Request for Incidental Harassment Authorization

Interstate 580 Richmond-San Rafael Bridge Project

Caltrans District 04
Contra Costa and Marin Counties
Interstate 580
CC 580 (Post Mile 6.1/7.8) MRN 580 (Post Mile 0.0/2.6)
EA 04-3G474

STATE OF CALIFORNIA
Department of Transportation

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Acronyms

Abbreviation	**Term**
BSA	Biological Study Area
Caltrans	California Department of Transportation
CDFW	California Department of Fish and Wildlife
CNDDB	California Natural Diversity Database
dB	Decibel
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FR	Federal Register
I-	Interstate
IHA	Incidental Harassment Authorization
Leq	Average weighted noise level during measurement period
Lmax	Maximum weighted noise level during measurement period
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NPS	National Park Service
PCA	Project Construction Area
SFEI	San Francisco Estuary Institute
TMMC	The Marine Mammal Center

1 Detailed Description of the Activity

1.1 Project History

The California Department of Transportation (Caltrans) proposes Phase II of the restoration and painting of the Richmond-San Rafael Bridge on Interstate (I) 580. The Richmond-San Rafael Bridge is 5.5 miles in length and connects the City of Richmond in Contra Costa County to the City of San Rafael in Marin County, California. The proposed restoration work would replace degraded steel bridge components, remove the traveler rail system, repair damaged road deck concrete, and replace expansion joints on the lower deck. Painting of the bridge structure would require the removal of all existing paint through sand blasting and rotary sanding. An enclosed scaffold system would be constructed to ensure complete containment of paint and construction debris. Barges would be used for staging personnel, equipment, and materials.

Construction of the Richmond-San Rafael Bridge began in 1953 and was opened to traffic in 1956. Including approaches, the bridge is 5.5 miles in length and spans two ship channels with a maximum vertical clearance of 185 feet. The bridge stands on 79 reinforced concrete piers supported on steel H-piles. Nine piers stand on land, eight are in cofferdams near the Richmond terminus, and the remaining 62 are bell-type piers with a flared base. As completed, the bridge has two decks, each capable of carrying three lanes of traffic. Westbound traffic rides on the upper deck and is marked with two lanes of vehicle traffic and a separated bike path, while eastbound traffic rides on the lower deck and features two lanes of vehicle traffic as well as a third lane that is activated during evening commute hours and serves as a shoulder when not in use.

In the fall of 2001, the bridge underwent an extensive seismic retrofit to allow the two-tier bridge to withstand a 7.4 magnitude earthquake on the Hayward Fault and an 8.3 magnitude quake on the San Andreas Fault. The foundation piers were strengthened by wrapping the lower section of structural steel in a concrete casing, installing new shear piles, and adding bracing to the structural steel towers. Isolation joints and bearings were also added to the main bridge structures (cantilever spans over the navigation channels) to strengthen the structure. Portions of the bridge substructure were painted during the 2001 seismic retrofit.

1.2 Project Location and Area

The Richmond-San Rafael Bridge is 5.5 miles in length and is a heavily travelled commute corridor connecting the City of Richmond in Contra Costa County to the City of San Rafael in Marin County, California. Figure 1-1 illustrates the Project vicinity and specific location. The bridge within the project area runs roughly east to west and consists of an upper and lower deck with two to three lanes each in the eastbound direction and two lanes and a separated bike path in the westbound direction. The Project will consist of repairs and maintenance work on the bridge, and no major modifications are proposed.

The Project area consists of the existing roadway, existing bridge location, adjacent waters of the San Francisco Bay, a small portion of shoreline and landscaped areas on the east end of the bridge, and the industrial complex of the Chevron Richmond Refinery (Figure 1-2). Much of the project area is located over the waters of the San Francisco Bay, while the east end includes a small portion of shoreline and landscaped areas, and the industrial complex of the Chevron Richmond Refinery.

The Project Construction Area (PCA) is the area where construction activities associated with the Project would occur. Phase I of the Project included work on and between Piers 0-47 of the Richmond-San Rafael Bridge. The current phase of the Project is Phase II and includes work on and between Piers 48-78 of the Richmond-San Rafael Bridge. The PCA includes the existing bridge structure and all other areas that would be used for staging, materials storage, access, painting, and restoration for Phase II. The estimated area of the PCA is 88.29 acres. The biological study area includes the PCA and adjacent sensitive habitats for Phase II. The estimated biological study area is approximately 803.97 acres.

There are three known biologically sensitive resources located in the biological study area (Figure 1-3). There is approximately 40.21 acres of mapped eelgrass (*Zostera marina* L.) located at the east end of the biological study area [San Francisco Estuary Institute (SFEI) Aquatic Science Center, 2019]. There is a rock outcropping known as Castro Rocks, which is a known haul-out site for harbor seals (*Phoca vitulina*). Additionally, there is a known double-crested cormorant (*Phalacrocorax auratus*) breeding colony located on the Richmond-San Rafael bridge superstructure mainly between Piers 51 to 56 of the bridge.

1.3 Project Purpose

The purpose of this Project is to maintain and preserve the integrity of the Richmond-San Rafael Bridge from the adverse impacts of general operation and the marine environment. The Project is needed to replace degraded and damaged bridge components and road deck. Without the Project, the corrosion of the bridge metalwork will continue which may lead to a reduction in the lifespan of the bridge.

1.4 Description of Proposed Project

The Phase II Project is expected to take 210 working days. It is anticipated that one to four teams of five to eight individuals will be working simultaneously. Nighttime lane closures outside of commute hours will be required. Materials and personnel will be transported to the work area either via boat from Richmond Harbor to the barge platforms and work areas or would be delivered to the site during nighttime lane closures on the bridge. The Project will occur on approximately 1.2-mile section of the bridge between Pier 48 through Pier 78.

The Project consists of four elements: (1) the scaffolding and containment system, (2) barges for equipment, operations, and materials storage, (3) sandblasting, cleaning, and painting of the upper and lower decks and (4) repair of road deck, and expansion joints on the lower deck. Figures 1-4 through 1-6 show a portion of the proposed work locations on the Richmond-San Rafael Bridge. Additional sample photographs of similar work on the San Mateo Bridge and the proposed work locations on the Richmond-San Rafael Bridge are included in Figures 1-4 to 1-14.

Figure 1-1. I-580 Richmond San Rafael Bridge Maintenance: Project Location

Figure 1-2. I-580 Richmond San Rafael Bridge Maintenance: Biological Study Area and Land Classification

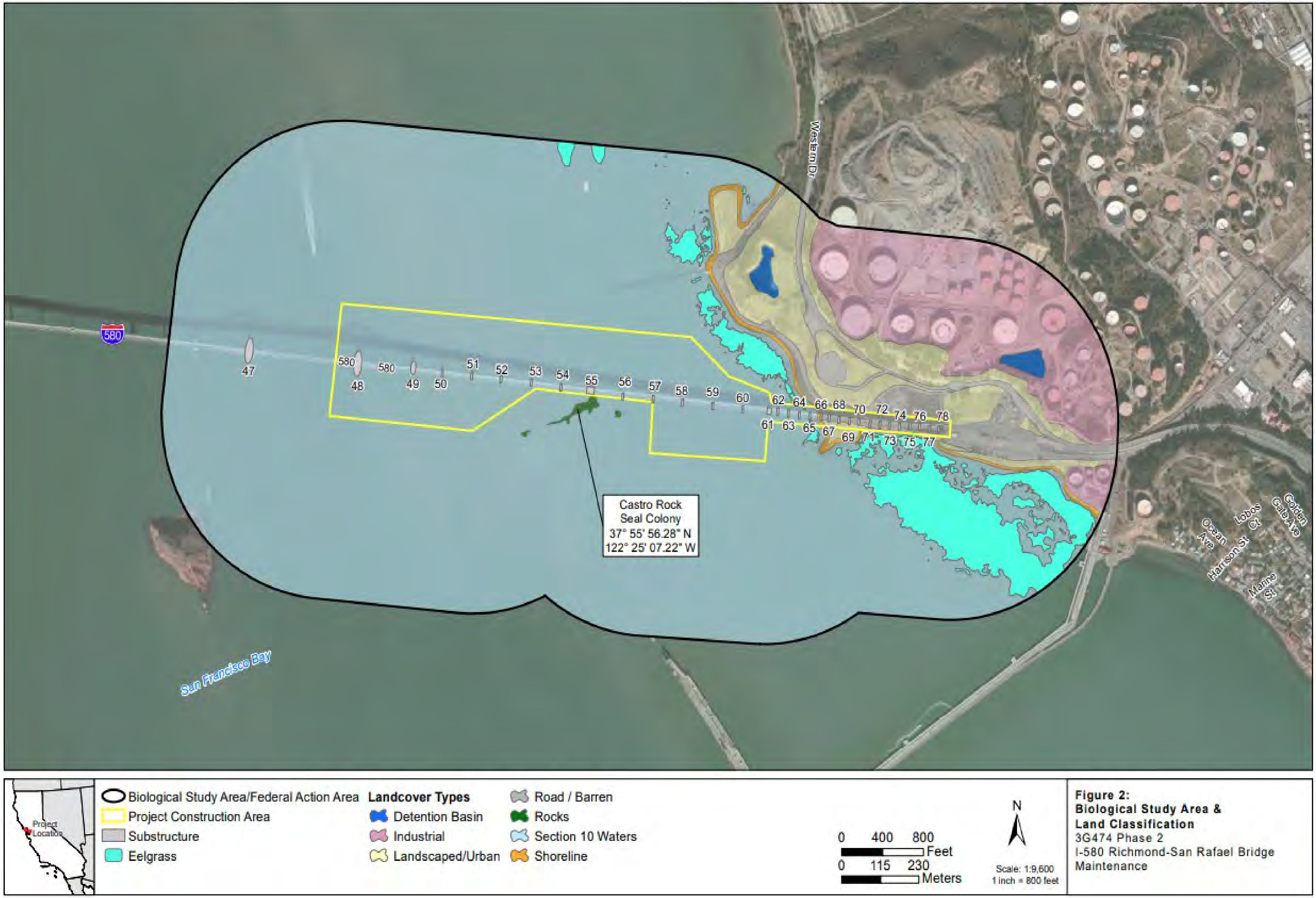


Figure 1-3. I-580 Richmond San Rafael Bridge Maintenance: Sensitive Biological Resources

