration of large blocks of tidal marsh has numerous advantages. For example, large marshes increase distances from upland predator den/nest sites and impede terrestrial predators. Large areas of marsh have fewer urban edge effects, including human-related disturbance, contaminant inputs, and litter that can attract rodent predators. In addition, the size and complexity of tidal slough networks increase as marsh size increases. Elevation increases in higher order tidal sloughs, providing more nesting areas and high tide refugia. Large-scale restoration projects are also more efficient than smaller efforts, and yield larger net benefits to the species covered in this draft recovery plan.

However, we also specifically mentione under Central/South San Francisco Bay Regional Recovery Strategies, that "pocket" marshes or fringing marshes may support important local populations of rare or declining species (such as *Cordylanthus maritimus* ssp. *palustris* (northern salt marsh bird's-beak) and *Polygonum marinense*), or provide hard-to-find suitable settings for species reintroductions and are worth preserving. We also state that this TMRP seeks to maximize connectivity for species that move through the Central Bay, providing resting or stepping-stone habitat in as large and healthy remnants as possible. To that end, the isolated remnant marshes in this recovery unit (Central/South San Francisco Bay) should be protected against encroachment and degradation. Where feasible, they should be either expanded or modified to add missing associated habitats, such as terrestrial ecotones, shallow lagoons, pans, fresh-brackish ecotones, etc.

50.) *Comment:* One commenter suggested that 1) one additional measure for limiting rats is to avoid use of riprap and 2) a recommendation should be added that the outboard sides of all levees adjacent to tidal marshes be vegetated with native shrubs and grasses to provide buffers to protect refugial habitat.

Response: The text has been revised to encourage minimization of the use of riprap slope protection and the text under San Francisco Bay Regional Recovery Strategies has been revised in regard to levee vegetation.

51.) *Comment:* One commenter wished to remind us that the Service approved expansion of seven walkways in the Corte Madera Ecological Reserve (Muzzi Marsh) and that, while gates were eventually required, no mitigation was ever required as far as they were aware. That commenter recommended the Service, at a minimum, ensure that no more such structures are approved and constructed and that these large boardwalks that were built over tidal sloughs that are rail habitat, be removed or, at a minimum, reduced in size and mitigated.

Response: We recognize that other types of infrastructure can degrade the function of high quality habitat, therefore, we have revised the text under the regional strategy discussion for San Francisco Estuary to include the recommendation to remove "other infrastructure" in addition to the types listed. However, it should be noted that the TMRP is not a regulatory document and has no authority to require either mitigation or the removal of these facilities.

52.) *Comment:* One commenter stated that the list of priority actions on pages 208-209 should include Gallinas Creek. Also, diked marshes to the north should be expanded to include all low-lying lands to Highway 101 and diked and low-lying lands to the north bounded by Bel Marin Keys and Gallinas Creek.

Response: Page 208-209 is not intended to be an exhaustive list of potential restoration projects within the San Pablo Bay Recovery Unit, but rather describes those general regions of San Pablo Bay that the Service believes, in the absence of site-specific restoration proposals, should be of highest restoration priority.

53.) *Comment:* One commenter suggested that the discussion on page 235 regarding Muzzi Marsh contains two conflicting sentences. It states both that the restoration of the majority of Muzzi Marsh has been unsuccessful and that Muzzi Marsh was successfully restored. In fact, the commenter states, the paragraph should be revised to make clear that the entire marsh is populated with rails and that though extensive dendritic channels may not have developed, there are lessons to be learned from this restoration and it can hardly be considered "not successful".

Response: Text has been revised to read: Other tidal marsh restoration projects have not been successful in establishing *the quality clapper rail habitat that was expected*, for example, Warm Springs restoration in Fremont, New Alameda Creek salt pond restoration, the majority of Muzzi Marsh, and Bel Marin Keys mitigation on Tubbs Island.

54.) *Comment:* One commenter stated that 1) the list on page 236 should include tidal marshes that can be expanded: Gallinas Creek marshes, marshes along Corte Madera Creek, and San Rafael, 2) that Bahia is shown incorrectly to be in Solano County when it is actually in Marin County, 3) that the discussion of the marshes south of Black John Slough needs to be updated and 4) that Marin Audubon Society has breached and lowered dikes on a 100 acre parcel in 2006 that is adjacent to the Petaluma marsh, north of Redwood Landfill and south of Neil's Island.

Response: The text and maps have been revised by adding the requested language or map features.

55.) *Comment:* One commenter is concerned that the TMRP does not evaluate the adequacy of local land use regulations to protect high tidal marsh habitat from accelerated sea level rise resulting from climate change.

Response: No text has been revised. The Service is not aware of any existing local land use regulation aimed at protecting high tidal marsh habitat from accelerated sea level rise, nor has the commenter provided information regarding the existence of such regulations. Consequently, there are no regulations along these lines for which the Service can assess adequacy, as the commenter requests.

56.) *Comment:* One commenter stated that the physical alterations in wetlands could be buffered by inner lagoons, connected to tributaries, that would provide superior refugia, as well as inner channels and seasonal wetlands that hold urban runoff flows until high storm waters in the Bay recede.

