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**BIG LAGOON WETLAND AND CREEK
RESTORATION PROJECT,
MUIR BEACH, CALIFORNIA
PART I. SITE ANALYSIS REPORT**

Prepared for

The National Park Service

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maintain a stable opening. In fact, increasing the size (or tidal prism) of the lagoon would have little impact on closure frequency. Therefore, the existing tidal lagoon will remain open only as long as freshwater inflows are sufficiently high to scour an outlet channel through the beach berm.

The lagoon exhibits four seasonal modes of behavior, defined as follows:

1. Fully Closed: The lagoon outlet is entirely filled with sand, and the beach berm is at +6 feet NGVD or higher. The lagoon may fill initially with freshwater, but eventually diminishes due to evaporation and seepage. This mode occurs following closure in the mid-summer, and persists until the first major winter storms.
2. Open, Nontidal: Periods of strong onshore sand transport build the beach berm up to a level that prevents tidal inflow. At the same time, freshwater inflows are sufficient to maintain an open channel across the berm. During the field monitoring of 1992-1993, this occurred in March of 1993.
3. Open, Tidal on Spring Tides: The beach berm is built up to a level that allows tidal inflows only during spring higher high tides; neap tides do not enter the lagoon. Freshwater inflows are still sufficient to maintain an open outlet. This occurs in the spring and early summer prior to full closure.
4. Open, Partially Tidal: The outlet channel is scoured to as low as +1 feet NGVD, allowing tidal inflow during all tidal cycles. Low tides are still muted. This mode occurs during the winter when flood flows are very high and the beach profile is eroded by winter storm waves.

Volunteers organized by the National Oceanic and Atmospheric Administration (NOAA) have been monitoring the status of the tidal lagoon mouth since the fall of 1998 approximately every two weeks. The status of the lagoon mouth (i.e., open or closed) observed from 1998 to 2002 generally support the seasonal pattern described above. The mouth was observed to be open on 44% of fall field visits, 100% of winter and spring field visits, and 80% of summer field visits. A fully closed lagoon mouth was generally observed only in late summer and early fall.

Since 1994, the lagoon surface area has decreased as the back beach flow was initially reduced then moved landward. By moving the scouring action of the back beach channel landward, wave overtopping and wind transport have filled the tidal lagoon and reduced its area. A more complete description of this process is presented in Section 4.2.4.2.

4.3 BIOLOGICAL RESOURCES

Between 1992 and 1993, PWA *et al.* (1994) monitored existing and former wetland habitats within the historic Big Lagoon ecosystem. The biological monitoring focused on major wetland-dependent floral and faunal groups to establish a qualitative and quantitative description of species composition and

relative abundances. The description was made in part to help develop potential restoration alternatives, and also to document existing biological conditions and patterns of seasonal change as a baseline from which to compare the results of future restoration efforts. Vegetation and wildlife groups that depend on existing wetland habitats and are sensitive to increases or decreases in the quality and quantity of wetland habitat were monitored, including plant assemblages, aquatic invertebrates, fishes, reptiles, amphibians, and birds. For each group, monitoring sites were selected to characterize different types of existing habitats or potential restored habitats within the larger wetland complex. This information was summarized in the 1994 Preliminary Environmental Assessment (PWA *et al.* 1994).

The biological resources information contained in the 1994 PWA *et al.* report has been updated to reflect recent knowledge and changes in existing conditions since 1993, based on existing information made available from NPS and the PRBO. This includes updated vegetation mapping completed as part of 2002 and 2003 wetland delineation, classification (following Cowardin *et al.* 1979) mapping, post-1993 survey results for wildlife and fish species, and updated information on the status and presence of special-status species at the site. No new field monitoring was conducted specifically for this report. If certain vegetation or wildlife communities have not changed significantly, or if no new information was provided, the 1994 PWA *et al.* descriptions and survey results provide the sole source of information. No additional historical information (i.e., prior to 1992) has been added.

4.3.1 Vegetation/Habitat Types

Existing vegetation at the project site is largely comprised of riparian forest and scrub, and seasonally to semi-permanently flooded emergent wetlands (Figure 21), containing both native and non-native plant species. The NPS has compiled a plant list (Appendix C) from various surveys conducted in the Big Lagoon project area, including the species reported by PWA *et al.* (1994). Of the 219 species reported, 64 percent (n = 140) were native and 36 percent (n = 79) were non-native. Predictably, most non-native vegetation grows in disturbed areas currently impacted by human activity (e.g., roadsides, trailsides, and picnic areas). In contrast, species number and cover of native species are greater in less-impacted riparian, aquatic and upland sites. In general, non-native species (e.g., annual grasses and white clover [*Trifolium repens*]) dominate the higher, drier areas of the Green Gulch pasture, and a mix of native species and non-native weeds (particularly invasive Mediterranean annual grasses) have established on habitat edges such as the levee. Riparian, aquatic, dune and marsh habitats are comprised mainly of native species. The dune area has the lowest species richness (n = 16) compared to all other habitat types (Appendix C).

Six major plant associations in the lowland were quantitatively sampled during 1992–1993 as part of the 1994 EA (PWA *et al.* 1994; see Appendix D, Figure D-1 for transect locations). They were, with approximate area, pasture (8 acres), salt marsh (1 acre), disturbed (1.25 acres), riparian (4.25 acres), aquatic (nearly 1 acre), and dune (1.5 acres). Eight transects were established for quantitative seasonal surveys along the major subhabitats within the existing and historic wetland: one in disturbed habitat dominated by Kikuyu grass (*Pennisetum clandestinum*), one in the salt marsh, one in the lower riparian (or aquatic), and five in the Green Gulch pasture. An additional transect was established in the upland hillsides. Details about qualitative and quantitative survey methods can be found in Appendix D.

Since the 1993 surveys, there have been four additional surveys that have included vegetation within the Big Lagoon project area:

- PORE survey in 2002 (cited in Appendix C);
- Rare plant surveys within the project boundary, spring 2002 and spring 2003;
- ACOE Jurisdictional Wetland Delineation, 2003 (Figure 22);
- Wetland mapping using the Cowardin classification system, 2002, with additional area within the project boundary mapped in 2003 (see Figure 21 and Appendix E, which associated plant species list by polygon).

These recent surveys document an expansion of the riparian forest south and east of the parking lot, and a shift from dry upland pasture in the Green Gulch pasture to a seasonal wetland with increased inundation and saturation (see Figures 3 and 21). More specific information on changes since 1993, species composition, and location within the Big Lagoon project area by habitat type is discussed below.

4.3.1.1 Riparian Forest and Scrub

In 1993 the riparian corridor included areas of low, aquatic herbaceous vegetation grading into the tidal lagoon and in the quiet water along the levee. The main riparian forest/scrub at the site extended between the present and former creek channels, bounded by the levee road, Pacific Way, and the parking lot (Appendix D, Figure D-1). Today riparian vegetation also extends 1) in a small linear strip along the eastern side of the levee road; 2) around the eastern and southern side of the parking lot, on sediment deposited downstream of the footbridge more than a decade ago; 3) along Green Gulch Creek; and 4) in the vicinity of and continuing upstream of the Pacific Way bridge (Figures 3 and 21). Most of the riparian vegetation in these areas is no more than 40 to 50 years old and is recovering from agricultural clearing (aerial photographs taken in 1947 indicate that the riparian corridor along Redwood Creek downstream of Pacific Way was cleared for grazing [Vick, 2002]).

Riparian vegetation at the site is composed primarily of a dense canopy of red alder (*Alnus rubra*), arroyo willow (*Salix lasiolepis*) and yellow willow (*Salix lucida*), and an understory of thimbleberry (*Rubus parviflorus*), blackberry (*Rubus ursinus* and *Rubus discolor*), and red elderberry (*Sambucus racemosa*) mixed with thick stands of nettles (*Urtica dioica*), water parsely (*Oenanthe sarmentosa*), hedgenettle (*Stachys ajugoides*), native morning glories (*Calystegia* spp.), and non-native cape ivy (*Delairea odorata*) and English ivy (*Hedera helix*). Patches of cattail (*Typha latifolia*) and other emergent vegetation grow at the waters edge.