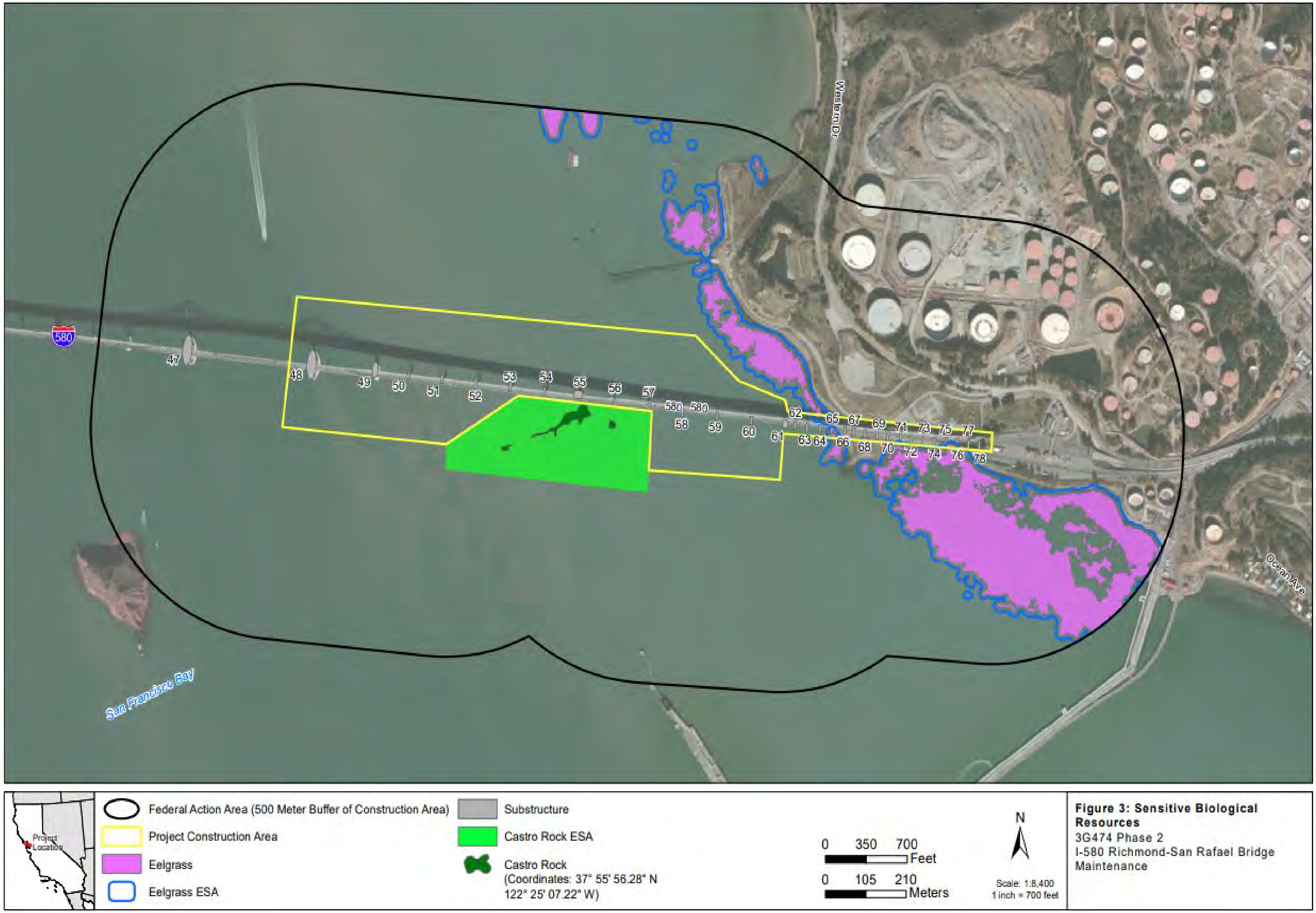


Figure 1-4. View of the Richmond-San Rafael Bridge (facing west) from pier 48

Figure 1-5. View of the underside of the Richmond-San Rafael Bridge (facing east). Castro Rocks are located on the right hand side of the photo.

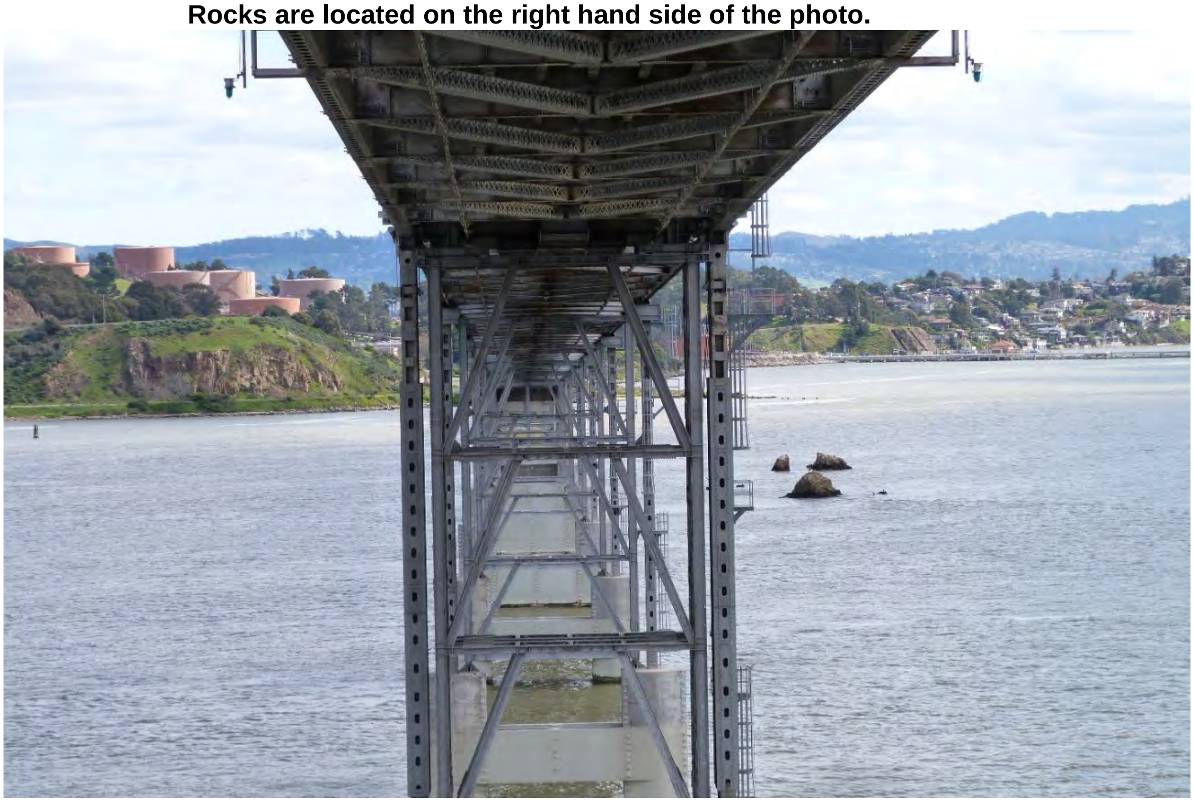
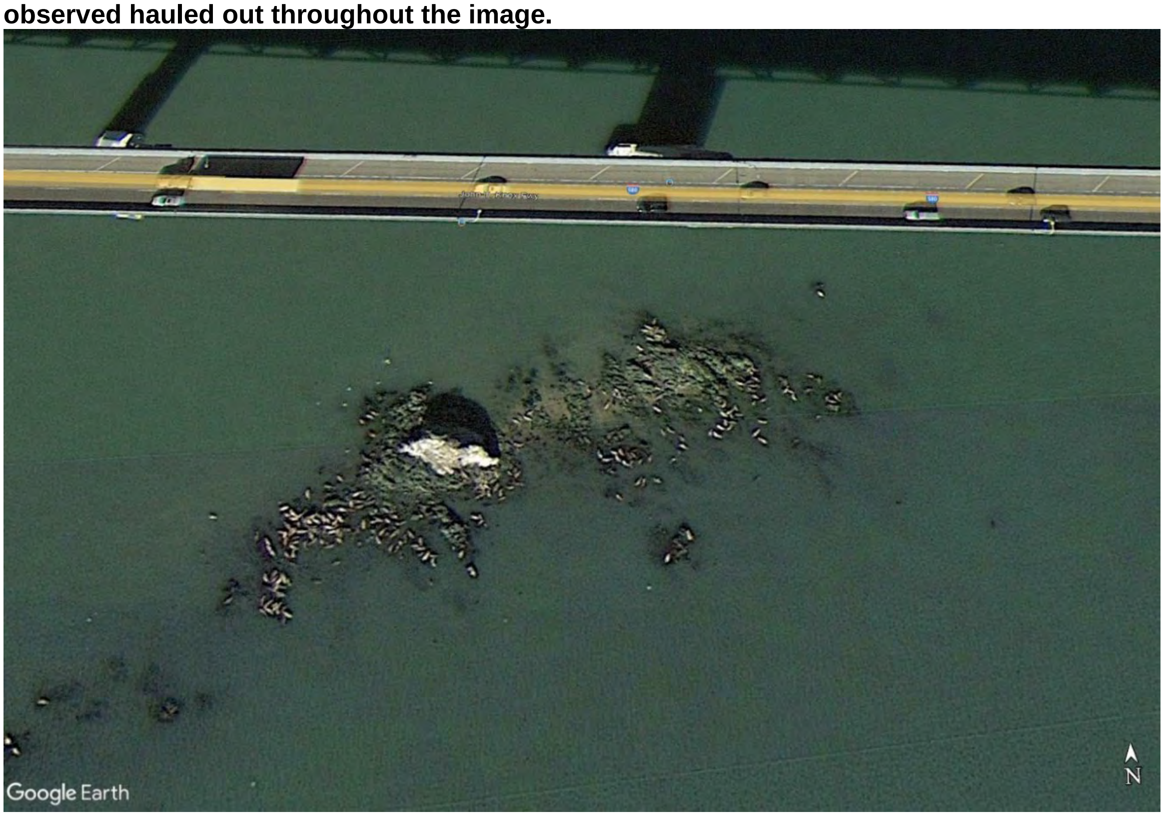


Figure 1-6. Close up of Castro Rocks from pier 48 at high tide (facing east).