Response: No text has been revised. This restoration technique may be appropriate in some locations and not others.

57.) *Comment:* One commenter stated that, in an addendum, some mention could be made about the invasive species of *Phragmites* that has taken over inner wetlands of Palo Alto's flood basin.

Response: *Phragmites australis* (common reed) is already mentioned in the Introduction under Factor A, Invasive Species as the subject of local suppressive management actions. Action 2.1.7.1.5 of the Draft TRMP is to "Develop a system for early-detection and rapid response to invasive plant species". Implementation of this recovery action will hopefully result in coordination with the Bay Area Early Detection Network on this infestation and its root causes.

58.) *Comment:* One commenter suggested that as possible funding for marsh species recovery, refuge wildlife stamps should be requested from federal postal authorities and that Bay Area artists would provide beautiful pictures for this.

Response: The Service supports this concept and appreciates the suggestion.

59.) *Comment:* One commenter stated their concern in regard to **Figure III-21**, that Ponds A1, A2, A3, A6, A7, A8, and A8S and variable sub-pond divisions are not surrounded by pink contour lines designating that they are part of the San Francisco Bay National Wildlife Refuge.

Response: Though the correct ownership boundaries for the San Francisco National Wildlife Refuge were depicted, overlapping of the ownership, recovery unit and marsh parcels lines was confusing. Every effort has been made to make the maps clearer.

60.) *Comment:* One commenter stated that it is now believed that the majority of sediments entering and staying in Bolinas Lagoon are of marine origin. For more details, the commenter referred us to Marin County Open Space District report 2006: Bolinas Lagoon Ecosystem Restoration Feasibility Project. The commenter went on to say that consultant Bill Carmen, who is hired by the county to work on this project, could provide us the most current estimates which are something like 75 percent marine and 25 percent alluvial.

Response: The text has been revised to reflect that sediments are of primarily marine origin.

61.) *Comment:* One commenter stated that though the document says Bolinas Lagoon formerly supported clapper rails, the occasional sightings were probably vagrants. As far as the commenter is aware, there has never been evidence of California clapper rails breeding at Bolinas.

Response: The text has been revised to reflect that rails seen at Bolinas were vagrants.

62.) *Comment:* One commenter stated that there is a proposal to remove part of the Pine Gulch Creek Delta to increase tidal prism and potential wind-wave erosional action on the tidal flats.

Response: The text has not been revised. As stated in the document under Tidal Marsh Conservation, Restoration, and Management, any attempt to catalog restoration efforts is certain to be dated by the time of publication, and to neglect many important participants and projects.

63.) *Comment:* One commenter noted an inconsistency between text regarding rails at Elkhorn Slough on page 24 and page 96 and referred us to Monterey Birds by Don Roberson (1985) and to work by Varoujean (1972).

Response: The text has been revised slightly. No inconsistency was determined between pages 24 and 96, however, text was revised to add Varoujean 1972 and Roberson 1985 as additional references in the former section.

64.) *Comment:* One commenter noted that Spautz and Nur (2004) did not find that mallard nesting density was reduced in *Lepidium*-invaded areas as stated in the text.

Response: The text has been revised by deleting the portion of the sentence discussing mallard nesting density.

65.) *Comment:* Two commenters noted that information from Liu *et al*. 2009 and Liu *et al*. 2010 in regard to clapper rail population trends needs to be fully incorporated into the clapper rail species account and the recovery criteria need to be revised in light of these findings.

Response: The text has been revised in light of these recent studies.

66.) *Comment:* One commenter stated that one of the important findings highlighted by Liu *et al*. (2009) is that overall clapper rail densities declined between 2005 and 2008, at a rate of over 20 percent per year. In particular, the decline for the San Pablo Bay-San Francisco Bay regions (combined) was 46 percent (S.E. = 6.8 percent, $P < 0.001$) between 2007 and 2008. This does indicate the volatility of the population and brings into question its ability to sustain catastrophic mortality as well as sources of chronic mortality. They state that the decline indicates threats to the long-term persistence of clapper rail populations in the Estuary and raises concerns about the ability of this species to recover.

Response: The text has been revised to incorporate the findings of Liu *et al*. 2009.

67.) *Comment:* One commenter suggested that distribution of shapefiles for recovery units should be made available for GIS overlay/analysis purposes (*e.g*., to determine how they coincide with other spatial layers).

Response: Traditionally GIS shapefiles do not accompany published recovery plans, however, they are available from our office upon request.

68.) *Comment:* One commenter stated that 1) clapper rails in the Suisun Bay Recovery Unit would be likely to increase with increases in salinity, not sea level rise per se (loss of high marsh refugia would likely outweigh benefits of increased low marsh foraging habitats), 2) high sediment concentrations throughout much of the San Pablo Recovery Unit would also contribute to the maintenance of current tidal marsh habitats, and 3) sea level rise impacts are expected to be variable in the Central/South San Francisco Bay Recovery Unit, with variable sediment concentrations and erosion/deposition patterns.

Response: The text has been revised to clarify that rails could benefit from salinity increases, not sea level rise, per se and to add the respective characteristics of the San Pablo Bay and Central/South San Francisco Bay Recovery Units.