Fifteen of the 49 species (31 percent) identified in riparian areas were non-native (Appendix C). Most of the non-native species occupied the riparian edge; however, a relatively high cover of non-native English and cape ivy occurred well within the forest. Alvarez (1999) conducted a field study to determine the effects of cape ivy invasion on plant communities within the GGNRA. Within the Redwood Creek vicinity, plots where cape ivy was dominant (> 70 percent cover) had lower plant species diversity, altered species composition in favor of non-native species, and reduced abundance and diversity of

seedlings (Alvarez 1999). In plots where cape ivy was removed, there was a significant increase in plant species richness, predominantly due to increases in seedling recruitment of grasses and forbs (Alvarez 1999). Cape ivy invasion has also been found to alter the riparian terrestrial invertebrate community within Redwood Creek (Fisher *et al.*, 1997). Plots invaded by cape ivy had significantly lower abundance of flies (Diptera) and beetles (Coleoptera) and increased abundance of springtails (Collembola) than plots that were devoid of the ivy (Fisher *et al.*, 1997). These alterations in riparian community structure and composition may affect vertebrate taxa as well. Restoration efforts should consider removal of cape ivy as a priority.

4.3.1.2 Seasonal Wetlands in the Green Gulch Pasture

The Green Gulch pasture area (Figure 3) was historically a wetland, and then was filled with as much as 6 feet of sediment (through deposition and mechanical fill), as discussed in Section 3.2.2. The Green Gulch pasture area has since transitioned from a relatively dry, elevated, flat grazing area dominated by grasses, back to a seasonal wetland as surface and groundwater levels have risen over the past 10 years (discussed in Section 3.2.3).

There are currently three distinct water regimes and corresponding vegetation communities in the pasture, moving from west to east (Figures 3 and 21), including 1) a semi-permanently flooded region that runs adjacent to the levee road and is dominated by cattails (*Typha latifolia*) transitioning into 2) a seasonally flooded emergent wetland area; and 3) the seasonally saturated rectangular field between Green Gulch Creek and an unnamed tributary (Field 7; see Figure 3). In addition to cattails, dominant native species include obligate or facultative wetland species such as spikerush (*Eleocharis macrostachya*), water plantain (*Alisma plantago-aquatica*), silverweed (*Potentilla anserine*), and water parsley (*Oenanthe sarmentosa*). Of the 56 plant species recorded, however, 30 (54%) were non-native (Appendix C). These non-native species, including annual grasses (*Polypogon monspeliensis*, *Lolium perenne*), penny royal (*Mentha pulegium*), creeping bent (*Agrostis stolonifera*), clustered dock (*Rumex conglomeratus*), bull thistle (*Cirsium vulgare*), poison hemlock (*Conium maculatum*), and ox-tongue (*Picris echioides*) are concentrated around disturbed areas (e.g., adjacent to the levee road, trail, or horse paddock area) and areas that are more elevated and dry (e.g., the pasture between Green Gulch Creek and the unnamed tributary, which is dominated by annual bluegrass [*Poa annua*]). A few native trees grow along the pasture side of the levee, including black cottonwood (*Populus balsamifera*) (native to coastal California but not historically locally native), California buckeye (*Aesculus californica*), shore pine (*Pinus contorta*), and an elderberry (*Sambucus* spp.).

Recent management activities by NPS conducted in late 2002 to excavate the channel (discussed in Section 3.2.3) have reduced backwater effects and lowered groundwater elevations, improving drainage of Green Gulch pasture. If these efforts continue, the vegetation within the pastures will likely shift from obligate wetland species to more facultative and upland species such as those present during 1992–1993 surveys (see Section 3.3.2).

Cattails, which can spread both vegetatively and by seed, currently dominate the semi-permanently flooded area of the Green Gulch pasture. Although cattails are native, they can clone rapidly and produce

a large leaf surface area, which outcompete other emergent vegetation and produce a dense, monospecific stand. Restoration efforts will need to address continued encroachment of cattails into any perennially wet areas to ensure that a diversity of native wetland vegetation is allowed to establish at the site. It should be noted, however, that the cattails are currently providing breeding habitat and cover for California red-legged frogs in the study area (see discussion under Section 4.3.2.1), so the benefits of habitat diversity versus red-legged frog habitat will need to be considered.

4.3.1.3 *Permanently Flooded and Intermittently Exposed Habitat*

PWA *et al.* (1994) considered areas with standing water, such as channels or broad regions of low elevation, to be aquatic habitat. These included human-made excavations that held or conducted water most or all of the year. The channels included Redwood Creek, as well as two channels or ditches through the Green Gulch pasture (Figure 3). Currently, the only areas mapped as permanently flooded or intermittently exposed habitat (Figure 21), besides the willow/alder grove already discussed in section 4.3.1.1 (Riparian forest and scrub), are the Redwood Creek channel and the unnamed tributary through the Green Gulch pasture (see Figure 3).

Nineteen of the 52 species (37%) recorded in permanently flooded or intermittently exposed habitat within the Big Lagoon project area were non-native (Appendix C). Although the area of permanently flooded or intermittently exposed habitat has decreased, the species composition has not changed significantly since the 1992–1993 surveys (Appendix E). During 1992–1993 surveys in lower Redwood Creek, non-native species were concentrated along the lower creek edges; the dominant cover here included ox-tongue (*Picris echioides*), creeping bent grass (*Agrostis stolonifera*) and pennyroyal (*Mentha pulegium*). The non-native knotgrass (*Paspalum* spp.) covered much of the shallow water flats downstream of the footbridge. Three emergent native plants were most common: three square rush (*Scirpus americanus*), cattail (*Typha latifolia*), and species of bulrush (*Scirpus* spp.). Other native wetland species which grew along the transect area included water plantain (*Alisma plantago-aquatica*), tall cyperus (*Cyperus eragrostis*), monkey flower (*Mimulus guttatus*), and small red alders. Other species present today include water parsley (*Oenanthe sarmentosa*), dotted smartweed (*Polygonum punctatum*), floating marsh pennywort (*Hydrocotyle ranunculoides*), silverweed (*Potentilla anserina*) and Baltic rush (*Juncus balticus*).

4.3.1.4 *Brackish Marsh*

A brackish marsh area is present between the tidal lagoon and the parking lot, divided by a former beach access trail, and bounded by the willow/alder grove and the hillside residential area. A buried retaining wall (built in conjunction with the former tavern) appears to serve as a barrier between the brackish marsh community and the disturbed area dominated by Kikuyu grass located immediately adjacent to the parking lot (discussed in the following section). Recent wetland mapping shows the area between the tidal lagoon and the parking lot, excluding the willow/alder grove, as a mix of seasonally to semipermanently flooded emergent wetland, with a small strip of permanent tidal emergent wetland (Figure 21). The species composition is currently dominated by salt rush (*Juncus leseurii*), salt grass (*Distichlis spicata*), and silverweed (*Potentilla anserina*), similar to that described following quantitative surveys during

1992–1993 by PWA *et al.* (1994). There are not very many communities like this south of Point Reyes (NPS Technical Scoping Notes, 2002).

Two salt marsh species were observed in 1992–1993 in the marsh in very small patches (less than 1 m² each). A few alkali heath (*Frankenia salina*) plants grew along the sandy northwest edge of the marsh and a patch of jaumea (*Jaumea carnosa*) grew along the east side of the path. Neither species was observed during 2002 wetland mapping (Appendix E). One gum plant (*Grindelia stricta*) plant was observed in 2003.

4.3.1.5 Disturbed Habitats

The existing condition and composition of plant communities on most of the wetland habitats in the project area indicate that the area was historically and continues to be disturbed by human land use. In addition to habitat edges and high traffic areas (e.g., the levee road and trail), a disturbed association begins immediately adjacent to the parking lot (beach-side) and grades into the brackish marsh area. The name refers to the weedy and invasive nature of the plants comprising that association. Although the disturbed site does not cover a large area, it should be considered as a candidate site for restoration efforts both to restore native habitat and to reduce the risk of non-native plants spreading to other areas.

This disturbed site was noted in PWA *et al.* (1994) as a site of heavy human use throughout this century. Kikuyu grass comprised nearly 100 percent cover along the transect sampled in 1992–1993, except during the spring when non-native vetch (*Vicia sativa*) was a co-dominant. Kikuyu grass graded into the brackish marsh where rushes and silverweed became dominant; into the urbanized upland dominated by weedy and ornamental species; and into the parking lot/picnic area covered by herbaceous weeds such as annual grasses and scarlet pimpernel (*Anagallis arvensis*). The only native species observed were occasional rushes. Today, grasses, curly dock (*Rumex* spp.) and creeping bentgrass (*Agrostis stolonifera*), typical of the seasonal wetland that used to be more dominant in the Green Gulch pasture area, dominate vegetation of the area between the tidal lagoon and the parking lot (NPS Technical Scoping Notes 2002). It is interesting to note that a buried retaining wall from the old tavern appears to be a barrier between the brackish marsh and this disturbed association.