Figure 1-7 Google Earth aerial of Castro Rocks at low tide (February 2018). Harbor seals can be observed hauled out throughout the image.



1.5 Project Overview

There are four main components of the Project, as described in the following subsections:

1) the scaffolding and containment system, 2) barges for equipment, operations, and materials storage, 3) sandblasting, cleaning, and painting of the upper and lower decks and 4) repair of road deck, and expansion joints on the lower deck.

The first order of work is the installation of the scaffolding and containment system. Once this protective system is installed; the three remaining projects components may occur simultaneously. Once all work is completed the scaffolding and containment system will be removed.

Scaffolding and Containment System

Prior to the start of sand blasting and painting, a scaffolding system will be installed to access the underside of the bridge deck. The scaffolding system is modular and would be hung from the lower road deck. It is anticipated that the scaffolding system will be installed over a section of three bridge piers at any given time (approximately 650-800 feet). Scaffolded areas will include the underside of the lower bridge deck, and the first ten feet above the bottom chord of the lower bridge deck. Conduit for the delivery of power, compressed air, water, and air purification will be constructed into the scaffolding system.

Once the scaffolding is installed it will be enclosed to contain all debris, slurries, and paint generated by the work. All paint debris associated with sandblasting will be vacuumed to a filtration system located on barges staged outside of the Castro Rock Environmentally Sensitive Area (ESA). Liquid slurries associated with pressure washing will also be captured and pumped to baker tanks located on the barges for full containment. The original paint used on the Richmond-San Rafael Bridge was lead based and all paint debris will be managed as a hazardous waste and disposed at an approved facility.

The scaffolding and containment system will also act a visual barrier between the construction operations and the seal colony on Castro Rocks. Installation of the containment system is anticipated to take 20 working days and 10 working days to remove.

Figure 1-8 Inside scaffolding and containment system used for Phase 1 of the Richmond-San Rafael Bridge Painting project (November 2021).

Figure 1-9 Looking down on scaffolding and containment system used for Phase 1 of the Richmond-San Rafael Bridge Painting project from the lower bridge deck (November 2021).

Barges – Equipment, Operations, and Materials Storage

It is anticipated that a floating barge will be used for equipment operations and materials storage. The barge will either be tethered to the concrete bridge piers or anchored adjacent to the work area and will be moved for each bridge pier. The barges will not be staged within the two main shipping channels. No piles will be driven or vibrated to create staging locations. Equipment operated on the barges may include cranes, generators, air compressors, baker tanks, air purification systems, water pumps, oxy-acetylene welding and cutting tools, concrete pumps, and paint sprayers. Materials stored on the barges may include miscellaneous replacement steel, sand blasting aggregates, paint and primer, fuel, water, concrete mix, solid paint, and liquid slurry waste. All equipment and materials will receive both primary and secondary containment to ensure that no fuel or hazardous materials enters the waters of the San Francisco Bay. Hazardous materials will be contained in sealed 50-gallon drums and held in a separate containment area on the barges. To reduce impacts to nearby eelgrass beds, all equipment associated with construction activities would be kept within the Project Construction Area footprint (Figure 1-3). Barges will not be staged between piers 52-57 and will be staged on the northern side of the bridge and outside the Castro Rocks ESA.

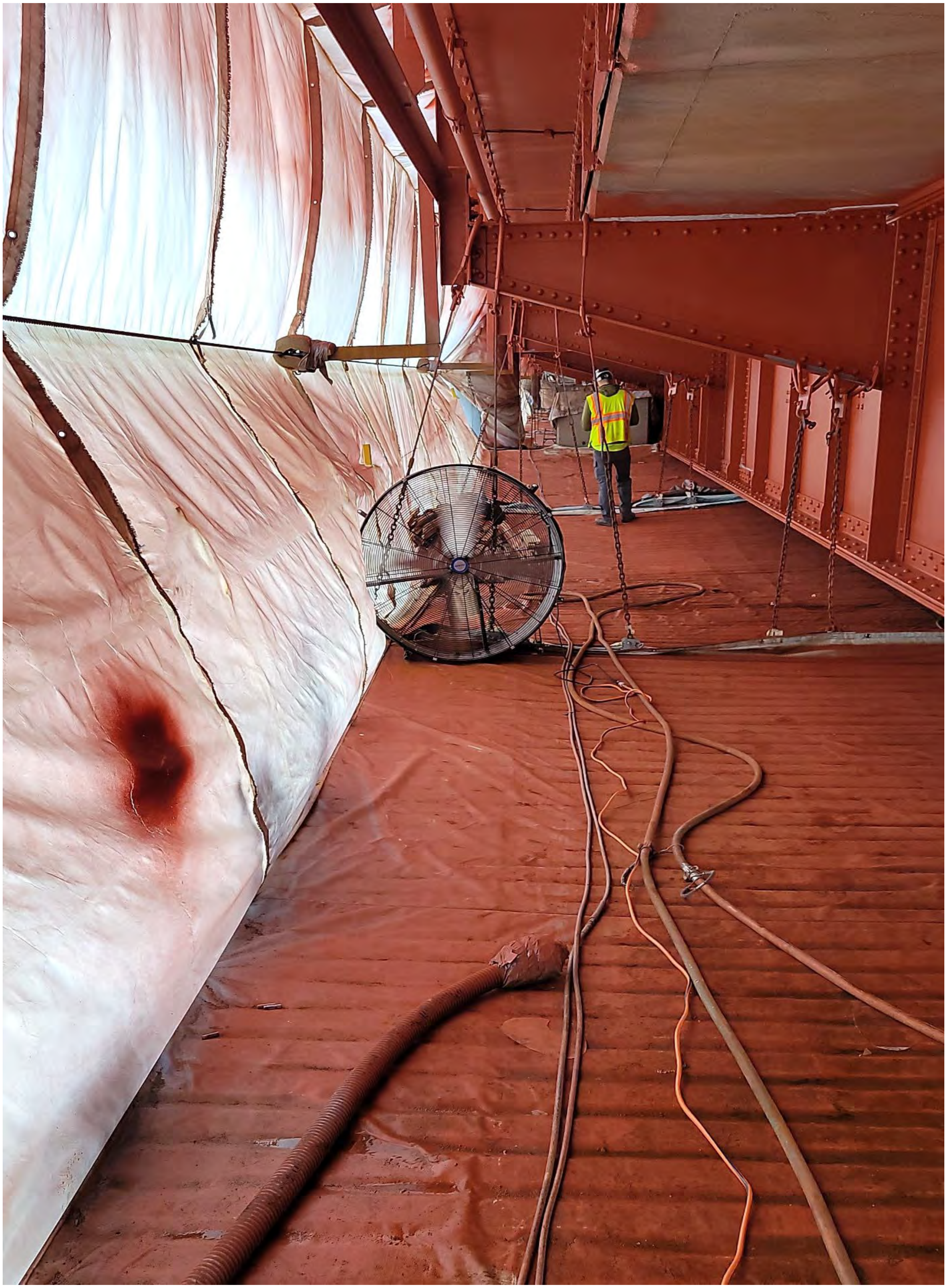
Figure 1-10 Example of barge with equipment and materials recently used for San Mateo Bridge

Sandblasting, Cleaning, and Painting

All steel elements will be rotary sanded or sandblasted to remove old paint and expose bare metal prior to painting. Compressed air and sand aggregates will be delivered to the work area through a series of conduit originating from the barges. Another series of return conduit will be used to vacuum all airborne dust and debris to air purification and containment systems located on the barges. All debris generated during the sandblasting process will be collected and stored as hazardous waste. For areas of the bridge that only require pressure washing prior to painting, water and power will be supplied through conduit originating from the barge. All slurries generated during the pressure washing process will be captured and returned to baker tanks located on the barge.

Both primer and paint will be applied to the bridge structure using a pneumatic paint sprayer. Compressed air, primer, and paint will be delivered to the work area through a series of conduit originating from the barges. All painting will occur inside the containment system to avoid paint from entering the water.

Figure 1-11 Sandblasting and painting operations inside scaffolding and containment system used for Phase 1 of the Richmond-San Rafael Bridge Painting project (November 2021).