69.) *Comment:* One commenter asked why the South Bay regional planning units are so much smaller than San Pablo and Suisun Bay Units.

Response: Marsh complexes were not intentionally designed to be smaller in the South Bay. When map scale of **Figures III-2** through **III-4** is taken into consideration, the sizes are more similar.

70.) *Comment:* One commenter asked if the Bay Institute really did publish the PWA and Faber restoration guide.

Response: No text has been revised. The Bay Institute published the guidelines in coordination with PWA/Faber and with funding from the California Coastal Conservancy.

71.) *Comment:* One commenter suggested that references should be cited when describing benefits of large, intact marshes and high marsh ecotones. For example, they stated that Spautz *et al*. (2006) showed that song sparrow abundance increases with marsh patch size and surrounding natural upland proportion, common yellowthroat abundance decreases with perimeter-area ratio (an index of fragmentation), and black rail abundance increases with tidal marsh patch connectivity as well as surrounding natural upland proportion.

Response: The text has been revised to bolster justification for large marsh tracts.

72.) *Comment:* One commenter stated that under Regional Recovery Stategies for San Francisco Bay Estuary (Page 197), we should add 'Enhance source populations.' In the same section, the commenter stated that we need to restore and maintain small populations, not just areas that are in large contiguous areas, and that the former can improve connectivity among subpopulations, which is important.

Response: It is not clear what the commenter means by "enhance" source populations. Populations *will* benefit from the implementation of the ten actions listed. In the case that the commenter meant "augment" or "reintroduce," it should be clarified that this particular section deals with guidelines or principles by which restoration should occur. In regard to small populations, we have reworded the sentence to be more clear.

73.) *Comment:* One commenter stated that it may not always be beneficial to remove dikes, which can provide restoring marshes with protection from erosion.

Response: The text has been revised to clarify that dikes in place for protection from erosional forces should not be removed.

74.) *Comment:* One commenter stated that research needs apply to all aspects of demography of clapper rails and other tidal marsh birds, including effects of flooding on nests and factors influencing predation rates, including susceptibility to predators.

Response: The text has been revised in this portion of the recovery plan (regional strategies for San Francisco Bay) to more generally state research needs. In the Stepdown Narrative, no text was revised because the specific case for targeted research on these demographic aspects in relation to rail recovery has not been made.

75.) *Comment:* One commenter stated that the language regarding surveys on page 210 seems misplaced. They state that while comprehensive surveys of invasive species may be lacking, PRBO conducts numerous bird surveys with associated vegetation measurements in this region. Also, they state the need for nest-monitoring to determine reproductive rates and gain insight into factors that may be reducing reproductive success.

Response: The text has been revised to acknowledge PRBO Conservation Science bird surveys. Also, text of regional recovery strategy has been revised to reflect need for nest surveys. Stepdown Narrative was not revised because Action 3.1.2.5.3 already pertains to studying the survival and mortality of rails.

76.) *Comment:* One commenter felt that, given the high level of urban development and very minimal upland buffer regions in this area, this plan should be explicit about the importance of allowing no new development within the current and future (under high sea level rise scenarios) intertidal baylands zone.

Response: No text has been revised. It is not the place of the TMRP to recommend restrictions on development but only to recommend where restoration should occur. However, the TMRP will be used extensively by Service staff conducting consultations under sections 7 and 10 of the Endangered Species Act, as amended, to determine where effects to the species and habitat may occur and where recovery may be inhibited or prevented.

77.) *Comment:* One commenter stated some justification should be provided for the restoration priorities listed on page 215.

Response: The text has been revised to clarify that general priorities are those set forth by local restoration planning groups.

78.) *Comment:* One commenter stated that given the potential trade-offs between restoring tidal marsh and preserving existing salt marsh harvest mouse populations in currently diked baylands (in addition to ponds currently used by waterbirds), can a spatially-explicit restoration sequence be developed to optimize the viability of multiple species' populations over time? If not, they stated that this is an important research (modeling) question.

Response: The text has been revised in the ecosystem strategies and the salt marsh harvest mouse species account sections to recommend that such a restoration sequence be developed by the Recovery Implementation Team.

79.) **Comment:* One commenter stated that land development and expansion or alterations of water treatment and other industrial facilities, threaten remaining open space lowlands bordering the South Bay's baylands and that the TMRP must adequately address the recent emergence of this geomorphic and ecological reality as a primary threat to endangered species survival and recovery.

Response: The threat of development is discussed thoughout the plan, including the threats analysis; therefore, no text has been revised. Though we agree these factors threaten endangered species survival and recovery in the Bay Area, it is not feasible for the TMRP to provide an updated catalog of all the development and/or expansion/alteration projects mentioned. Also, it is not the place of the TMRP to recommend restrictions on development but only to recommend where restoration should occur. However, the TMRP will be used extensively by Service staff conducting consultations under sections 7 and 10 of the Endangered Species Act, as amended, to determine where effects to the species and habitat could occur and where recovery may be inhibited or prevented.