Some of the introduced species provide a major challenge to eliminate. None may be more difficult than Kikuyu grass. This species is a perennial, with leaves that brown seasonally, but build up heavy, suffocating cover that makes it difficult for other species to establish seedlings. The grass grows in a large variety of habitats, produces a deep, thick root system, is difficult to eliminate with herbicides, and is not preferred forage for grazing animals.

4.3.1.6 Dunes

The dune community at the site occupies the narrow fringe between the intertidal zone and the lower creek channel (Figure 3). This area has historically been degraded by visitor use and has been the focus of restoration efforts conducted by the NPS since 1995 (Shoulders, *pers comm*, 2003). The area continues to

provide restoration opportunities to improve natural dune formation processes and the presence of a more diverse native plant community.

In 1992 and 1993, PWA *et al.* sampled three tiers of dunes: four low mounds above the high intertidal zone, two large back dunes footing the upland hillside, and two larger mounds intermediate between the first two tiers. Sixteen species of plants were observed on dune habitat. Only three true dune species occurred: beach bur (*Ambrosia chamissonis*), native dune grass (*Leymus mollis*) and sand verbena (*Abronia latifolia*). An additional coastal native species, lizard tail (*Eriophyllum staechadifolium*), was found in the backdune. However, it is not restricted to dunes, but is common in coastal scrub communities as well. Seven non-native species grew in the dune habitat, including the highly competitive European beach grass (*Ammophila arenaria*), ripgut brome (*Bromus diandrus*) and Hottentot fig (*Carpobrotus edulus*) (ice plant). One non-native, sea rocket (*Cakile maritima*), is actually considered a favorable early colonizer of the lowest, wave- and wind-disturbed foredunes. The other non-natives were typical of upland habitat and were not abundant.

The low count of native dune species was indicative of the degraded state of the habitat. Though the narrow area available between foredune and hillside restricted development of mid- or backdune plant communities, the most important inhibitor to the establishment of a healthy dune community was overuse by visitors. Trampling killed plants, destabilized sands, and thus precluded re-establishment of native vegetation. The foredunes were more species-poor and had lower vegetative cover than healthy dune communities in other coastal areas, such as the better developed local dunes at Stinson Beach. Species present included both natives (beach bur) and highly invasive non-native species (ripgut brome and European dune grass). Middunes were also vegetated by natives (e.g. beach bur, dune grass) and non-natives (Kikuyu grass). Back dunes graded into the hillside and supported moderate to dense cover of natives (mugwort [*Artemisia douglasiana*], sand verbena and native dune grass) mixed with a significant cover of non-natives like ripgut brome and mustard (*Brassica* spp.).

Beginning in 1995, NPS has made several efforts to protect and restore the dune community in this area, including protective fencing, re-direction of pedestrian traffic, and removal of invasive non-native plant species (Shoulders, *pers comm*, 2003). Dune restoration since 1995 has also included removal of nearly all iceplant from the dunes. With these efforts, the dune area has expanded, although the lobes that have developed continue to be disconnected by visitor paths across the beach, limiting the processes of natural dune formation (Shoulders, *pers comm*, 2003). Additionally, the dune plant community is still characterized by very low species diversity, and non-native weeds such as ripgut brome are more extensive than native species (Shoulders, *pers comm*, 2003). Dominant species include beach burr, sand verbena, and sea rocket. Dune grasses (*Leymus* spp.) also occur at the foredunes, and some riparian species such as mugwort (*Artemisia douglasiana*) and California bee plant (*Scrophularia californica*) occur where dunes intergrade with wetland areas.

Natural disturbance of the dunes by wave wash may have almost as much impact on dune vegetation as human disturbance. Winter storms commonly wash most of the central and northern section of the beach, with sea water running into the tidal lagoon. This disturbance occurred during several high tides and winter storms in 1993.

4.3.1.7 Upland Hillsides

Upland habitat of modified coastal scrub grows adjacent to the site on the surrounding hills. The upland hillsides adjacent to the project site have not been quantitatively sampled recently. One plant transect was regularly surveyed along the hillside coastal scrub community during PWA *et al.* (1994) surveys (see Appendix D, Figure D-1). The site was dominated by high cover of non-native annual species, including hair grass (*Aira caryophyllea*), soft chess (*Bromus hordeaceus*), geranium (*Geranium dissectum*), annual fescues (*Vulpia* spp.), hedgehog dogtail (*Cynosurus echinatus*), and plantain (*Plantago* spp.). These non-natives comprised 47 percent of the species recorded in upland sites (Appendix B). Needle grass (*Nassella pulchra*), blue wild rye (*Elymus glaucus*) and yarrow (*Achillea millefolium*) were the most common natives recorded.

Aside from the single upland transect station, only a broad qualitative assessment was made of the uplands near the site as part of the PWA *et al.* (1994) efforts, and no attempt was made to generate a comprehensive species list. However, 49 plant species were recorded along or near the transect, a large number considering the small area sampled. About one half of them were non-native.

A nearly 150-year history of cattle grazing is likely responsible for the high proportion of non-native plant cover observed during 1992–1993 surveys. In addition to non-natives recorded, dense thickets of Harding grass (*Phalaris aquatica*), thistles and poison hemlock grew in swales where cattle had likely congregated in the past. Many smaller, short-lived non-natives were numerous and indicative of heavy grazing disturbance.

Recent photos (1991) document some recovery from livestock disturbance. The hillside grassland of non-natives is apparently being replaced in some areas by native shrubs, probably mostly coyote brush (*Baccharis pilularis*). Native herbaceous species, including perennial grasses such as needle grass and blue wildrye, are present. However, the abundance of non-native species indicates that the uplands are still significantly damaged from past disturbances.

4.3.1.8 Discussion

The existing plant communities indicate a wetland complex that is recovering from historical disturbance, and certain areas (e.g., the dunes) that continue to be disturbed. The number of non-native and invasive species is high, covering parts of Green Gulch pasture and surrounding permanent human structures such as the parking lot, roads, and levee road. Many of these species present a major challenge to eliminate.

The plant communities with the greatest native composition and cover were usually wetter, occupying the riparian and aquatic habitats. The species present in these communities (e.g., willows) are typically first to colonize bare, wet surfaces, and have quickly established in degraded areas fenced off from visitors by the NPS in 1998 and 1999 (e.g., the small wetland area near the pedestrian bridge, and the former picnic area south of the parking lot) (Shoulders, *pers comm*, 2003).

However, the wetlands are highly susceptible to invasion by non-native plants as the landscape dries. The Green Gulch pasture community is an excellent example. These historical wetlands were elevated, ditched, and drained to create pasture for grazing, most notably during the time the property was owned by George Wheelwright (1960s). The number of non-native invasive species was likely high, especially since some of the non-native grasses were introduced or encouraged for grazing (e.g., meadow foxtail and white clover). Surface and groundwater levels in the pasture have risen over the last 10 years, and the pasture is returning to a wetter condition supporting more obligate wetland species, especially in the area immediately adjacent to the levee. Now, cattail and bulrush have established. Recent efforts to improve drainage may cause the pastures to dry again, returning the area to a condition susceptible to re-invasion by non-native grasses.

The pattern is also present in the tidal lagoon, where the dry years of the 1980s probably diminished the health of rushes and silverweed, allowing non-native weeds to become established and persist (evident during 1992–1993 surveys). Weed abundance was likely stimulated by chronic disturbance from wandering dogs and people. Many of the weeds may be inundated and die back during wetter years (e.g., growth of silverweed in the summer of 1993 appeared more robust than the previous year, perhaps a response to wetter conditions), but the large seed bank and ability to outcompete natives would likely allow quick re-establishment, in both the brackish marsh and the Green Gulch pasture, when conditions dry.

4.3.2 Fish and Wildlife

This section presents summary discussions of available data for amphibians, reptiles, birds, mammals, fish, and invertebrates in the Big Lagoon project site. In addition, more complete results of wildlife surveys (invertebrates, bird, mammals, and fish) over the past 15 years are presented in Appendices F through I.

4.3.2.1 *Amphibians*

Several surveys focused on two special-status species, the foothill yellow-legged frog (*Rana boylei*) and California red-legged frog (*Rana aurora draytonii*), have recently been conducted at the project site (Fong 2000, Cook 1998, Fellers and Kleeman 2003, Fellers and Guscio 2003). Incidental observations of other amphibian species made during these surveys are presented in Table 4-5. Amphibian surveys conducted in the project area in 1992 and 1993 focused on key amphibian habitats. In addition to the creeks and riparian zones, these included locations where ponded surface water was present (e.g., in the pasture areas). Species composition and relative abundance were estimated in qualitative surveys made each month and more frequently during wet periods when wetland usage was greater (see Appendix D for survey methods). The results are summarized below, and special-status information is provided in Section 4.3.3.3.