Repair of Road Deck, and Expansion Joints on the Lower Deck

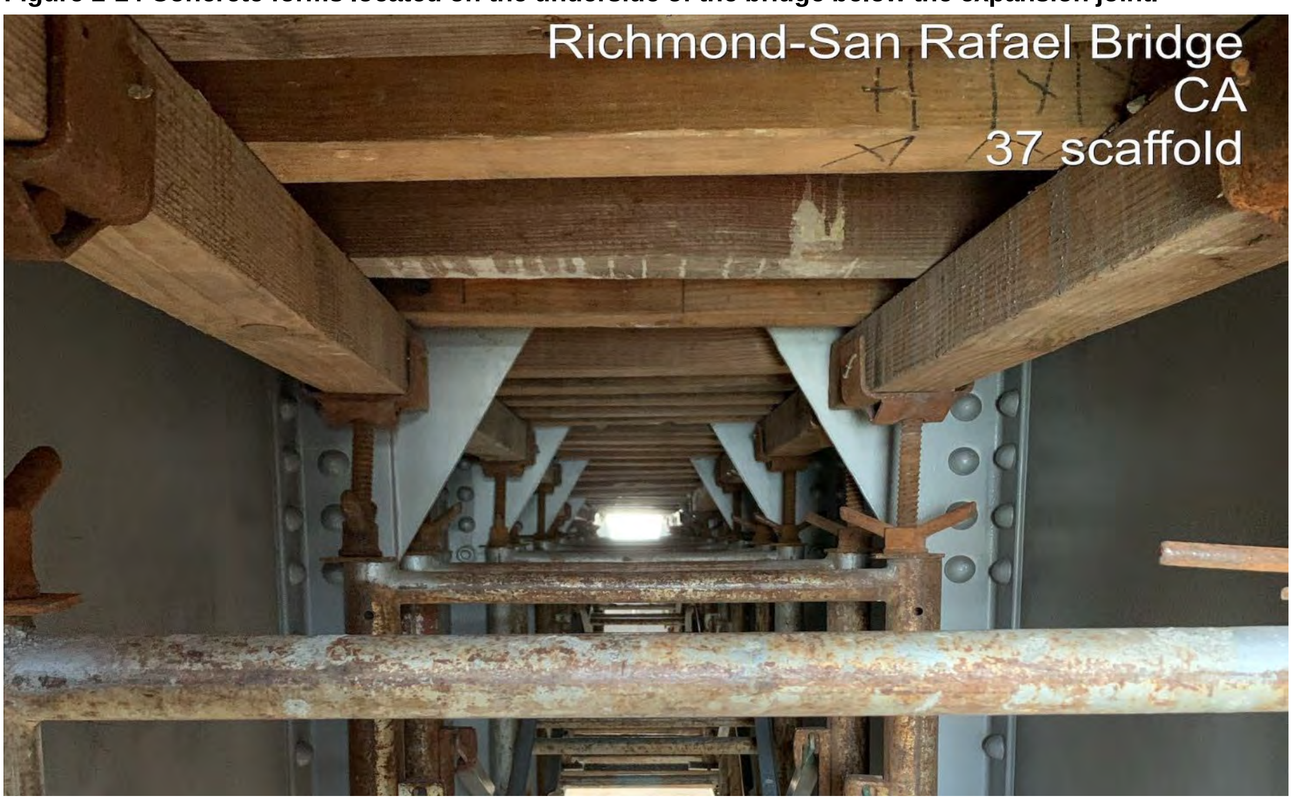
Localized spalled road deck concrete will be repaired and damaged concrete will be removed using pneumatic air chisels. All exposed rebar will be sandblasted prior to placement of new structural concrete in the spalled area. All spalled concrete repair will occur within the painting containment system. Bridge joints (Figure 1-12) will be replaced on the lower deck of the Richmond-San Rafael Bridge. Removal of the old bridge joints requires saw cutting the last 1.5 feet of deck concrete and removing it in sections. The plate steel joint covers, debris gutters, and supporting frames will be removed. Structural concrete will be poured once concrete forms (Figure 1-14) and steel reinforcements are embedded in the existing bridge deck. Galvanic anodes will be installed inside the replaced concrete for corrosion protection. Rubber joint seals will be added to prevent roadway debris from falling through the road deck.

All expansion joint repair will occur within the painting containment system or have a separate containment system installed (Figure 1-13). Saw cutting and replacement of the bridge joints will occur during nighttime lane closure on the lower deck. All concrete debris and slurries associated with the bridge joint replacements will be captured and not allowed to enter the Bay waters.

Figure 1-12 Example of expansion joint to be replaced

Figure 1-13 Scaffold system located on the underside of the bridge for expansion join replacement. A debris screen will be placed around the scaffold system prior to construction operation.

Figure 1-14 Concrete forms located on the underside of the bridge below the expansion joint.



2 Dates, Duration, and Region of Activity

2.1 Dates and Duration of Construction

There would be approximately 210 working days for Phase II of the Richmond-San Rafael Bridge painting project. Work window limitations would apply to project locations between Piers 52-57 near the Castro Rocks Environmentally Sensitive Area. Installation or removal of the debris containment system will not occur between Piers 52-57 from March 1 to August 1 due to the pupping and molting period of harbor seals. Between March 1 and August 1, work may continue inside the containment system as it will act as a visual barrier and noise attenuator between the construction operations and Castro Rocks. Installation of the scaffolding and containment system between piers 52-57 is anticipated to take 20 days to install and 10 days to remove.

2.2 Project Location

As described in Section 1, the Richmond-San Rafael Bridge is located in the San Francisco Bay and connects the City of Richmond in Contra Costa County to the City of San Rafael in Marin County, California (see Figure 1-1).

3 Species and Numbers of Marine Mammals

There are three marine mammal species that are considered resident species within San Francisco Bay: Pacific harbor seals, California sea lions, and harbor porpoises. Additional species that may be found occasionally within San Francisco Bay include Steller sea lions, northern fur seals, bottlenose dolphins, gray whales, and humpback whales.

3.1 Pacific Harbor Seal

The Pacific harbor seal (*Phoca vitulina richardii*) occurs in temperate coastal habitats along the northern coasts of North America, Europe, and Asia. This species occurs on the U.S west coast from California to the Bering Sea and are found year-round in the San Francisco Bay. Harbor seals feed in the deeper waters of San Francisco Bay near the Golden Gate Bridge and along the deeper channels extending into the North and South Bay. Their diet includes a variety of fish such as perch, gobies, herring, and sculpin. Pacific harbor seals spend about half their time on land and half in water. They require rocks, reefs, or beaches to temporarily rest on land. This behavior is called hauling out and may be useful for predator avoidance, thermal regulation, social activity, mating, and rest. In San Francisco Bay, seals haul out on offshore rocks, sandy beaches, and floating docks, wharfs, and other man-made structures. Areas where seals aggregate to haul out are termed haul-out sites.

In California, harbor seals mate from June to July. Harbor seal pups are born between March and May, weighing about 20 to 24 pounds at birth. Adult females usually mate and give birth every year. They may live for 25 to 30 years (NMFS 2019).

Castro Rocks is a known harbor seal haul-out site located within the biological study area. It is a composed of a chain of six rock clusters and spans the distance of three bridge piers. The nearest rock is located approximately 21 meters (70 feet) from Pier 55 and the farthest rock is located approximately 145 meters (475 feet) from Pier 52.

The National Park Service has surveyed the harbor seals at Castro Rocks as part of an inventory and monitoring program since 2005. Multiple surveys are conducted by the National Park Service biologists, ranging anywhere from 5 to 13 surveys conducted between March and October of a given year. The most recent available survey data is from 2019 (Codde and Allen 2013, 2015, 2017, 2020; Codde 2020). During the molting season, as many as 300 harbor seals have been observed using Castro Rocks (Codde and Allen 2020). The highest number of pups observed was 41 in April 2016 (S. Codde personal communication, February 22, 2019).

Pacific harbor seals within the biological study area are expected to experience direct impacts from the proposed Project. Impacts to Pacific harbor seals may result from construction noise and human disturbance near the known haul out site at Castro Rocks. Both juveniles and adults are known to haul out at Castro Rocks, located within the biological study area, and are known to migrate and forage within the biological study area.

All work associated with the proposed Project work consists of activities above the water line, and the only marine impact from the work will be the temporary presence of two construction barges that will remain mainly stationary and make small movements from pier to pier as construction progresses. The barges will be staged in areas where they will not make contact with the San Francisco Bay substrate. Smaller boats will ferry workers and supplies to and from the Richmond Harbor and observe all watercraft regulations. The level of boat presence for this work is minimal in relation to the existing boat traffic in the vicinity of the Richmond-San Rafael Bridge, which hosts both larger commercial ships and smaller ferry and recreational boats. A 100-meter boat traffic and barge staging exclusion zone will be maintained around Castro Rocks.

No underwater noise is expected from this Project beyond the engines of the barges and the boats travelling to and from the barges. There is no in-water construction work associated with the Project. Harbor seals may swim in close proximity to the Project barges or boats, however technical consultation with NOAA staff confirmed that the proposed work would not have an impact on in-water marine mammals (J. Carduner personal communication, February 5, 2019).

Construction activities associated with the installation and removal of the scaffolding and debris containment system has the potential to impact hauled out harbor seals. In 2001, a large-scale seismic retrofit project was undertaken on the Richmond-San Rafael Bridge. The work area for the seismic retrofit project includes the PCA for this project. During construction of the seismic retrofit project, harbor seals at Castro Rocks were monitored to assess any effects construction may have had on the seal colony (Green et al. 2004). Disturbance of hauled out harbor seals on Castro Rocks were observed as a result of construction activities between piers 52-55 during the monitoring of that project. The number of seals hauled out at Castro Rocks was highest at nighttime between 1900 hours and 0300 hours. During the pupping season, haul out numbers were highest mid to late afternoon. As part of the current Project, work activities at Piers 50-57 of the Richmond-San Rafael Bridge, including the installation and removal of the scaffolding and debris containment system, would be limited to work windows outside of March 1 to August 1 due to the pupping and molting period of harbor seals.

Due to the proximity of the proposed construction area at the Richmond-San Rafael Bridge to the Castro Rocks haul-out site, it is likely that harbor seals would be incidentally harassed during the installation and removal of the scaffolding and debris containing system (30-days) while they are present at the Castro Rocks haul out site in the vicinity of the Richmond-San Rafael Bridge.

3.2 California Sea Lion

The California sea lion (*Zalophus californianus*) can be found year-round in the San Francisco Bay Estuary, where they spend time in the pelagic zones of the open ocean, near shore waters, and land. They breed in Southern California and the Channel Islands and migrate north up the Pacific coast (NOAA 2019a). Their lifespan is estimated to be 15 to 24 years. Sea lions use temporary haul-outs like the Pacific harbor seal. Their diet includes fish such as Pacific whiting, rockfish, anchovy, hake, flatfish, small sharks, and cephalopods including squid and octopus.