80.) *Comment:* One commenter stated that the TMRP must be robust enough to address any invasive species that begins to dominate the landscape rather than select a few.

Response: The TMRP addresses the current primary invasive species threats, but cannot accurately and specifically anticipate all future invasive species threats. However, in the down/de-listing criteria for *Cordylanthus mollis* ssp. *mollis* (now *Chloropyron molle* ssp. *molle)*, it states that there "must be less than 10 percent total cover of other non-native invasive perennial or non-native winter annual grass species, including, but not limited to" a list of nine species, "within 50 feet of extant *C. molle* ssp. *molle* populations". The phrase "but not limited to" was added during this revision, in response to this comment. In addition, within the Stepdown Narrative, Actions 2.1.7.1.4 and 2.1.7.1.5 deal with developing and implementing management plans to control *other* invasive non-native plants and developing a system for early-detection and rapid response to invasive plant species (in general), respectively. We consider these criteria and recovery actions to sufficiently address *other* invasive species.

81.) **Comment:* One commenter stated that the recovery tasks and maps refer only to general tidal marsh restoration acreages and generalized "high quality" tidal marsh criteria, as though this would automatically ensure adequate and timely development of high tidal marsh sub-habitats suitable for endangered species, regardless of estuarine position, landscape context or topography.

Response: Some uncertainty inevitably exists when attempting to predict success of marsh restoration and management to support endangered species. However, down/de-listing criteria for each of the species, under Factor A, describes what constitutes high quality habitat. Combined with the restoration maps which do take into account such elements as marsh position, landscape context and topography (to the extent we know it), we consider the TMRP to provide the accurate level of guidance.

82.) *Comment:* One commenter stated that the final TRMP should be carefully updated to increase uniformity of important information relevant to threat assessments and recovery tasks.

Response: The Service has attempted to bring all parts of the TMRP up to date.

83.) *Comment:* One commenter stated that the TMRP should be refocused on long-term survival of listed species through management, active restoration and migration of high tidal marsh. The commenter state that protection of existing marsh in place, an action widely featured in recovery strategies and maps, will most likely be infeasible for the long-term recovery of listed species.

Response: Management, active restoration, and migration of high tidal marsh are, indeed, already foci of the TMRP. In addition, though protection of existing marshes "in place" may be infeasible in the long-term, it is crucial in the short-term, given that sea level rise will occur gradually over many decades. Listed species populations need refugia while adjacent habitat is being actively restored and becoming suitable as habitat.

84.) **Comment:* One commenter stated that the lack of even an abbreviated scientific and habitat management rationale for recovery maps significantly weakens the TMRP, and is associated with many unexplained and inconsistent features in the maps.

Response: No text has been revised. Considerable effort went into creating maps that, though information-dense, are straightforward and user-friendly, obviating the need for an associated rationale appendix.

85.) **Comment:* One commenter advocated that the plan should envision range re-expansion of clapper rails to Humboldt Bay as a 'bet-hedging' strategy to offset catastrophic population declines in core San Francisco Bay populations due to independent catastrophic events such as oil spills, severe co-seismic subsidence of bay sediments, or severe storm events. The commenter state that the explanation for the elimination of the North Coast recovery unit is inconsistent with the rest of the plan.

Response: Little to no dispersal habitat exists between the Golden Gate and Humboldt Bay today and there is no proof that this area supported anything, historically, but vagrant California clapper rails. We have developed recovery criteria that specify a certain minimum number of rails at Tomales Bay and Suisun Marsh that will lessen the risk of extinction due to stochastic events in San Francisco Bay, should they occur.

86.) **Comment:* One commenter stated that given that no recovery unit has been proposed for Humboldt Bay, there is no reason for the TMRP to include "Northern" in the title. The commenter state that the title should either be changed to reflect this or the plan should include a recovery unit in the north coast.

Response: We have retained the name as "Recovery Plan for the Tidal Marsh Ecosystems of Northern and Central California." Although listed species do not occur in all areas within this region, this plan is an ecosystem plan. It is important to retain the Humboldt Bay and North Coast Stream mouth estuaries and lagoons background sections within the Introduction as it describes the ecological landscape along the coast, and those are important parts of the ecosystem. Many of the stated recovery strategies could apply to areas north of San Francisco Bay.

87.) **Comment:* One commenter stated that the California clapper rail species account should conclude with an overall perspective on the relative severity of threats in current and future conditions, including interactions of the threats.

Response: The text has been revised to add a summary paragraph including reference to severity of threats.

88.) **Comment:* One commenter stated that the recovery strategy on page 234 should distinguish between expected or intended restoration outcomes for clapper rail recovery and the more realistic, nuanced interpretation of habitat restoration uncertainty discussed on page 244.

Response: No text has been revised, as it is unclear what the commenter means. Page 234 contains a discussion of acquisition history and strategy (not restoration) while page 244 contains a discussion of habitat restoration history and strategies.

89.) **Comment:* One commenter stated that the loss or persistent reduction of upper marsh vegetation is not only ongoing due to grazing in Suisun marsh at the margins of the rails range, it is also caused by routine mowing up to wetland edges below levee trails in occupied clapper rail habitat in San Francisco Bay (such as at Muzzi Marsh, Corte Madera).