4.3.2.1.1 Red-legged frog surveys (2002–2003)

Fellers and Guscio (2003) conducted nighttime and egg mass surveys for red-legged frogs at the site in the fall, winter, and spring of 2002–2003. The surveys found that adult red-legged frogs were present in small numbers (likely a maximum of 10 individuals) in the area, and that the frogs were reproducing on a limited basis (three egg masses were found in the vicinity of the levee road adjacent to the lower stretch of Redwood Creek, and one red-legged frog tadpole was also found). Most of the frogs were found in the dense cattails just east of the levee road (in the Green Gulch pasture), indicating that a fairly small portion of the total site area is being used. Unfortunately, successful reproduction was unlikely, as the area where egg masses were found dried before tadpoles would have had a chance to metamorphose (Fellers and Guscio, 2003). No frogs, egg masses, or tadpoles were found in the Green Gulch drainage, nor were they observed in Redwood Creek upstream of Highway 1.

Nine male red-legged frogs were fitted with radio transmitters as part of a larger telemetry study conducted at nine different sites in west Marin County (Fellers and Guscio, 2003; Fellers and Kleeman 2003). Preliminary results indicate that of the 117 frogs tracked, the frogs typically disperse approximately 600 feet to the nearest suitable non-breeding area (Fellers and Kleeman, 2003). The tagged frogs from the Big Lagoon project area typically moved only 30 to 75 feet between locations, although one frog traveled 1300 feet (Fellers and Guscio, 2003). This indicates that red-legged frogs present in the project area are limited to a small portion of the site, and may not move out of the area.

4.3.2.1.2 Winter frog breeding surveys (1998–1999)

Winter frog breeding surveys were conducted by trained volunteers during 1998–1999 (Cook, 1998, as cited in Fong, 2000) and 1999–2000 (Fong, 2000) in Lower Redwood Creek, the Big Lagoon project area, and Green Gulch Creek. Red-legged frogs were the focus of the surveys, which included weekly night calling and egg mass surveys (see Fong, 2000 for further discussion of survey methods). Red-legged frogs were heard calling in the project area on one occasion (January 27, 1999), although no egg masses were observed in the area (Fong, 2000). In addition, adult Pacific tree frogs and California newt egg masses were observed in abundance. No red-legged frogs were observed in the Green Gulch Creek area from 1998 to 2000.

4.3.2.1.3 1992–1993 Amphibian Survey Results

Seven of the 10 native amphibian species historically present were found during surveys conducted from April 1992 to September 1993 (PWA *et al.* 1994, Ely 1993) (Table 4-5). No non-native species, including bullfrogs, were observed, although extensive surveys were conducted up Redwood Creek and the ponds at the Green Gulch Farm (PWA *et al.* 1994). California newts (*Taricha torosa*) were the most abundant adult individuals observed. Their numbers peaked with breeding concentrations in January, but individuals were present throughout the year (PWA *et al.* 1994). California newt spawning occurred from December to February (PWA *et al.* 1994). Other adult amphibian species occurred in low numbers year-round (PWA *et al.* 1994). Adult Pacific tree frogs were seen or heard from December through May. The ensatina (*Ensatina eschscholtzi*) and slender salamander (*Batrachoseps attenuatus*) were occasionally

encountered on the margins of wetland habitat in the winter and spring months. The California red-legged frog was observed on at least two occasions during spring.

Table 4-5. Amphibian Observations in the Big Lagoon Project Area and Vicinity

Common Name	Scientific Name	Observations				
		Historic ¹	1992-93 ²	1998-99 ³	1998 ⁴	2003 ⁵
Arboreal salamander	<i>Aneides lugubris</i>	X	X			
California slender salamander	<i>Batrachoseps attenuatus</i>	X	X			
Western toad	<i>Bufo boreas</i>	X	X			
California giant salamander	<i>Dicamptodon ensatus</i>	X				
Ensatina	<i>Ensatina eschscholtzi</i>	X	X			X
Pacific tree frog	<i>Pseudacris regilla</i>	X	X	X	X	X
California red-legged frog	<i>Rana aurora draytonii</i>	X	X	X		X
Foothill yellow-legged frog	<i>Rana boyleii</i>	X				
Rough-skinned newt	<i>Taricha granulosa</i>	X	X		X	X
California newt	<i>Taricha torosa</i>	X	X	X	X	X

¹ Adapted from PWA *et al.* 1994.

² Source: PWA *et al.*, 1994 and Ely, 1993.

³ Source: Fong, 2000. Survey targeted for winter frog breeding. Other amphibians observed were incidental.

⁴ Source: Cook, 1998. Survey targeted for California red-legged frog and bullfrogs. Other amphibians observed were incidental.

⁵ Source: Fellers and Guscio, 2003. Survey targeted for California red-legged frogs for radiotracking. Other amphibians observed were incidental.

Larval stages of four amphibian species were also observed during the 1992–1993 surveys at the site. California newts and Pacific tree frogs were most abundant; California newt larvae were found into October as a result of prolonged rains. Pacific tree frog larvae were found April through July in suitable localized breeding areas in Green Gulch Creek near the confluence with the backwater channel, in the ditch south of the lower pasture, and in the channel near the entrance to the lower lagoon. Two other species, the western toad and rough-skin newt, were found in much lower numbers and only in larval stages in 1992–1993 (PWA *et al.* 1994).

In addition to the surveys performed at Big Lagoon, Ely (1993) conducted four afternoon surveys between April and September 1993 in reaches of Redwood Creek within Muir Woods. These surveys were specifically targeted for foothill yellow-legged frogs, however, although high quality habitat was observed, no foothill yellow-legged frogs were reported. Ely also reported that California red-legged frogs were present, but uncommon, throughout the Marin Headland drainages (including Rodeo Creek, Tennessee Creek, and Redwood Creek).

4.3.2.1.4 Discussion

Amphibians are among the most sensitive and threatened vertebrate species in California freshwater wetland systems (Moyle 1973; Jennings and Hayes 1985; Hayes and Jennings 1986; Jennings 1991). In

recent years they have been indicators of global environmental conditions (Phillips 1990; Cowen 1991) and habitat destruction (Jennings and Hayes 1985, Pechmann *et al.*, 1991). Most amphibians are closely tied to an aquatic environment due to their aquatic larval stage. With the exception of ensatina, slender salamander and arboreal salamander, which are upland terrestrial species without larval stages, the amphibian species observed at the site were documented primarily at ponded or channeled areas. These standing water locations are essential to the viability of the amphibian assemblage at the site. It is in these localized wet spots that wetland vegetation provides necessary cover for reproductive activities and a basis for amphibian prey species. The current complement of amphibians at the site both in terms of numbers and species no doubt reflects the marginal size and health of available wetland habitat.

Pacific tree frogs and California newts appear to be the most successful breeding species in the area. Insect surveys during 1992 and 1993 indicated appropriate prey were available to developing frog and newt larvae in the ponded sites (see Appendix F). The large Pacific tree frog larval population observed during 1993 surveys probably reflected the above-average rainfall, which provided suitable breeding habitat in drainages until at least mid-July (PWA *et al.* 1994). Pacific tree frogs are closely tied to the water throughout their life history, though they require standing water only for chorus, breeding, spawning and a short 3-month tadpole stage. This species is thus able to breed successfully in the pasture ponds.

Only two species that were historically abundant in this region according to museum records were not observed during recent surveys: the California giant salamander (*Dicamptodon ensatus*) and the yellow-legged frog (Table 4-5). These species are more likely to be found farther up in the Redwood Creek drainage. The California giant salamander occurs primarily in humid well-forested areas (Stebbins, 1954), and the yellow-legged frog lives in riffled streams with at least cobble-sized substrate (Hayes and Jennings, 1989). However, habitat conditions for yellow-legged frogs in Redwood Creek were found to be excellent during 1993 surveys by Ely, but no adult frogs or larvae were found (see Section 4.3.3.3).

Recent efforts by NPS to improve drainage in the area (i.e., dredging downstream of the footbridge) have lowered surface water in lower Redwood Creek and groundwater in the Green Gulch pasture, degrading habitat for red-legged frogs and potentially threatening their continued survival at the site (Fellers and Guscio, 2003). NPS will be conducting interim measures in fall 2003 to encourage ponding in this area until implementation of the restoration project. More extensive cattails and additional areas of ponded water that remain wet long enough for metamorphosis to occur would improve site conditions for the frogs (Fellers and Guscio, 2003).