Caltrans concluded marine mammal monitoring in 2004 for the Richmond-San Rafael Bridge seismic retrofit project (Green et al. 2004). Monitors sighted at least 90 California sea lions during the course of the work for the Richmond-San Rafael Bridge seismic retrofit, but the species was not reported at the Castro Rocks haul out site (Green et al. 2004). California sea lions have been observed using docks near Pier 39 in San Francisco as a haul out site, outside of the project construction area (Caltrans 2018) and is not anticipated to use haul out sites within the project construction area. One dead California sea lion was observed on Red Rock, directly west of Castro Rocks (Green et al. 2004). Therefore, they are expected to occur within the biological study area.

California sea lions within the biological study area are not expected to experience direct impacts due to implementation of the proposed Project. This species is expected to move through and forage within the biological study area. The biological study area consists of a small area within the context of the surrounding San Francisco Bay waters. The majority of the proposed Project work consists of activities above the water line, and the only marine impact from the work will be the temporary presence of two construction barges that will remain mainly stationary and make small movements from pier to pier as construction progresses. The barges will be staged in areas where they will not make contact with the San Francisco Bay substrate. Smaller boats will ferry workers and supplies to and from the Richmond Harbor and observe all watercraft regulations. The level of boat presence for this work is minimal in relation to the existing boat traffic in the vicinity of the Richmond-San Rafael Bridge, which hosts both larger commercial ships and smaller ferry and recreational boats. California sea lions are expected to easily avoid the limited barges and support boats as they move through San Francisco Bay.

No underwater noise is expected from this Project beyond the engines of the barges and the boats travelling to and from the barges. There is no in-water construction work associated with the Project. California sea lions may swim in proximity of the Project barges or boats but are expected to easily avoid them. Technical consultation with NOAA staff confirmed that the proposed work would not be expected to have an impact on in-water marine mammals (J. Carduner personal communication, February 5, 2019). There is an existing shipping channel under the Richmond-San Rafael Bridge that receives heavy boat traffic, and the noise associated with this work is not expected to exceed the existing in-water noise disturbance levels in the vicinity. California sea lions are not expected to use haul out sites within the project construction area. Given that project construction activities will not result in in-water noise disturbances that could result in take, and California sea lions are not anticipated to use Castro Rocks as a haul out site, this species is not considered further.

3.3 Stellar Sea Lion

Steller sea lions (*Eumetopias jubatus*) forage near shore and pelagic waters. For this species, haul-outs and rookery sites usually consist of beaches (gravel, rocky or sand), ledges, and rocky reefs. San Francisco Bay is near the southern end of the range for this species. The species is known to occur along the coast of California but is not known to enter the Bay. Steller sea lions have been reported at the Farallon Islands and at Año Nuevo Island between Santa Cruz and Half Moon Bay (Fuller 2012). Steller sea lions were only rarely sighted during the winter in the San Francisco Bay at haul out sites associated with California Sea Lions (SF Bay Subtidal Habitat Goals Report, Cohen 2010). The biological study area is outside of the expected range of this species.

This species is considered a rare visitor to San Francisco Bay. Given that project construction activities will not result in in-water noise disturbances that could result in take, this species is not considered further.

3.4 Northern Elephant Seal

Northern elephant seals (*Mirounga angustirostris*) occur in the eastern and central North Pacific Ocean ranging from Alaska to Mexico. Adults return to land between March and August to molt and return to their feeding areas again between the spring/summer molt and the winter breeding season. Males feed near the eastern Aleutian Islands and in the Gulf of Alaska, and females feed farther south, in the offshore waters of Washington and Oregon. Near San Francisco Bay, elephant seals breed, molt, and haul out at Año Nuevo Island, the Farallon Islands, and Point Reyes National Seashore (Lowry et al. 2014). Haul-out and pupping sites are typically on sandy coastal beaches (Caltrans 2019). Northern elephant seals haul out to birth and breed from December to March, and pups remain onshore or in shallow water through May (Caltrans 2015). Northern elephant seals may make occasional stops near San Francisco Bay (Caltrans 2015). Elephant seal pups are regular seasonal patients at The Marine Mammal Center (TMMC) in Sausalito, California, and a healthy juvenile male was observed basking at Aquatic Park, in San Francisco, in the Spring of 2019 (Hernández 2020).

This species is known to migrate up the coast of California but may only occasionally enter the San Francisco Bay. The BSA is outside of the expected range of this species. Known rookeries for the species are located along the coast. This species is considered a rare visitor to San Francisco Bay. Given that project construction activities will not result in in-water noise disturbances that could result in take, this species is not considered further.

3.5 Northern Fur Seal

The range of the northern fur seal (*Callorhinus ursinus*) varies between seasons. In the winter, the southern boundary of the range extends across the Pacific Ocean, between southern California and Honshu Island, Japan (NMFS 2015). In the spring, most migrate to breeding colonies in the Bering Sea. Pregnant adult females begin winter migration in November to either the central North Pacific Ocean or to offshore areas along the west coast of North America to feed. They primarily inhabit two types of habitat: open ocean and rocky or sandy beaches on islands for resting, reproduction, and molting. Adults are at sea about 80 percent of the year.

This species is known to inhabit deeper ocean water habitat far offshore. The BSA is outside of the expected range of this species. There is one record of a baby northern fur seal found in Hayward in 2016 during a time when ocean conditions were causing northern fur seal pups to be stranded along coastal beaches in California (Dineen, 2016). No other documentation of this species entering the San Francisco Bay was found during the document review process. Should any errant northern fur seal enter the BSA, it is expected that this species will easily avoid the marine construction activity which is slow moving and limited to small work areas at individual piers. There is no significant underwater noise generation associated with the proposed work that could cause harassment of this species.

This species is considered a rare visitor to San Francisco Bay. Given that project construction activities will not result in in-water noise disturbances that could result in take, this species is not considered further.

3.6 Harbor Porpoise

Harbor porpoises (*Phocoena phocoena*) are generally found in cool temperate-to-subarctic waters over the continental shelf in both the North Atlantic and North Pacific. In the North Pacific, they are found from Japan north to the Chukchi Sea and from Monterey Bay to the Beaufort Sea. Harbor porpoises are usually observed in groups of two to five individuals, and prey on small schooling fish such as anchovy and herring as well as squid. Calves are born in late spring (Read and Hohn 1995). They have an average lifespan of 10 to 12 years but can live up to 20 years. The population near California is estimated at 40,000, and census data suggest a stable population trend (Carretta et al. 2011).

This species was known to inhabit the San Francisco Bay historically before they were found to be extirpated by the 1940s due to anthropogenic disturbance including pollution from industrialization, World War II activities, dredging, and construction (Stern et al. 2017). This species was rarely observed in the San Francisco Bay again until 2008. Since 2008, sightings of harbor porpoise within the Central San Francisco Bay have increased dramatically, and this species is presumed to be present in the Bay year-round. According to observations made by Golden Gate Cetacean Research during a multiple year assessment, approximately 225 harbor porpoises have been observed in San Francisco Bay (Caltrans 2012). Harbor porpoises have been observed north of the Richmond San-Rafael Bridge in recent years, therefore this species could potentially occur in the biological study area.

Harbor porpoises within the biological study area are not expected to experience direct or indirect impacts due to implementation of the proposed Project. This species is expected to move through and forage within the action area. The action area consists of a small area within the context of the surrounding San Francisco Bay waters. The majority of the proposed work consists of activities above the water line, and the only marine impact from the work will be the temporary presence of two construction barges which will remain mainly stationary and make small movements from pier to pier as construction progresses. The barges will be staged in areas where they will not make contact with the San Francisco Bay substrate. Smaller boats will ferry workers and supplies to and from the Richmond Harbor and observe all watercraft regulations. The level of boat presence for this work is minimal in relation to the existing boat traffic in the vicinity of the Richmond-San Rafael Bridge, which hosts both larger commercial ships and smaller ferry and recreational boats. Harbor porpoises are expected to easily avoid the limited barges and support boats as they move through San Francisco Bay.

There will be no underwater noise beyond the engines of the barges and the boats travelling to and from the barges proposed for this Project. There is no in-water construction work associated with the Project. Harbor porpoises may swim near the Project barges or boats but are expected to easily avoid them. Technical consultation with NOAA staff confirmed that the proposed work would not be expected to have an impact on in-water marine mammals (J. Carduner personal communication, February 5, 2019). There is an existing shipping channel under the Richmond-San Rafael Bridge that receives heavy boat traffic, and the noise associated with this work is not expected to create in-water noise disturbances above existing background levels and therefore will not cause impacts to harbor porpoise. Given that harbor porpoises are not expected to experience in-water impacts from the project, this work is not anticipated to result in impacts to harbor porpoises and this species is not considered further.

3.7 Bottlenose Dolphins

The common bottlenose dolphin (*Tursiops truncatus*) is found in coastal waters and estuaries. The species is typically found in groups of five to ten individuals. The species eat a variety of fish, squid, and crustaceans. The range of the California coastal stock has expanded north along the Pacific Coast (Carretta et al. 2013, Wells and Baldridge 1990). The species occurs as far north as the San Francisco Bay region and have been observed in areas along the coast including Half Moon Bay in San Mateo County, Ocean Beach in San Francisco, and Rodeo Beach in Marin County. Bottlenose dolphins are considered an occasional visitor to San Francisco Bay.

This species is considered a rare visitor to San Francisco Bay. Given that project construction activities will not result in in-water noise disturbances that could result in take, this species is not considered further.