Response: The text has been revised to add mowing near Muzzi Marsh as a threat.

90.) **Comment:* One commenter stated that recreational conflicts and impacts with clapper rails should include unpermitted establishment and use of windsurfer and kitesurfer trails through occupied clapper rail habitat, including nesting habitat, such as Heerdt Marsh/Corte Madera Ecological Reserve.

Response: The text has been revised to include impacts from access routes for kiteboarding and other water sports.

91.) **Comment:* One commenter stated that habitat degradation text on page 110 incorrectly emphasizes obsolete factors such as dike construction (new dikes are no longer constructed in tidal marsh except for tidal restoration projects) and locally excessive sedimentation induced by diking of tidal creeks (again, this is an historic impact or residual impact, not a current threat), and marsh subsidence due to groundwater withdrawl (also largely historic or residual impact, ceased in Santa Clara Valley). The commenter states that habitat degradation should emphasize primary current and expanding threats such as accelerated sea level rise, estuarine and fluvial sediment budget deficits, and spread of dominant invasive tidal marsh plant species.

Response: The text has been revised to emphasize that habitat degradation refers to *remaining* impacts from *historic* actions of dike construction. Though few new dikes are constructed, existing dikes continue to fragment habitat, cause locally excessive sedimentation behind dikes, reduce high tide refugia, etc. Rising sea level is stated as a primary threat (under Habitat Loss) and a summary at the end of the section (Rail threats) restates the relative severity of all threats.

92.) **Comment:* One commenter stated that the species account should provide a clear conclusion regarding the sustainability of tidal marsh habitats in North and South Bay with regard to salt marsh harvest mouse suitability during accelerated sea level rise, and in particular the sustainability of diked Suisun Marsh salt marsh harvest mouse habitats.

Response: No text has been revised. The text already reflects this issue to the best of our knowledge.

93.) **Comment*: One commenter stated that the species account emphasis on high marsh habitat, terrestrial ecotones, flood refuges, is appropriate and instructive, yet this is not reflected in the Stepdown Narrative or recovery maps.

Response: Both the Stepdown Narrative and the restoration maps have been revised accordingly.

94.) **Comment:* One commenter stated that the relative importance of *Apium graveolens* (wild celery) as a competitor and non-native invasive species threat within the very restricted high marsh sub-habitats of *Cirsium hydrophilum* var. *hydrophilum*, originally identified by Dr. Brenda Grewell, has been validated by the last 10 years of vegetation change at Rush Ranch and should be reflected in the species account.

Response: The text has been revised in several places in the document to discuss the threats presented by wild celery.

95.) **Comment:* One commenter stated that the narrow distribution of Suisun thistle in relatively well-drained fresh-brackish high marsh habitat along steep peaty banks of mature tidal marshes (but generally not along gently sloping terrestrial edges of tidal marshes, or recently deposited fine mineral sediments) should be emphasized.

Response: The text has been revised in the species account to describe these specific details of Suisun thistle habitat.

96.) **Comment:* One commenter stated that the relative importance of establishing new populations of *Cirsium hydrophilum* var. *hydrophilum* (Suisun thistle) and soft bird's beak, in unoccupied suitable habitat, versus colonization of new or restored habitat in subsided baylands requires more critical assessment in the recovery strategy, especially in context of recent data on sea level rise trends and sediment deficits in Suisun Marsh (Ganju and Schoellhammer, 2009, pp559-2723).

Response: The text and maps have been revised to place an increased emphasis on protection of undeveloped lands adjacent to existing marsh in an effort to support the relatively long-term landward migration of species and habitat in the face of rising sea level. However, in the short-term, existing and newly restored marshes will be critical to support existing populations of *Cirsium hydrophilum* var. *hydrophilum*, and *Chloropyron molle* ssp. *molle*, and other species.

97.) **Comment:* One commenter stated that the recovery strategy should include additional guidance to balance and integrate the contrasting high marsh habitat requirements of soft bird's beak and salt marsh harvest mice in large tidal marsh settings, including restoration projects.

Response: No text has been revised, as it is not clear what the commenter specifically suggests as additional guidance.

98.) **Comment:* One commenter stated that the opportunistic colonization of sand islets (artificial beach plain habitat) within diked baylands at Montezuma Wetlands was not adequately assessed as an indicator of feasibility for habitat recovery compatible with *Suaeda californica* and western snowy plovers.

Response: The text has been revised to describe this opportunity for benefits to multiple species.

99.) **Comment:* One commenter stated that the section entitled Habitat Loss and Fragmentation fails to distinguish the contrast between negligible recent loss of tidal marsh relative to historic loss and fragmentation of tidal marsh.

Response: The Service feels that appropriate distinction was given in the sections entitled Habitat Loss and Fragmentation and Habitat Degradation and Disturbance to historic versus present threats and the magnitude thereof, therefore, no text has been revised.

100.) **Comment:* One commenter stated that Algerian sea lavender (*Limonium ramossisimum*) which now ranges from San Francisco to Foster City, and seaside goosegrass (*Puccinellia maritima*) which now ranges from at least Burlingame to outer Bair and Greco Island, are becoming local dominants in high marsh vegetation.