To date, no bullfrogs have been reported within the project area, although they are common in the nearby Tennessee Valley and could conceivably enter the site. Bullfrogs indicate a modified pond habitat that is less suitable for native species. Red-legged frogs may be particularly intolerant of bullfrog invasions (Moyle, 1973; Hayes and Jennings, 1986). It is not clear if bullfrogs are the sole factor or, more likely, if habitat alteration coupled with predation and competition by bullfrogs cumulatively have caused extensive red-legged frog declines throughout California (Moyle, 1973; Hayes and Jennings, 1986). Bullfrog range has expanded since their introduction to California in 1896 (Heard, 1904 in Hayes and Jennings, 1986), while the range of the red-legged frog has diminished by at least two-thirds.

4.3.2.2 Reptiles

Historically, 12 reptile species have been observed in the project area (Table 4-6). Less than half of these species were observed in the early 1990s. Surveys specifically for reptile species have not been conducted recently, so it is unclear how current conditions compare to those from 5 to 10 years ago. Three reptile species were incidentally observed in 2002 during surveys for red-legged frogs (Fellers and Guscio 2003), including yellow-bellied racer (*Coluber constrictor*), western fence lizard (*Sceloporus occidentalis*), and western terrestrial garter snake (*Thamnophis elegans*) (Table 4-6). Five reptile species were observed during 1992 and 1993 herpetological surveys at the site (PWA *et al.* 1994, Ely 1993): the western pond turtle (*Clemys marmorata*), western fence lizard, western terrestrial garter snake, northern alligator lizard (*Elgaria coeruleus*), and the western aquatic garter snake (*Thamnophis couchi aquaticus*). No western pond turtles were observed at the site during species-specific surveys conducted in 1996 (Fong 2002b). The western fence lizard occurred as an upland resident, and the coast garter snake was observed foraging in upland as well as wetland and riparian habitats. While garter snakes were less common in the afternoon amphibian surveys (PWA *et al.* 1994), they were seen in substantial numbers during qualitative reptile surveys (survey methods described in Appendix D).

Many reptile species known to historically occur in the area were not observed during surveys conducted in the early 1990's. Several of these species are associated with drier sites or open areas at the margins of forests, such as the western skink (*Eumeces skiltonianus*), southern alligator lizard (*Elgaria multicarinata*), and the yellow-bellied racer (*Coluber constrictor*). Typically these species are more common residents of upland areas, which were not included in the 1992 and 1993 survey efforts. The upland and drier sites likely support substantial populations of lizards and snakes (Ed Ely, pers. comm., as cited in PWA *et al.* 1994). A few reptile species that were not observed, however, are known to forage in wetland areas (ring-necked and sharp-tailed snakes) or in pools and along stream banks (rubber boa). Increasing the size and quality of these habitats may improve conditions for these species at the site.

Two special status snakes, the federal and state listed endangered San Francisco garter snake (*Thamnophis sirtalis tetrataenia*, a subspecies of the common garter snake) and the state listed threatened giant garter snake (*Thamnophis couchi gigas*), a subspecies of the western aquatic garter snake, occur farther to the south and east and are not expected to occur at Redwood Creek.

Table 4-6. Reptile Observations in the Big Lagoon Project Area and Vicinity

Common Name	Scientific Name	Observations			
		Historical ¹	1992-93 ²	1996 ³	2002 ⁴
Rubber boa	<i>Charina bottae</i>	X		NA	
Western pond turtle	<i>Clemys marmorata</i>	X	X	none found	
Yellow-bellied racer	<i>Coluber constrictor</i>	X		NA	X
Ringneck snake	<i>Diadophis punctuatus</i>	X		NA	
Northern alligator lizard	<i>Elgaria coeruleus</i>	X	X	NA	

Common Name	Scientific Name	Observations			
		Historical ¹	1992-93 ²	1996 ³	2002 ⁴
Southern alligator lizard	<i>Elgaria multicarinata</i>	X		NA	
Western skink	<i>Eumeces skiltonianus</i>	X		NA	
Gopher snake	<i>Pituophis melanoleucus</i>	X		NA	
Western fence lizard	<i>Sceloporus occidentalis</i>	X	X	NA	X
Western aquatic garter snake	<i>Thamnophis couchi</i>	X	X	NA	
Western terrestrial garter snake	<i>Thamnophis elegans</i>	X	X	NA	X
Common garter snake	<i>Thamnophis sirtalis</i>	X		NA	

¹ Adapted from PWA *et al.* 1994.

² Source: PWA *et al.*, 1994 and Ely, 1993. Surveyed only for western pond turtles.

³ Source: Fong, 2000b. Survey was targeting California red-legged frogs. Reptile observations were incidental.

⁴ Source: Fellers and Guscio, 2003. Survey targeted for California red-legged frogs for radiotracking. Other amphibians observed were incidental.

4.3.2.3 Birds

Four primary sources of recent information on birds exist for the Big Lagoon project area:

- (1) PWA *et al.* (1994) conducted seasonal surveys for 1.25 years, 1992/1993. A total of 11 surveys at 16 stations were conducted in all seasons. Survey stations were stratified by general habitat type. The objective was to measure seasonal use of a range of habitats that would potentially be affected by restoration activities.
- (2) Stallcup (1995) produced an annotated bird list for the site by surveying the entire area once per month for one year (May 1994 to April 1995) and summarizing the National Audubon Society's Christmas Bird Census from 1978 to 1992. These data represent an excellent inventory of the avifauna of the site and immediate environs.
- (3) PRBO has been monitoring breeding bird populations in the project area using nationally standardized protocols from 1997 to the present. This study focuses on passerines and near passerines and is part of a much larger monitoring effort in the GGNRA and the Point Reyes National Seashore (Gardali and Geupel 1997, Gardali *et al.* 1999, Holmes *et al.* 1999, Scoggin *et al.* 2000, Gardali *et al.* 2001).
- (4) Dybala (2002) conducted surveys for waterbirds at the site beginning on December 12, 2001, and continuing approximately every two weeks until February 12, 2002. In total, 5 surveys were conducted at the site in the Green Gulch pasture and horse paddock (Figure 3). Surveys were conducted at three sites: Pasture A, Pasture B, and the Riding Ring (see Appendix G for site map). Visual surveys were conducted from a fixed point at each site. The duration of each survey was at least 15 minutes per site.

The results from PWA *et al.* 1994 are summarized in Appendix G. Results of the other three studies are described in more detail below. A complete inventory of bird species documented in the site project area is also included in Appendix G (Table G-1), as are all of the tables referred to in the text below.

4.3.2.3.1 Annotated Bird List (Stallcup, 1995)

One hundred eighty-five species were identified; 85 more than previous work (PWA et al. 1994). Of these, three are not native to North America, 45 were documented as breeders, 6 others were noted as possible breeders, and 12 were considered accidental. Riparian habitats were identified as "the most thoroughly used" in all seasons, which is in agreement with PWA et al. (1994). Stallcup (1995) did not quantify species abundance. However, he notes that some of the most common nesting species were Swainson's thrush (*Catharus ustulatus*), Wilson's warbler (*Wilsonia pusilla*), song sparrow (*Melospiza melodia*), Brewer's blackbird (*Euphagus cyanocephalus*), and American goldfinch (*Caruelis tristis*). Stallcup (1995) noted that confirmed breeding of Townsend's warblers (*Dendroica townsendi*) reported in PWA et al. (1994) is in error.

4.3.2.3.2 Riparian Monitoring (PRBO, 1997 to Present)

Methods for the following results have been described in detail elsewhere (e.g., Gardali et al. 1999, Holmes et al. 1999) and use nationally recommended guidelines (Ralph et al. 1993, Martin et al. 1997). In general, four permanent point count survey stations were establish at 200 meter intervals along the riparian corridor in the Big Lagoon project area and one nest monitoring and territory mapping plot spanned the extent of the point count survey stations and was restricted to riparian habitat. Mist-netting was conducted nearby at the Banducci site in the autumns of 2001 and 2002. Point counts survey all bird species while nest monitoring focuses on those using the riparian vegetation. Autumn mist-netting provides information on habitat use of birds during migration (species abundance and composition), post breeding, and an index of reproductive productivity (number of young captured and young-to-adult ratio); it does not provide a complete inventory.