3.8 Whales

3.8.1 Gray Whale

Gray whales (*Eschrichtius robustus*) occur mainly in shallow coastal waters in the North Pacific Ocean. The eastern North Pacific geographic distribution of gray whales is found along the west coast of North America in the northern Bering and Chukchi Seas, and along the west coast of North America. The species migrates to wintering and calving areas off the coast of Baja California, Mexico.

This species was typically known to migrate along the California coast and not enter the San Francisco Bay. However, this species has been known to enter the Bay in recent years. The species tends to stay near the Golden Gate Bridge and Angel Island, though individuals have been sighted moving into the Bay as far as Yerba Buena Island (Martichoux 2019). Monitoring near the Richmond-San Rafael Bridge recorded 12 living gray whales and two dead gray whales in the Central Bay and North Bay, and the majority of the sightings were during the months of April and May (Winning 2008). In spring 2019, 12 dead gray whales were observed on the San Francisco Bay shoreline and in Ocean Beach, San Francisco (TMMC 2019). The Oceanic Society in 2001 reported that most gray whales only travel one to two miles into San Francisco Bay but occasionally moved into San Pablo Bay, north of the Richmond-San Rafael Bridge (Self 2012). If gray whales travel north as far as the BSA, it is expected that this species will easily avoid the marine construction activity which is slow moving and limited to small work areas at individual piers. There is no significant underwater noise generation associated with the proposed work that could cause harassment of this species.

This species is considered a rare visitor to San Francisco Bay. Given that project construction activities will not result in in-water noise disturbances that could result in take, this species is not considered further.

3.8.2 Humpback Whale

Humpback whales (*Megaptera noveangliae*) occur throughout the world's oceans migrating up to 5,000 miles between high-latitude summer feeding grounds and tropical winter mating and calving areas located in shallow, warm waters commonly near offshore reef systems or shores. Feeding grounds for this species are generally in cold, productive waters. The species is known to occasionally enter and feed in San Francisco Bay.

This species was typically known to migrate up the California coast and not enter the bay. One errant whale nicknamed “Humphrey” passed under the Richmond-San Rafael Bridge in 1985

(Fimrite 2005). However, since 2015, numerous humpbacks have entered San Francisco Bay during the summer and fall months, probably following prey species. The recent whales entering the Bay tend to stay near the Golden Gate Bridge and Angel Island area (Loeb, 2018). If the whales come as far north as the biological study area, it is expected that this species will easily avoid the marine construction activity which is slow moving and limited to small work areas at individual piers. There is no significant underwater noise generation associated with the proposed work that could cause harassment of this species.

This species is considered a rare visitor to San Francisco Bay. Given that project construction activities will not result in in-water noise disturbances that could result in take, this species is not considered further.

4 Status and Distribution of the Affected Species

4.1 Pacific Harbor Seal

The Pacific Harbor Seal is protected under the Marine Mammal Protection Act (MMPA), but not listed under the Endangered Species Act (ESA). Pacific harbor seals have the broadest range of any pinniped, inhabiting both the Atlantic and Pacific Oceans. In the Pacific, they are found in near-shore temperate coastal and estuarine habitats. Pacific Harbor seal habitat ranges from Baja California to Alaska, and from Russia to Japan. Pacific harbor seals do not typically migrate annually.

There are three recognized populations of Pacific harbor seals along the west coast of the continental United States: California Coastal Stock, Oregon-Washington Coastal Stock, and Washington Inland Coastal Stock (NOAA 2015). The three recognized populations along the west coast of the continental United States are genetically distinct. The geographical boundary between the Oregon-Washington Coastal Stock and California Stock is approximately the state boundary between Oregon and California (NOAA 2015). There are approximately 400 to 600 harbor seal haul-out sites in California, distributed widely along the mainland and offshore islands (NOAA 2015). The estimated population of the California stock is 30,968 (Table 4-1). This record is consistent with the 2020 Final Pacific Marine Mammal Stock Assessments and the 2021 U.S. Pacific Marine Mammal Stock Assessments (Carretta et al. 2022; NOAA 2020a). The population assessments are estimated from the number of Pacific harbor seals ashore during the 2012 surveys (NOAA 2020a).

The Pacific harbor seal population increased between 1981 and 2004, followed by a steady decline from 2005 to 2010. In the California statewide count, the California Pacific harbor seal stock sharply declined between 2009 and 2012. The breeding population of the Pacific harbor seals at the Farallon Islands was below the ten-year average in 2018, but the pupping rate did not change (Duncan 2020). Since the MMPA was passed in 1972, the California Pacific harbor seal stock has increased overall but seal counts are considered small within San Francisco Bay (Sedlak and Greig 2012). The California stock may be stabilizing at the carrying capacity of the region (Duncan 2020). Annual population declines of the Pacific harbor seal occur due to fisheries mortalities, vessel strikes, disturbance, entanglements in fishing gear, and habitat loss.

Table 4-1: Stock Assessment of Marine Mammal Stock Present in San Francisco Bay

Species	Stock Name	Stock Abundance	Relative Occurrence in San Francisco Bay	Season(s) of Occurrence
Pacific harbor seal *(Phoca vitulina)*	California stock	30,968	Common	Year-round

Source:
NOAA 2019a, NOAA 2020a, Carretta et al. 2022

Castro Rocks and other haul-out sites in San Francisco Bay are part of the regional survey area for long-term National Park Service (NPS) monitoring studies of harbor seal colonies. The NPS monitoring has been conducted since 1976 (NPS 2014). In 2019, the population numbers at Castro Rocks averaged 291 individuals (adults and pups) during breeding season, and 237 during the molting season (Codde 2020). Monitoring survey data indicates that the rate of seals using Castro Rocks as a haul out site has steadily increased in recent years. The largest number of harbor seals observed at Castro Rocks was in 2019 (Codde 2020). Regional population counts in 2017 to 2019 during breeding and molting seasons show the 2019 population of seals at Castro Rocks is within the 17-year average (Codde and Allen 2020).

5 Type of Incidental Take Authorization Requested

5.1 Take Authorization Request

Under Section 101 (a)(5)(D) of the MMPA, Caltrans requests an authorization from the National Marine Fisheries Service (NMFS) for incidental take (as defined by Title 50 Code of Federal Regulations, Part 216.3) of Pacific harbor seals during restoration and painting of the Richmond-San Rafael Bridge in San Francisco Bay. With implementation of the measures outlined in Section 11, no serious injury is anticipated, and the potential for take through non-serious injury (Level A Harassment) will be avoided. Caltrans requests an Incidental Harassment Authorization (IHA) for incidental take of Pacific harbor seals described in this application for visual disturbances (Level B Harassment) over approximately 30 calendar days during the installation and removal of the scaffolding and debris containment system. Proposed activities will be conducted during a one-year period from 2022-2023.

5.2 Method of Take

The Project, as outlined in Sections 1 and 2, has the potential to result in incidental take of marine mammals by construction and human related disturbance during the installation and removal of the scaffolding and debris containment system (30 days). These activities have the potential to disturb or displace harbor seals from the nearby haul-out site at the Castro Rocks. The nearest outcropping of the Castro Rocks, where marine mammals are known to haul out, are located approximately 21.3 meters (70 feet) from Pier 55, and the farthest outcropping is located approximately 145 meters (475 feet) from Pier 52. The proposed activities may result in “take” in the form of Level B Harassment (behavioral disturbance only) from proposed project activities. Construction is expected to occur for approximately 210 calendar days. The predominate form of “take” of Pacific harbor seals will be associated with visual disturbances by the installation and removal of scaffolding and containment system. Airborne noise from construction activity may result in Take but will be limited to a relatively small area within 30.4 meters of Castro Rocks. Section 11 contains additional details on impact reduction and mitigation measures that are proposed for this Project to minimize take events.

6 Number of Marine Mammals that May Be Affected

Project construction activities may result in temporary behavioral changes in marine mammals due to visual and auditory disturbance generated during the installation and removal of the scaffolding and containment system. This section describes the airborne noise levels that are expected to be generated by the Project activities, and the potential impacts on marine mammal species that could be found in the Project area.

6.1 Acoustic Modeling and Marine Mammals Impact Analysis

Proposed construction is expected to generate noise levels that exceed the ambient (baseline) noise levels and may have the potential to disturb federally protected marine mammals. NOAA Fisheries has identified airborne sound thresholds that could impact marine mammals. These thresholds are expressed in decibel (dB) units, which is a measurement of the relative amplitude of sound. Table 6-1 summarizes these thresholds (NMFS 2022).

Table 6-1: NOAA Fisheries Current In-Air Acoustic Thresholds

Criterion	Criterion Definition	Threshold
Level A	Injury to marine mammals	None established
Level B	Behavioral disruption for harbor seals	90 dB
Level B	Behavioral disruption for non-harbor seal pinnipeds	100 dB

Notes:

1 The airborne disturbance guideline applies to hauled-out pinnipeds.

2 Thresholds are based on the NMFS: Summary of Marine Mammal Protection Act Acoustic Thresholds; In-Air Level B Harassment Acoustic Thresholds (NMFS 2022).

dB = decibel

A field investigation was conducted to quantify the ambient noise environment of the area surrounding Castro Rocks on April 10 and 11, 2019 by Illingworth and Rodkin Inc. Acoustics and Air Quality Consultants (Appendix C). The dominant existing noise source in the Project vicinity is vehicular traffic on the Richmond-San Rafael Bridge. The nearest outcropping of the Castro Rocks, where marine mammals are known to haul out, are located approximately 21.3 meters (70 feet) from Pier 55, and the farthest outcropping is located approximately 145 meters (475 feet) from Pier 52. Long- and short-term noise measurement locations were selected to represent the ambient noise environments at various distances from the bridge deck. Sound measurements at 30 meters (95 feet) for the bridge confirmed traffic noise between 60-75dBA.