Response: Many potential invasive plant species exist within San Francisco Bay estuary and the scope of the TMRP does not allow for a comprehensive treatment of every invasive species. Nevertheless, Section I.D. describes invasive species as a threat under Factor A, stating that there are a number of invasive plants that can have impacts. Though some of the most notable plants are listed, the TMRP states that this list is not exhaustive.

101.) **Comment:* One commenter stated that the emphasis on "incomplete understanding of recovery needs" (page 44) is irrelevant and misleading in the context of restoration and management. They state that it is not necessary to completely understand listed species habitat needs or restoration requirements in order to set forth reasonable and appropriate recovery actions that meet the statutory ESA standard of "best available scientific data".

Response: Reasonable and appropriate recovery criteria and actions *have* been developed. However, this section (threats under Factor E) explains that data gaps exist for each of the covered species.

102.) *Comment:* One commenter expressed confusion over the terms tidal marsh "width" and "depth." These descriptions, they said, are used inconsistently even in the same context. They state that marsh width or narrowness refers to horizontal extent of marsh, especially fringing marshand and that marsh depth generally refers to thickness of marsh sediment or peat, and should not be confused with idiomatic reference to marsh width**.**

Response: Though the Service acknowledges that it is initially slightly confusing, we (with agreement of several ecosystem experts) consider that describing the distance between shore and bay as "depth" is more appropriate than referring to it as "width", which is more appropriate to describe the linear distance along a shoreline. We define our use of the term "depth" early in the document (Chapter 1) and have revised the places in the TMRP which used the term inconsistently.

103.) *Comment:* One commenter stated that the TMRP neglects to acknowledge the opportunity to maintain, enhance, and restore the high marsh-riparian interface along the eastern and northern boundaries of the San Jose/Santa Clara Water Pollution Control Plant (WPCP).

Response: Fortunately, many different entities are restoring lands around the bay. However, providing recent accurate status updates for each of them is infeasible and sure to neglect many important participants and projects. It is one of the primary responsibilities of the RIT to assess restoration options on a site-specific level and to prioritize them. Maps in the South San Francisco Bay Area have been revised.

104.) *Comment:* One commenter suggested we include data for Suisun thistle population survey on Rush Ranch: Total area coverage of 8.55 acres was documented; the population contained approximately 137,500 individuals.

Response: The text has been revised to add the recent survey data.

105.) *Comment:* One commenter stated that the DFG owned-lands in Suisun Marsh are managed for more than just waterfowl hunting, even though this is a major activity on these lands, however, on page 64, we state that "Wetlands owned by California Department of Fish and Game have been managed for waterfowl hunting in the Suisun Marsh ."

Response: The text has been revised to clarify that CDFG lands are *primarily* managed for waterfowl hunting.

106.) *Comment:* One commenter stated that we should add Hill Slough and Joice Island to the list on page 76 about where *Lepidium latifolium* threatens *Chloropyron molle* ssp. *molle* populations.

Response: The text has been revised to add these two locations.

107.) *Comment:* One commenter noted that on page 97, the TRMP states that "There has not been a recent complete survey of California clapper rail population and distribution within the estuary.", but then goes on to describe Point Reyes Bird Observatory efforts, which are a recent complete survey. Also, the commenter states that when each geographical area is described, the old data are used, rather than these new, comprehensive survey data.

Response: The text stating that no recent complete California clapper rail survey has been done has been deleted. The PRBO Conservation Science 2009 data was inadvertently left out of the regional distribution section. Text has been revised accordingly.

108.) *Comment:* One commenter stated he/she is interested in the HT Harvey 1977 reference cited on page 108 that seems to have been tracking clapper rail sightings in Suisun Marsh long enough to find this pattern of association with drought periods. According to their literature reviews, clapper rails were first recorded in Suisun in late 1978 by the Audubon Society (Harvey 1980) and in early 1979 by Harvey (1980) and that prior to that time, there is little evidence of clapper rails in Suisun, possibly due to fresher water conditions (Albertson and Evens 2000).

Response: The text referring to increased sightings of rails in drought conditions in Suisun has been deleted.

109.) *Comment:* One commenter stated that trapping by CDFG and CDWR have found that the northern salt marsh harvest mouse and western harvest mouse become torpid in the Suisun Marsh when cold (L. Barthman-Thompson and P. Quickert unpublished data).

Response: The text has been revised in **Table II-5** to reflect torpor in Suisun Marsh salt marsh harvest mice.

110.) *Comment:* One commenter stated that the finding on page 124, in regard to taxonomy, were also confirmed by S. Brown (2003a) which showed that *R. megalotis* and *R. zacatecae* are most closely related, and *R. raviventris* and *R. montanus* are most closely related.

Response: No text has been revised, as sufficient references are already listed.

111.) *Comment:* One commenter asked, in regard to criteria "A/4: Natural tidal cycles must be restored at Hill Slough and the ponded area at Rush Ranch to return periodic flooding", in what way tidal cycles at First and Second Mallard Branches are measured. The commenter wondered if it was by height and time and how a restored marsh can be made to match the tidal cycles in another part of the marsh.