In all of the tables discussed below (located in Appendix G), we highlight (species name in **bold**) riparian focal species as designated by the Riparian Habitat Joint Venture and California Partners in Flight (RHJV 2000). Focal species were chosen so that, as a group, their breeding requirements represented the full range of critical riparian ecosystem/habitat elements. Individual species were chosen so that they also met as many as possible of the following criteria: (1) use the riparian habitat as their primary breeding habitat, (2) warrant special management status, (3) are from a variety of taxonomic groups, and (4) are useful for monitoring management actions because they have large enough populations to obtains good sample sizes. Additionally, they are thought to show quick, strong or consistent responses to habitat attributes, management, or restoration. Hence, focus should be placed on these species for monitoring post-restoration.

Point Counts.

A total of 51 species was detected by point count (not including those species flying over) from 1998 to 2002 (Table G-2). Red-winged blackbird, song sparrow, Swainson's thrush, cedar waxwing, Wilson's warbler, American robin, and black-headed grosbeak were the most commonly detected species. All of these species breed at the site with the exception of cedar waxwing (flocks often counted in early spring migration).

Territory Mapping.

PRBO mapped the territories of breeding birds from 1997 to 1999 at the site. These data provide information on breeding densities of territorial species (versus an index of abundance from point counts). Appendix G presents territory numbers for RHJV (2000) focal species (Table G-3). The song sparrow and common yellowthroat are year-round residents while the other four species are Neotropical migrants. The song sparrow held the most territories in all three years.

Nest Monitoring.

A total of 151 nests for 26 species were located and monitored at the Big Lagoon project area from 1997 to 1999 (Table G-4). Results (reproductive success) from nest monitoring are a better indicator of ecosystem health than simple presence or abundance as obtained from other methods. Note that none of the Wilson's warblers nests were successful.

Mist-netting.

Mist-netting was conducted at the nearby Banducci site during fall migration in 2001 and 2002. This site likely has similar species composition and abundance as the Big Lagoon project area. The year-round resident song sparrow was the most commonly captured species followed by hermit thrush, warbling vireo, Pacific-slope flycatcher, Swainson's thrush, and Wilson's warbler (Table G-5).

4.3.2.3.3 Waterbird Monitoring (Dybala, 2002)

Dybala (2002) observed the peak number of waterbirds at the site on December 20, 2001, with 27 individuals, a 125% increase over the peak number observed by Osbourn (unpublished data, as cited in Dybala, 2002) during the winter of 2000–2001. Surveys on December 12, 2001 and January 23, 2001 resulted in the lowest number of birds observed, which may have been correlated with excessive noise due to roadwork on the adjacent levee trail.

Species diversity during Osbourn surveys was very low, with only mallards (*Anas platyrhynchos*) observed at the site. Surveys by Dybala (2002) the following year observed three species: mallards, killdeer (*Charadrius vociferus*), and bufflehead (*Bucephala albeola*), yet mallards represented 88% of the total number of individuals observed (Table G-6).

4.3.2.3.4 Discussion

The bird surveys and incidental sightings recorded document a predictable assemblage of coastal riparian and wetland birds that varies seasonally according to the breeding and wintering habits of each species. Big Lagoon harbors bird species that are members of several wetland communities, including freshwater marsh, freshwater stream, coastal riparian forest, and more restricted brackish marsh and coastal dune communities (Shuford, 1993). As discussed in Section 2, all are remnants of what were once large expanses of coastal wetlands and watersheds. Current numbers of species and individuals are undoubtedly a fraction of what this system supported 200 years ago, prior to human-induced filling of stream corridors and wetlands, decreases in freshwater input, severe habitat fragmentation, replacement of native wetland

and upland vegetation with non-native pasture vegetation, and ongoing disturbance by human visitors and pets. Enhancing the quality and size of wetland habitat should significantly increase the diversity and abundance of native birds at the site. As a note, one of the biggest impacts on the success of the songbird breeding season at the area is trash from the site and the nearby communities, which attracts ravens, raccoons, brown-headed cowbirds and other nest predators/nest parasites (NPS Technical Scoping Notes, 2002).

4.3.2.4 Mammals

Though no mammalian surveys were conducted at the site during 1992–1993 field work by PWA *et al.* (1994), three species were incidentally noted in the project area (O. Onorato, P. Slattery pers. obs., as cited in PWA *et al.*, 1994). Mule deer tracks were observed in the dense willow thicket between bird stations 5 and 10 in spring 1993, and occur here relatively commonly. Both bobcats and gray foxes were seen infrequently along the riparian corridor. Gray foxes regularly use the dense willow thicket as a denning area. Appendix H lists all the mammals that were historically found or may currently be found in the vicinity of the Big Lagoon wetlands, and that may at least periodically use a large freshwater wetland as a source of food or water.

Live trapping for small mammals was conducted at the site from 28 October to 1 November 2002 by the USGS (Takekawa *et al.*, 2003). Traps were set in dune, pasture, riparian, tidal lagoon, and wetland areas. The following four species were captured, in order of abundance: western harvest mouse (*Reithrodontomys megalotis*), deer mouse (*Peromyscus maniculatus*), California vole (*Microtus californicus*), and roof rat (*Rattus rattus*). Deer mice were only captured in the dune area. No special status species (e.g., salt marsh harvest mouse, Pt. Reyes jumping mouse) were detected, despite careful examination of tail characteristics that distinguish the more common western harvest mouse from the endangered salt marsh harvest mouse.

Takekawa *et al.* (2003) characterized vegetation along each trapping grid location, including species present, litter, bare ground, and height, and percent cover was then calculated. They noted that pasture and wetland habitat had very similar plant community composition and structure, and also had the highest abundance of small mammals (primarily western harvest mice), as defined by number of captures per 100 trap nights. This is consistent with dietary requirements (seeds, grasses, leafy plants) and is where dense vegetation affords the best cover. Restoration efforts should promote dense vegetative cover in order to improve habitat conditions for small mammals in the riparian and pasture areas (Takekawa *et al.*, 2003). Additionally, roof rats, a non-native species and known predator of riparian passerines, were only found in the riparian areas. Removal of this species as part of restoration efforts may be necessary in order to ensure more successful breeding of riparian bird species (Takekawa *et al.*, 2003).

No small mammals were captured in the tidal lagoon area, presumably because of lack of tidal wetland vegetation (e.g., *Spartina* and *Salicornia* spp.). Improving tidal flows within the lagoon may encourage establishment of these plant species and improve conditions for their associated small mammal community.

4.3.2.5 Fish

Several investigations have been performed since 1992 to document fish distribution and abundance in Redwood Creek and its estuary. Fish surveys were conducted in 1992 and 1993 for the Preliminary EA (PWA *et al.*, 1994). Subsequent investigations have included a report on the use of lower Redwood Creek and Big Lagoon by juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*) (Fong 1996), annual distribution and abundance surveys for juvenile coho salmon and steelhead (Smith 1994b, 1995, 1996, 1997, 1998, 2000, 2001), salmonid outmigrant trapping in 1996 (Fong, 1997a), an anadromous salmonid spawner and carcass survey, conducted in the winter of 1996-1997 (Fong, 1997c), and a study of the use of the Big Lagoon estuary (and other central California estuaries) by rearing coho salmon and steelhead (Laidig, 2003). Table 4-7 shows the fish species documented in the above surveys. Smith (1994a, 1994c) also analyzed the effects on coho salmon and steelhead of streamflow reductions in Redwood Creek due to drought and groundwater pumping. In addition to the species documented during the above surveys, NPS has observed Sacramento blackfish (*Orthodon microlepidotus*) and yellowfin gobies (*Acanthogobius flavimanus*) at the site.