For the field investigation and modelling purposes, Illingworth and Rodkin used the Federal Highway Administration's (FHWA's) Roadway Construction Noise Model (RCNM) to calculate the maximum and hourly average noise levels anticipated for the worst-case scenario. This construction noise model includes representative sound levels for the most common types of construction equipment and the approximate usage. It should be noted that RCNM and other known noise levels for construction equipment are A-weighted values. However, the NOAA Fisheries Air Acoustic Thresholds are not A-weighted value. Therefore, there are discrepancies between the modeled distances for the 90dB and 100dB behavioral disruption thresholds between the Illingworth and Rodkin report and the NOAA isopleth calculator for in-air noise (Scholik 2021).

For the purpose of this application, the 90dB and 100dB behavioral disruption thresholds will be estimated using the NOAA isopleth calculator for in-air noise. Based on the maximum estimated construction noise of 96dB, the 90-dB behavioral disruption criterion for harbor seals would be exceeded within 30.4 meters (99.7 feet) of the active construction work, and the 100-dB behavioral disruption criterion for non-harbor seal pinnipeds would be exceeded within 9.62 meters (31.55 feet).

The NOAA isopleth calculator does not take into consideration that all construction work is restricted to the underside of the lower bridge deck which is situated 17.7 meters (58 feet) above the waterline at its closest point to Castro Rocks. Based on the vertical and horizontal distances ($\sqrt{21.3^2 + 17.7^2}$), the Castro Rocks are 27.69 meters (90.84 feet) diagonally from the proposed construction area. This places the closest portion of Castro Rock at pier 55 within the projected 90dB behavioral disruption zone of 30.4 meters (99.7 feet) for in-air noise. It is estimated that 353 square meters (3,800 square feet) of Castro Rock will be subject to in-air noise greater than 90dB during the installation of the scaffolding and containment system. It is anticipated that once the scaffolding and containment system is installed, it will actively attenuate the construction noise and that the 90dB behavioral disruption will not be exceeded for construction operations occurring within the containment system. A reduction of 2dB in the maximum construction noise, due to noise attenuation from the containment system, will result in a reduction of the 90dB behavioral disruption zone for in-air noise to 24.2 meters (79.2 feet), which is less than the diagonal distance between Castro Rocks and the work area.

6.2 Description and Estimation of Take

For this analysis, the potential numbers of marine mammals that may be exposed to take as defined in the MMPA was determined by utilizing population data from recent annual surveys of haul outs in the Bay conducted by the NPS (Codde and Allen 2013, 2015, 2017, 2020; Codde 2020) and construction-related disturbances observed during daytime monitoring (1998-2005) at Castro Rocks for the Richmond-San Rafael Bridge seismic retrofit project (Green et al. 2004).

All impacts are considered temporary and would not have an adverse impact on the population. Mortality or physical harm to the species is not expected given the nature of the work.

6.2.1 Pacific Harbor Seal

Given the proximity of the project to Castro Rocks, the total estimated daily number of individuals that may occupy the haul out site is used to estimate the number of harbor seals potentially exposed to Level B harassment (take) from visual disturbance. Castro Rocks is the largest harbor seal haul out site in northern San Francisco Bay and is the second largest pupping site in San Francisco Bay (Kopec and Harvey 1995). The harbor seal pupping season is from March to July in San Francisco Bay. Seals are present on the haul out year- round during medium to low tides (Green et al. 2004). For harbor seals, the yearly maximum counts in the 2004 Richmond-San Rafael Bridge Monitoring report ranged from approximately 238 individuals to 271 individuals at Castro Rocks (daytime) during pupping and molting season (Green et al. 2004). In the fall and winter seasons of 2004, the maximum count of harbor seals at Castro Rocks (daytime) ranged from 336 individuals to 594 individuals (Green et al. 2004). More recent observations at the Castro Rocks haul out site reported approximately 300 seals during the pupping and molting seasons (Codde and Allen 2020). The highest mean number of harbor seals observed at Castro Rocks during recent annual NPS surveys was 237 seals observed in 2019 (Codde and Allen 2013, 2015, 2017, 2020; Codde 2020).

The Castro Rocks are located to the south side of Richmond-San Rafael Bridge at Pier 55. The closest outcropping of Castro Rocks where harbor seals are known to haul out is located approximately 21 meters (70 feet) from Pier 55, and the farthest outcropping is located approximately 145 meters (475 feet) from Pier 52. The seals at Castro Rock have habituated to some sources of human disturbance such as large tanker traffic and the noise from automobile traffic on the bridge, but often flush into the water when small boats maneuver close-by or when people work on the bridge (Kopec and Harvey 1995).

Harbor seals will typically use haul out sites in the late afternoon and evening (Green et al. 2004). During molting and pupping season, time spent on the haul out sites rises to an average of 12 hours per day compared to 7 hours per day outside of molting and pupping season (NPS 2014). The number of harbor seals hauled out at Castro Rocks varies with the time of day, with more animals expected to be hauled out at Castro Rocks during the nighttime hours (Green et al. 2004). The number of harbor seals at Castro Rocks is expected to vary throughout the work period. For the purposes of calculating Level B take, the 2020 observation of 300 Pacific harbor seals by Codde and Allen will be used.

Monitoring efforts from the 2011 seismic retrofit project found that on average there were 0.16 construction related disturbance (flushes) per hour of field time caused by construction-related disturbances during daytime monitoring at Castro Rocks (Green et al. 2004). Construction-related disturbances at Castro Rocks consisted of two main factors: watercraft in the area of the haul-out site and construction activities including jackhammering, rivet work, and the movement of cranes on barges near the haul-out site (Green et al. 2004). Using a similar flush rate over a 12-hour construction period, this project may result in 57.6 flush events over a 30-day period during the installation and removal of the scaffolding and debris containment system. It is anticipated that all harbor seals that haul out on Castro Rocks would be subject to visual and noise disturbances associated with the installation and removal of the scaffolding and debris containment system.

Construction noise and activity from this project are considerably less that the seismic retrofit project due to the lack of jackhammering, rivet work and construction activities at water level. Once the scaffolding and debris containment system is installed on the lower bridge deck, the work area will be screened, and Level B take due to ongoing construction activities inside the containment system is not anticipated. Installation and removal of the debris containment system is expected to take 30 days, resulting in approximately 9,000 occurrences of Level B take.

A summary of the estimated take for harbor seal is provided in Table 6-2. Level A take is not requested due to the nature of the work on the Bridge, and mortality and physical harm are not expected to the species during construction activities.

Table 6-2: Level B Harassment Estimate for Pacific Harbor Seal (Total)

Species	Expected Average Individuals Per Day (hauled out)	Estimated Level B Take (Total)
Pacific Harbor Seal	300	9,000

6.3 Summary and Schedule of Estimated Take

Construction is expected to occur near Castro Rocks for approximately 210 calendar days. Take that may occur through Level B Harassment are related to short periods of construction during the installation and removal of the scaffolding and debris containment system as described in Section 2. The Level B Harassment estimates are estimated on the maximum construction-related takes per day, based on the most recent seal counts at Castro Rocks. It is assumed that an individual animal can only be taken once during a 24-hour period.

7 Anticipated Impact of the Activity on the Species or Stock

7.1 Effects of Airborne Noise on Marine Mammals

Based on the acoustic modeling conducted for the Project, harbor seal may be impacted by construction noise at a portion of Castro Rocks within the projected 90dB behavioral disruption zone of 30.4 meters (99.7 feet) for airborne noise. Level B harassment from airborne noise is anticipated to occur during the 30-day period to install and remove the scaffolding and containment system. It is anticipated that once the debris containment system is installed, it will actively attenuate the construction noise and that the 90dB behavioral disruption will not be exceeded for construction operations occurring within the containment system. Injury and Level A harassment is not expected to occur from airborne noise.

7.2 Effects of Human Disturbance on Marine Mammals

The visibility of workers in the Project area may also cause behavioral reactions such as flushing from the haul-out, not hauling out, head alerts, or moving farther from the disturbance to forage.

The seals at Castro Rocks have habituated to a degree to some sources of human disturbance such as large tanker traffic and the noise from vehicle traffic on the bridge, but often flush into the water when small boats maneuver close by or when people work on the bridge (Kopec and Harvey 1995). During construction monitoring (2001-2005) of the Richmond-San Rafael Bridge seismic retrofit project, it was observed that the work window exclusion zone between piers 52-57, provided “adequate protection during the pupping and molting season.” The overall population remained consistent, and the documented increase in the number of pups on Castro Rocks prior to construction continued throughout the seismic restoration project. Documented construction related disturbance occurred between piers 52-57, with over 50% of all disturbances occurring from construction activities on pier 55. Most of the construction-related disturbances were due to construction-related boats moving in the vicinity of Castro Rocks (Green et al. 2004). Caltrans proposes further mitigation measures in Section 11 to minimize human and boat traffic disturbance in the vicinity of Castro Rocks during construction activities. Boat traffic routes will be predetermined in consultation with the project biologist to avoid harassment or take of marine mammals in the vicinity of Castro Rocks.

Given the relatively short duration of the work, and the mitigation measures that will be implemented to minimize effects from human disturbance, exposure to human disturbance would not result in population level impacts or affect the long-term fitness of the species.

8 Anticipated Impact on Subsistence Uses

No subsistence uses of marine mammals occur within San Francisco Bay. No impacts are expected to the availability of the species stock as a result of the proposed Project.

9 Anticipated Impact of the Activity on the Habitat or the Marine Mammal Populations, and the Likelihood of Restoration of the Affected Habitat

San Francisco Bay is classified as Essential Fish Habitat (EFH) under the Magnuson-Stevens Fisheries Conservation and Management Act, as amended by the Sustainable Fisheries Act (NOAA 2019b). The EFH provisions of the Sustainable Fisheries Act are designed to protect fisheries habitat from being lost due to disturbance and degradation. The act requires implementation of measures to conserve and enhance EFH.

San Francisco Bay is classified as EFH for 20 species of commercially important fish and sharks that are federally managed under three fisheries management plans (FMPs): Coastal Pelagic, Pacific Groundfish, and Pacific Coast Salmon. The Pacific Coast Salmon FMP includes Chinook salmon.