Response: The text has been revised to replace the word "cycle" with "range". The intent is to recommend the return of a full tidal regime, which was present historically in the region. The intent was not to recommend an engineered surrogate to mimic the tidal regime in another area.

112.) *Comment:* One commenter stated that the most obvious linkage between San Pablo Bay and Suisun Bay is the Carquinez Strait, yet there is no mention of restoration there.

Response: Restoration within the Carquinez Strait is not mentioned because that area has an elevational profile (steep) that makes the development of tidal marsh habitat impossible.

113.) *Comment:* One commenter stated that the cost analysis to eradicate *L. latifolium* is only analyzed for FY1 and seems quite low for the extensive program that would be needed to control or eradicate such a large area.

Response: That particular action pertains only to the physical control of the invasive, not the planning or monitoring of it. We considered other eradication programs when developing this time and cost estimate and feel that it is reasonable.

114.) *Comment:* One commenter stated that assignment of specific tasks by priority, roles and responsibilities to implement recovery strategies in the master plan for recovery should be spelled out in detail.

Response: The TMRP Implementation Schedule (Chapter IV) spells out in as much detail as possible the above items.

115.) *Comment:* One commenter stated that the TMRP should include specific recognition of the critical function of providing public access and recreational opportunities in the education and outreach strategies, as a powerful and effective means to foster support and appreciation for tidal marsh habitat and species.

Also, the commenter states that the TMRP should recognize that, in some cases, some reduction in the habitat value of an area that is used or may be used by endangered species may be allowed if there is no feasible alternative for providing public access.

Response: The text has been revised in the threats and the recovery strategies sections to reflect the recognition by the Service that trails provide an effective means of garnering public appreciation of tidal marsh species. Further, recreation and public access are important components of Bay Area landscapes and can be done in a manner compatible with species conservation.

116.) *Comment:* One commenter stated that the TMRP, if implemented as proposed, potentially creates erosional (wave), subsidence, flood, and other geological hazards to existing infrastructure (roads, airport, and rail) by extending waters to and around existing facilities and levees.

Response: If tidal restoration has the potential to effect existing facilities, ways to eliminate or reduce those effects will be evaluated as site-specific restoration plans are proposed.

117.) *Comment:* One commenter stated that as the TMRP is described as voluntary, the plan should clearly state that it does not create an obligation on any agency, entity or person to implement it, and that it will not be used in making permitting decisions or evaluating projects under environmental review.

Response: While the TMRP is a voluntary document in regard to its implementation, it does indicate acreage (of appropriate quality) within a given region (marsh complex) which is necessary for recovery of the species. Therefore, the document will be utilized by regulatory staff to determine if proposed projects would impede the ability of a TMRP-covered species to recover. Text was added to the Disclaimer portion of the TMRP to clarify this point.

118.) *Comment:* One commenter stated that the TMRP recognizes that high tide refugia habitat on adjacent upland is vital during high tide events. But, they state, to assure refugia habitat is suitable, the recommendation should be expanded to include a description of vegetative characteristics that are needed to protect the California clapper rail and salt marsh harvest mouse from predation during high tide events.

Response: The text has been revised to bolster the discussion of short-term measures needed to provide refugial habitat to the California clapper rail in the absence of invasive *Spartina*. Plant species found in the high marsh and inner-marsh refugial zones are mentioned throughout the text. Specific plant palettes are not prescribed here, but would be appropriate as part of site-specific restoration planning.

119.) *Comment:* One commenter stated that we should provide more specific acreage targets for fully protected upland (within buffers).

Response: The text and maps have been revised to incorporate an even greater extent of adjacent uplands, particularly where those uplands are gently sloping and appropriate for migration of wetlands with sea level rise. Specific acreage targets are found in the recovery criteria and apply to tidal marsh habitats that must include sufficient refugia via the inner-marsh and/or high marsh-upland ecotone.

120.) *Comment:* One commenter stated that we should recommend no new Bay Trails within the targeted protected zones. They state that access in the Bay Area is not consistent with resource protection and restoration.

Response: Recreation is an important component of Bay Area landscapes and can be done in a manner compatible with species conservation. The Service and other resource agencies have, and will continue to, work closely with the Association of Bay Area Governments (The San Francisco Bay Trail) and other groups to ensure that consideration is given to species and habitat protection when planning for new trails.

121.) *Comment:* One commenter stated that we should consider effects of feral cats and dogs off leash, related to control, protection and monitoring for compliance.

Response: The text has been revised in regard to feral cats and dogs off leash.

122.) *Comment:* One commenter stated that we should use sea level rise projections to determine if acreage mix is sustainable.

Response: The text and maps have been substantially revised to account for best estimates of sea level rise.

123.) *Comment:* One commenter stated that some distinction was given in the document to the amount of engineering design on certain restoration projects throughout the Bay, and raised a concern that 'engineering of tidal restoration can be overdone.' However, they state, some level of engineering will be necessary. They state that reliance on natural processes with minimal engineering is ideal, but in many cases would have significant impacts on adjacent properties and not achieve restoration objectives.