Table 4-7. Fish Species Documented in Big Lagoon Estuary and Redwood Creek, 1992-2002

Fish Species	Native (N) or Introduced (I)	Year(s) Observed	Source	Tidal Lagoon	Redwood Creek
Sacramento blackfish (<i>Orthodon microlepidotus</i>)	I ^a	1992	PWA (1994)	X	
topsmelt (<i>Atherinops affinis</i>)	N	1995	Fong (1996)	X	
coho salmon (<i>Oncorhynchus kisutch</i>)	N	1992-1998 2000-2002	PWA (1994); Fong (1996, 1997a, 1997c); Smith (1994b, 1995, 1996, 1997, 1998, 2000, 2001); Laidig (2003)	X	X
steelhead (<i>Oncorhynchus mykiss</i>)	N	1992-1998 2000-2002	PWA (1994); Fong (1996, 1997a, 1997c); Smith (1994b, 1995, 1996, 1997, 1998, 2000, 2001); Laidig (2003)	X	X
threespine stickleback (<i>Gasterosteus aculeatus</i>)	N	1992-1996 2001-2002	PWA (1994); Smith (1994b); Fong (1996, 1997a); Laidig (2003)	X	X
prickly sculpin (<i>Cottus asper</i>)	N	1992-1996	PWA (1994); Smith (1994b); Fong (1996, 1997a)	X	X
coast range sculpin (<i>Cottus aleuticus</i>)	N	1995	Fong (1996)	X	
rifle sculpin (<i>Cottus gulosus</i>)	N	1992 1993 2001	PWA (1994); Smith (2001)		X

Fish Species	Native (N) or Introduced (I)	Year(s) Observed	Source	Tidal Lagoon	Redwood Creek
Pacific staghorn sculpin (<i>Leptocottus armatus</i>)	N	1992 1993 1995	PWA (1994); Fong (1996)	X	
striped bass (<i>Morone saxatilis</i>)	I	1992 1995 2002	PWA (1994); Fong (1996); Laidig (2003)	X	
Sacramento perch (<i>Archoplites interruptus</i>)	I ^a	1993	PWA (1994)	X	
yellowfin goby (<i>Acanthogobius flavimanus</i>)	I	1992 1993	PWA (1994)	X	
starry flounder (<i>Platichthys stellatus</i>)	N	1992 1993	PWA (1994)	X	

^a Native to other California river systems; introduced into the Redwood Creek drainage.

In addition to the limited aquatic habitat data collected as part of several of the above fish investigations, a comprehensive stream habitat inventory was conducted in 1995 by GGNRA staff (Fong, 2002a). This inventory includes data on channel morphology, substrate, water temperature, habitat types, large woody debris (LWD), residual pool volume, streamside cover, riparian canopy density, and benthic macroinvertebrates for approximately five miles of Redwood Creek, from the project site upstream to Bridge 4 in Muir Woods National Monument. In a separate study, woody debris abundance and distribution in Redwood Creek from 1994–1996 were reported by Vore (1996) for reaches in and immediately downstream of Muir Woods. The results of the numerous fish surveys performed between 1992 and 2002 are summarized in Appendix I.

Smith (1995–2001) repeatedly noted that groundwater pumping from the wells near the community of Muir Beach can exacerbate the effects of low stream flows in lower Redwood Creek and the upper portion of the tidal lagoon. This portion of the watershed has shown to be used extensively by rearing coho salmon and steelhead when suitable conditions exist, at which time it appears to provide important rearing habitat. The effects of low stream flows in this area include reduced availability of rearing habitat and macroinvertebrates for juvenile coho and steelhead, as well as poor water quality (elevated temperature, low D.O.). This is especially important in dry years, when flows are naturally low. Smith hypothesizes that habitat availability (especially pools for rearing coho) and food production are likely the two most important factors limiting salmonid production in the system.

Although only limited data are apparently available on LWD frequency in Redwood Creek, this habitat feature is known to be of key importance for rearing salmonids. Restoration efforts with a goal of increasing coho salmon and steelhead abundance in Redwood Creek and its tributaries should focus on ways to improve LWD recruitment.

4.3.2.6 *Invertebrates*

An inventory of benthic macroinvertebrates was conducted in August 1995 and November 1997 (Fong, 2002a) in Redwood Creek. In April 2002, invertebrate sampling was conducted at seasonally and perennially inundated sites at Muir Beach (Fong *et al.*, 2003). These two surveys are summarized briefly below, and a summary table of all invertebrates observed at Big Lagoon from 1992 – 2002 is provided in Appendix F, Table F-1. Surveys specifically for California freshwater shrimp (*Syncaris pacifica*) have also been conducted and are discussed in Section 4.3.3.2. Aquatic insects were sampled both qualitatively and quantitatively as part of the 1992–1993 survey efforts for the EA (PWA *et al.*, 1994) as discussed separately in Appendix F.

In addition, the western monarch butterfly (*Danaus plexippus*) is known to occur in the Muir Beach area (Monroe 2003). GGNRA staff and volunteers have been monitoring the Muir Beach area for monarch butterflies for over 15 years, using a monitoring protocol developed by the Xerces Society, the Monarch Program, and others. Observations are made starting in early fall, and continuing until early January. Large numbers of monarchs overwintered in the Muir Beach area during the 1970's and 1980's (up to 15,000), aggregating primarily at a stand of Monterey pines (*Pinus radiata*) located above Pacific Way at the Terwilliger Grove, and occasionally roosting in the Green Gulch Farm area (Monroe, 2003). Due to site changes at the Terwilliger Grove, monarchs have not been observed overwintering in such numbers since 1997, although they are still present in the area (10–20 monarchs can be observed on sunny days in the early fall) (Monroe, 2003).

4.3.2.6.1 1995 and 1997 Benthic Macroinvertebrate Inventory

Qualitative surveys presented by Fong (2002a) were conducted in 1995 and 1997 at six sample locations to provide a taxa list of stream macroinvertebrates and some index of relative abundance and “health.” Species observed at the Pacific Way Bridge station are listed in Appendix F, Table F-1. The sampled invertebrate community at the downstream-most station in the watershed, below the Pacific Way Bridge, had significantly different metric values than other stations (Fong, 2002a). This station had significantly lower Shannon diversity than two out of the other five sample locations in 1995, and also had significantly higher proportion of dominant taxa when compared to the other sites (Fong, 2002a). This dominance was associated with extremely large numbers of *Malenka* larvae, a stonefly (Fong, 2002a).

4.3.2.6.2 2002 Invertebrate Inventory

The objectives of the 2002 study were to (Fong *et al.*, 2003):

1. establish a baseline taxa list and reference collection of aquatic and semiaquatic macroinvertebrates from seasonally and permanently inundated sites within the project area; and
2. compare aquatic and semiaquatic macroinvertebrate fauna diversity and relative abundance between open water and emergent-open water interface habitats.

Samples were collected at six locations in April 2002 (Figure F-1). Freshwater wetland sites had higher invertebrate densities than other sites, which is similar to the results reported by PWA *et al.* (1994). PWA

et al. (1994) reported higher production of zooplankton and insects in the late winter and spring for the pasture wetlands when compared to open water habitat in Redwood Creek.

At each wetland site, the sample near the vegetated edge had greater density and greater taxa richness than the open water samples, suggesting a more heterogeneous habitat and most likely greater food availability. However, samples obtained in more stream influenced sites had opposite results. Samples along Redwood Creek at the backwater and below the pedestrian footbridge had higher densities at open water rather than the vegetated margins (Fong *et al* 2003).

The majority of the taxa collected were still-water taxa; however, three typically stream taxa were collected at the Below Footbridge sample sites, including the baetid mayflies (Ephemeroptera) *Centroptilum* and *Diphetera*, and the brachycentrid caddisfly (Trichoptera) *Amiocentrus*. Appendix F, Table F-1 lists all the species that were observed during 2002 surveys. Relatively high dissolved oxygen concentration and relatively low temperatures were evident at this site indicating the influence of Redwood Creek. No sensitive invertebrate taxa were encountered in surveys (Fong *et al* 2003).

The brackish wetland sample sites (Big Lagoon Marsh and Parking Lot Wetland) had lower abundance of invertebrates than the freshwater wetland sites. The brackish wetlands likely had variable salinities throughout the prior winter and spring depending upon the frequency and amount of rain and overwash from the ocean. These sites also had water depths that were typically lower than other sample sites, which may imply a greater tendency towards fluctuating conditions (e.g., water temperature). Such dynamic conditions may be difficult for the production of invertebrates (Fong *et al* 2003).

4.3.2.6.3 Discussion

The aquatic invertebrate sampling conducted in 1995, 1997, and 2002 (Fong 2002a, Fong *et al* 2003) generally confirms the conclusions presented in PWA *et al.* (1994) (see Appendix F). Aquatic invertebrate abundance and species composition varies with habitat type. Within the project site, aquatic invertebrate production and diversity appear to be highest in freshwater wetlands (e.g., Pasture Wetland A and B in Fong *et al* 2003) and lowest in the brackish wetlands (e.g., Parking Lot Wetland and Big Lagoon Marsh in Fong *et al* 2003), with stream habitats supporting intermediate levels of diversity and abundance. Sampling of invertebrates and physical habitat parameters indicate that water quality appears to be generally good. The brackish water wetlands appear to have the harshest conditions for invertebrates, with fluctuations in salinity, temperature, and dissolved oxygen likely limiting invertebrate production and diversity.