Response: The Service agrees with the emphasis the commenter puts on designing site-specific solutions to ultimately produce a self-sustaining and resilient ecosystem and realizes the value of proper engineering plans.

124.) *Comment:* One commenter stated that the TMRP understates the importance of dredged material reuse, particularly given sea level rise and the potential for reduced suspended sediment concentrations in San Francisco Bay. The commenter suggested that the statement on Page 197 'Placement of suitable dredged sediments or fill from excavated former marsh…' be expanded to acknowledge the potential need for dredged material to raise the elevation of diked lands around San Francisco planned for restoration, to allow for evolution to vegetated marsh plain.

Response: The text has been revised to expand the sentence as such.

125.) *Comment:* One commenter stated that there is an inconsistency between two passages (pages 23 and 220) in the TMRP, in regard to Elkhorn Slough habitat. The commenter notes that the statement, 'Elkhorn Slough's endangered species recovery potential, unlike that of San Francisco Bay, has not been greatly impaired by diking and agricultural reclamation, so tidal marsh restoration will not be a principal recovery strategy here' should be revised to read 'Elkhorn Slough's endangered species recovery potential has also been substantially impaired by diking and agricultural reclamation. Tidal marsh restoration will be a primary recovery strategy here.'

Response: The text has been revised to correct the inaccurate statement. The suggested language has been substituted.

126.) *Comment:* One commenter recommended deleting the statement that 'Elkhorn Slough… has less habitat for endangered tidal marsh species than the San Francisco Bay Estuary and Morro Bay.' They state that proportionate to the size of the estuary, Elkhorn Slough has an equivalent potential to host tidal marsh as those other areas.

Response: The text has been revised to delete the previous statement and to reflect that Elkhorn Slough has much potential to support tidal marsh species.

127.) *Comment:* One commenter stated that the Elkhorn Slough National Estuarine Research Reserve has identified and acquired fee title ownership of several subsided tidal marshes in addition to north Marsh and Parsons Slough. The commenter recommends changing Action 2.2.2.6 to read 'Conduct tidal marsh restoration at Parsons Slough, North Marsh, and other subsided historic marshes in Elkhorn Slough, as indicated in **Figure III-31**.'.

Response: The text has been revised to add the suggested language.

128.) *Comment:* One commenter requested the removal from Page 215 the following as outdated and inappropriate:

"Ultimately, if the remaining active salt ponds in Newark and Fremont on the east side of the Bay and west of the Ravenswood restoration area on the west side are someday no longer needed for salt production…The area northeast of Redwood City should be restored to create contiguous habitat between Bair Island and the Ravenswood Point salt ponds to be restored per the South Bay Salt Pond Restoration Project."

The commenter states that there is no need to acquire new, privately owned lands. They also state that TMRP is conditioned upon having a willing seller and that they are not a willing seller.

Response: The paragraphs referenced have not been deleted. These salt ponds exist on lands that were historically marsh habitat, and are adjacent to existing habitat and make up a relatively large parcel which could support either tidal marsh species, waterbird species, or both. There is no biological justification for not including them in lands that are recommended for restoration back to tidal conditions, should there be a willing landowner. The Service believes that additional lands may be necessary to achieve full recovery of these species and the text has been revised to clarify that acquisition for purposes of restoration is always dependent upon willing landowners.

129.) *Comment:* One commenter suggested the deletion of the following sentence: "However, full recovery of the California clapper rail still requires a substantial decrease in the amount of baylands currently used for commercial salt production."

Response: The text has been revised to remove the reference to salt ponds but retains the emphasis that lands are still needed for restoration to tidal marsh.

130.) *Comment*: One private landowner commented that any habitat restoration designation should be removed from their lands since, as a result of their past land sales and donations to the Service, the Habitat Goals acreage vision and the acreages required for implementation of the recovery plan in the South San Francisco Bay have been achieved.

Response: Although the recovery plan incorporated several conceptual elements from the Habitat Goals document (Goals Project 1999), it does not fully realize the goals of a recovery plan approved by the Service. For example, the Habitat Goals document does not lay out species-specific recovery criteria, recovery strategies and prioritized recovery actions, including responsible parties, cost estimates, and an estimated timetable for performance of actions. Whether or not the tidal marsh target acreage goals in the South San Francisco Bay in the Habitat Goals document have been met is independent of this current recovery planning effort.

Further analysis is needed to determine whether suitable tidal marsh acreage has been preserved to meet the species-specific acreage criteria for species covered in this recovery plan in the South/Central San Francisco Bay Recovery Unit. Even if the acreage target has been met, submergence of some lands under projected sea level rise scenarios may necessitate protection of additional habitat. Also, minimum acreage is not the sole criterion, as habitat must be high quality and have specific characteristics, such as sufficient movement corridors, as detailed in the criteria section for each species.

Literature Cited

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2010. Interim endangered and threatened species recovery planning guidance, version 1.3.

U.S. Fish and Wildlife Service. 2010. *Reithrodontomys raviventris* (salt marsh harvest mouse) Five Year Review; Summary and Evaluation. Feb 2010.