Increasing the amount of perennial freshwater wetlands should substantially increase the numbers, diversity, and persistence of aquatic insects and crustaceans found in the Big Lagoon project area. However, the greatest diversity of invertebrates and general food web support for vertebrate species (fish, amphibians and birds) will be provided by maintaining a diversity of aquatic habitat types (perennial and seasonal freshwater emergent marsh with patches of open water, stream habitat with well-shaded pools, brackish tidal marsh and open water lagoon) in the project area. Maintaining or creating more topographic complexity in the wetland areas should provide more complex habitat conditions, with deeper

permanently inundated areas providing a refuge for some species that require water year-round, while promoting seasonal inundation of vegetated areas where invertebrate production may be quite high and many invertebrates can find a partial refuge from predators (such as fish). In addition, promoting improved connectivity of the stream channel and the wetlands in its floodplain on the project site should help maintain general water quality, enhance invertebrate abundance and diversity, and improve food web support.

4.3.3 Special Status Species

4.3.3.1 *Plants*

A rare plant survey was conducted in the Big Lagoon project area during 2002 (Faden, 2002) and spring 2003 (Shoulders, pers comm). No threatened or endangered species were found. Two CNPS 4 (watch list) plant species were found in the hills near Muir Beach, California bottle-brush grass (*Elymus californicus*), and San Francisco wallflower (*Erysimum franciscanum*). California bottle-brush grass, which is well-documented in Muir Woods, was documented near the Middle Green Gulch Trail in the spring of 2003. No endangered, threatened or special status species of plants were observed on the site during surveys in 1993–1994 (PWA *et al.* 1994). Several additional CNPS-status species occur in lowland habitats in Marin County and could have occurred in Big Lagoon historically (Appendix J, Table J-1). These species may be considered for reintroduction as a conservation effort during restoration.

4.3.3.2 *Invertebrates*

Potential habitat exists for the federally endangered California freshwater shrimp (*Syncaris pacifica*) in the project area (B. Cox pers. comm., L. Serpa, *pers comm*, as cited in Fong 1999). However, surveys in March and August 1997 found no shrimp in lower Redwood Creek (Fong 1999), and no sensitive invertebrate taxa were encountered during surveys in April 2002 (Fong *et al.*, 2003).

Monarch butterflies were historically present in great numbers in the vicinity of the project area, but now are only present in small numbers (as discussed in Section 5.3.2.6). Other special-status invertebrate species that depend on coastal or marsh communities and may be locally present include the Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*), Ricksecker's water scavenger beetle (*Hydrochara rickseckeri*), and the San Francisco fork-tailed damselfly (*Ischnura gemina*).

4.3.3.3 *Amphibians and Reptiles*

Herpetological surveys documented that the site currently supports at least one special status species: the California red-legged frog (*Rana aurora draytonii*) (federally listed threatened¹, state listed species of special concern). The entire site is within the Point Reyes Critical Habitat Unit (Unit 12), defined by the USFWS (66 FR 14625–14674). This unit contains one of the largest known populations of red-legged

¹ The federal listing excludes areas in Sonoma and Marin counties, west and north of San Francisco Bay drainages and Walker Creek drainage, which includes the Big Lagoon project area.

frogs (Federal Register 2001, as cited in Fellers and Guscio 2003). Western pond turtles (*Clemys marmorata*) (state listed species of special concern) were seen throughout the year during 1992–1993 surveys by PWA *et al.* (1994) in two locations along the dredged portion of Redwood Creek, but were not observed during species-specific surveys conducted in 1996 (Fong 2002b). This species has not been observed at the site for several years and is not considered to currently occur at the project site. In addition, suitable habitat for foothill yellow-legged frog (*Rana boyleii*) (state species of special concern) exists further upstream in the Redwood Creek watershed, although the species has not been recently documented. The results of these surveys are discussed further in Sections 4.3.2.1 and 4.3.2.2 above.

4.3.3.4 Birds

Fully 36 species that have been documented within the Big Lagoon project area and immediate environs have at least one special status designation (Appendix J, Table J-2). One species, the California brown pelican, is federally listed as endangered and three species, California brown pelican, American peregrine falcon, and willow flycatcher, are state listed endangered. Five of the 36 (14%) special status species breed at Big Lagoon and three of these species use riparian vegetation (Allen's hummingbird, olive-sided flycatcher, and California Swainson's thrush). The special status species mostly likely to be affected (positively or negatively) by changes to the project area are those that primarily use the riparian and freshwater marsh habitats (14 of 36; 39%). A complete list of bird species within or near the Big Lagoon project area that have special status designation(s) are presented in Appendix J.

4.3.3.5 Mammals

No special status small mammal species (e.g., federal and state listed endangered salt marsh harvest mouse) were detected during trapping surveys within the Big Lagoon project area in fall 2002, despite careful examination of tail characteristics that distinguish the more common western harvest mouse from the endangered salt marsh harvest mouse (Takekawa *et al.*, 2003). Although no special-status large mammals have been observed recently at the site, Appendix H includes those that might occur (or historically did occur), including three species of bats, and four species of larger carnivores.

4.3.3.6 Fish

Fish communities currently found in the Big Lagoon site are discussed in more detail in Section 4.3.2.5. Of these, three species have special status.

Coho salmon in the Redwood Creek watershed belong to the Central California Coast Evolutionarily Significant Unit (ESU). Coho salmon belonging to the Central California Coast ESU were listed as a state endangered species by the California Department of Fish and Game (CDFG) effective December 31, 1995. The Central California Coast ESU was listed as threatened under the federal Endangered Species Act on October 31, 1996 (61 FR 56138–56149).

Steelhead in Redwood Creek belong to the Central California Coast ESU, which includes populations distributed from the Russian River south to Aptos Creek in Santa Cruz County. Steelhead belonging to the Central California Coast ESU were listed as threatened by the NMFS under the federal Endangered Species Act on August 18, 1997 (62 FR 43937–43954). This steelhead ESU is not currently listed under the California Endangered Species Act.

The tidewater goby, which is believed to have historically occurred in the Redwood Creek estuary, is a federally listed endangered species (59 FR 5494–5499). Critical habitat for the goby was designated by the USFWS in 2000 (65 FR 69693–69717). The USFWS proposed delisting the tidewater goby in 1999 (64 FR 33816–33825), but the proposal was withdrawn in 2002 (67 FR 67803–67818). This species is not currently known to occur in the Redwood Creek estuary.

4.3.4 Jurisdictional Wetlands

In 1993 Caltrans performed field surveys and mapped the wetland areas that would be under the jurisdiction of the ACOE under Section 404 of the Clean Water Act (PWA *et al.* 1994, Figure IV-40). Wetlands were mapped according to the methods described in the Corps of Engineers Wetland Delineation Manual (USACE, 1987). In 2003, NPS updated the delineation of potential ACOE jurisdictional wetlands (Figure 22), and is currently preparing the delineation report.

According to the 2003 wetland mapping, 26.6 acres are potential jurisdictional wetlands, and 3.5 acres are waters of the United States (Figure 22). The 2003 jurisdictional wetland area now includes the alder forest just upstream of Pacific Way (not included in the original 1993 area), the entire Green Gulch pasture, and additional areas south and east of the parking lot (Figure 22). See Section 4.3.1 for further discussion of wetland vegetation.

For comparison, jurisdictional wetlands identified in 1993 included brackish marsh between the tidal lagoon and the picnic areas, seasonal wetlands and drainages in the Green Gulch pastures, and riparian wetlands along Redwood Creek (PWA *et al.* 1994, Figure IV-40). Included within the 33-acre study boundary were 9.1 acres of wetland, 0.8 acres of wetland/drainage, 5.8 acres of riparian wetland, 2.2 acres of waters of the United States, and 15.1 acres of upland.

Most of the lower study area lies within jurisdictional wetlands, except the levees, parking lot, and small areas along Highway One. Note that with the exception of Redwood Creek, most of these wetlands exist in their current form because of recent site modifications, and generally do not reproduce the historic functions of the pre-1800's natural system. Efforts in late 2002 to improve drainage (discussed in Section 3.2.3) are decreasing the backwater effect and likely drying portions of the Green Gulch pasture similar to that seen under 1993 conditions, with seasonal wetlands rather than semipermanently flooded wetlands.

4.4 RESIDENT AND VISITOR USE

Muir Beach is a heavily used coastal recreational area. NPS estimates of visitor use at the site range from 225,000 to 430,000 people per year, depending on the year and the method upon which the estimate is