In addition to EFH designations, San Francisco Bay is designated as a Habitat Area of Particular Concern for various fish species within the Pacific Groundfish and Coastal Pelagic FMPs as listed above. This estuarine system serves as breeding and rearing grounds important to these fish stocks. A number of these fish species are prey species for pinnipeds.

No impacts to foraging habitat for marine mammals are anticipated given that there is no in-water construction work associated with the Project. The Project is not likely to have a permanent, adverse effect on marine mammal foraging habitat.

10 Anticipated Impact of the Loss or Modification of Habitat

Project construction activities are not expected to result in any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or populations. As the project does not include in-water construction activities, there are no anticipated in-water disturbances to foraging and dispersal habitat for marine mammals in the area. Temporary impacts to the Castro Rocks Environmentally Sensitive Area habitat will be minimized based on the Impact Reduction Methods identified in Section 11.

11 Impact Reduction Methods

Section 6 describes the potential number of marine mammals—by species—that may be exposed to acoustic or human disturbances that would be considered Level B Harassment by NOAA. Caltrans proposes the following mitigation measures to reduce the number of take events and potential disturbances of marine mammals during project activities.

11.1 Mitigation for Bridge Restoration and Painting

The following impact reduction methods are proposed as a method by which to limit, to the greatest extent practicable, the take of marine mammals. Project-specific avoidance and minimization measures include the installation of a full paint containment system that will capture all fugitive dust and screen the construction activities from the harbor seal haul out site. The project will be implementing work windows, establish a boat exclusion zone and employ biological monitors to conduct visual monitoring.

11.2 Castro Rocks Environmentally Sensitive Area

To protect the Castro Rocks Environmentally Sensitive Area, measures will be implemented to minimize potential affects from the project on marine mammals hauled out at the Castro Rocks site.

Seasonal Work Restrictions will include the following: Installation or removal of the debris containment system will not occur between Piers 52-57 from March 1 to August 1 due to the pupping and molting period of harbor seals. No work will take place outside of the containment system on the bridge between piers 52-57 from March 1 to August 1. The containment system will act as a visual barrier between construction operations and the seal colony on Castro Rocks.

A non-disturbance buffer will be established within 400 feet of Castro Rocks on the south side of bridge. Staging of barges will not be allowed in the Castro Rocks Environmentally Sensitive Area to minimize disturbance to marine mammals hauled out at the Castro Rocks site. Personnel on project-related watercraft would be required to receive marine mammal education including behavior related to marine mammals, steering watercraft so as not to approach marine mammal haul-out sites, and reporting of marine mammal sightings. Watercraft will be instructed to maintain a slow steady speed when passing by the haul-out site.

Routes for watercraft to reach work locations will be predetermined in consultation with the project biologist to avoid harassment or take of marine mammals hauled out at Castro Rocks. Watercraft will be instructed to maintain a slow steady speed whenever possible when passing by the haul-out site.

Project barges will either be tethered to the concrete bridge piers or anchored adjacent to the work area. No piles will be driven or vibrated to create staging locations. No barges will be staged within the two main shipping channels under the bridge. No anchoring, staging of barges, or boat traffic will be permitted on the south side of the bridge between Piers 52-57. All work for Piers 52-57 will need to occur from the north side of the bridge and outside of the Castro Rock ESA.

Marine mammal education for construction personnel will include environmental training by an approved biologist. All construction personnel would attend a mandatory environmental education program delivered by the project biologist prior to working in the project construction area. The program would focus on the conservation measures that are relevant to each employee’s personal responsibility and would include an explanation as how to best avoid take of sensitive species. Distributed materials would include a pamphlet with distinguishing photographs of sensitive species, species’ habitat requirements, compliance reminders, and relevant contact information. Documentation of the training, including sign-in sheets, would be kept on file and would be available on request.

11.3 Visual Monitoring

Visual monitoring will be conducted throughout the duration of the installation and removal of the scaffolding and debris containment system to record presence and behavior of marine mammals in and adjacent to the project construction area. Visual observation of marine mammals may be affected by multiple factors including the behavior of the animal, the monitor’s ability to detect the animal’s presence, environmental conditions, and monitoring platforms. Prior to the start of work, biological monitors will submit resumes to NOAA for approval. Further description of the proposed marine mammal monitoring is described in Section 13.

Caltrans will submit the names and qualifications of the biological monitor(s) for NOAA approval prior to initiating construction activities for the Project. The biological monitor will be present as needed, to monitor for the presence and behavior of special-status species. The biological monitor would have the authority to stop work if deemed necessary for any reason to protect the species. The biological monitor will record all instances of take of harbor seals and a detailed description of the potential causes. If at any time work is stopped due to species issues, the Project resident engineer or construction inspector would consult with the biological monitor on how to proceed. Details of visual monitoring protocols will be provided in the marine mammal monitoring plan, and the monitoring plan will be approved by NOAA prior to the start of construction.

11.4 Artificial Lighting

Construction lighting will be directed onto the area of work. Any construction lighting cast onto the waters of San Francisco Bay will be limited to the maximum amount practicable. The directing of light towards the Castro Rocks Environmentally Sensitive Area during nighttime hours will be avoided.

11.5 Mitigation Effectiveness

Level B Harassment to marine mammals in the project area will be minimized with the implementation of the proposed impact reduction methods. The proposed mitigation measures will minimize take incidents to the maximum extent practicable when project construction will take place near the Castro Rock Environmentally Sensitive Area.

Visual monitoring will be conducted throughout the project duration to record presence and behavior of marine mammals in and adjacent to the project construction area. Visual observation of marine mammals may be affected by multiple factors including the behavior of the animal, the monitor’s ability to detect the animal, environmental conditions, and monitoring platforms. Prior to the start of work, biological monitors will submit resumes to NOAA for approval.

12 Arctic Subsistence Uses, Plan of Cooperation

Not applicable. The proposed activity would take place in San Francisco Bay and no activities would occur in or near a traditional Arctic subsistence hunting area.

13 Monitoring and Reporting

Caltrans will develop a monitoring plan for conducting and documenting marine mammal monitoring. The marine mammal monitoring plan will provide details on data collection for each distinct marine mammal species observed in the Project area during the construction period. Monitoring will include the following: marine mammal behavior observations, count of the individuals observed, and the frequency of the observations. The plan would be submitted to NOAA for review and approval prior to the start of construction.

Specific details of marine mammal monitoring will be developed in conjunction with NOAA during finalization of the IHA, and any updates will be incorporated into the project Marine Mammal Monitoring Plan. Caltrans will collect sighting data and observations on behavioral responses to construction for marine mammal species observed in the region of activity during the period of construction. All observers will be trained in marine mammal identification and behaviors. The monitoring and reporting tasks would include the items listed below:

- Biological monitoring will occur within one week before the Project's start date, to establish baseline observations.
- Observation periods will encompass different tide levels and hours of the day. Monitoring of marine mammals around the construction site will be conducted using binoculars as necessary.
- Data collection will consist of a count of all pinnipeds and cetaceans by species, a description of behavior (if possible), location, direction of movement, type of construction that is occurring, time that bridge restoration and painting work begins and ends, any acoustic or visual disturbance, and time of the observation. Environmental conditions such as weather, visibility, temperature, tide level, current and sea state would also be recorded. Further data collection specifics are discussed below for each marine mammal sighting.
- Biological monitoring will occur from appropriate monitoring locations on the shoreline or construction barges to maintain a clear view of the project construction area and adjacent areas during the survey period. Monitors will be equipped with radios or cell phones for maintaining contact with work crews.
- A final report will be submitted to NOAA within 90 days after completion of the proposed Project.

Visual observations of marine mammals in the area during project activities will be conducted by Protected Species Observers (PSO's). Data collection during biological monitoring of the project will provide observances of take of marine mammals during the construction process. The proposed location of the Protected Species Observers will be at a monitoring platform positioned on Pier 55 of the Richmond-San Rafael Bridge, at the closest pier of the Richmond-San Rafael Bridge to Castro Rocks (Figure 15). Pier 55 is approximately 21 meters (70 feet) from the nearest rock at Castro Rocks harbor seal colony. The proposed position of the Protected Species Observer location will provide optimal visibility for marine mammal observation at the Castro Rocks haul out site and in the surrounding area during bridge restoration and painting activities.

Each Protected Species Observer will record their observation position, start and end times of observations, weather conditions (sunny/cloudy, wind speed, fog, visibility), temperature, tide level, current, and sea state. For each marine mammal sighting, the following will be recorded if possible:

1. Species
2. Number of animals (with or without pup/calf)
3. Age class (pup/calf, juvenile, adult)
4. Identifying marks or color (scars, red pelage, etc.)
5. Position relative to Richmond-San Rafael bridge (distance and direction)
6. Movement (direction and relative speed)
7. Behavior (logging [resting at the surface], swimming, spyhopping [raising above the water surface to view the area], foraging, etc.)
8. Duration of sighting or times of multiple sightings of the same individual
9. Details of any marine mammal behavioral disturbances

Details of any marine mammal disturbances will include documentation of behavioral reactions of marine mammals within the vicinity of the construction area. Data collection of behavioral reactions will provide records to quantify the marine mammal take events during project activities. Data collection techniques will include direct observations of the marine mammals conducted by the trained Protected Species Observers and documentation of any behavioral disturbances to the marine mammals. Behavioral reactions at the Castro Rocks haul out site can include harbor seals looking toward the direction of the disturbance source (head alert), harbor seals moving suddenly towards the water (approach water), seals entering the water (flushing), or if there is no response (Green et al., 2004). Behavioral reactions will be documented in marine mammal monitoring records. In relation to the Castro Rocks haul-out site, behavioral reactions such as flushing from the haul-out, not hauling out, head alerts, or moving farther from the disturbance to forage will be recorded in detail by the Protected Species Observers.

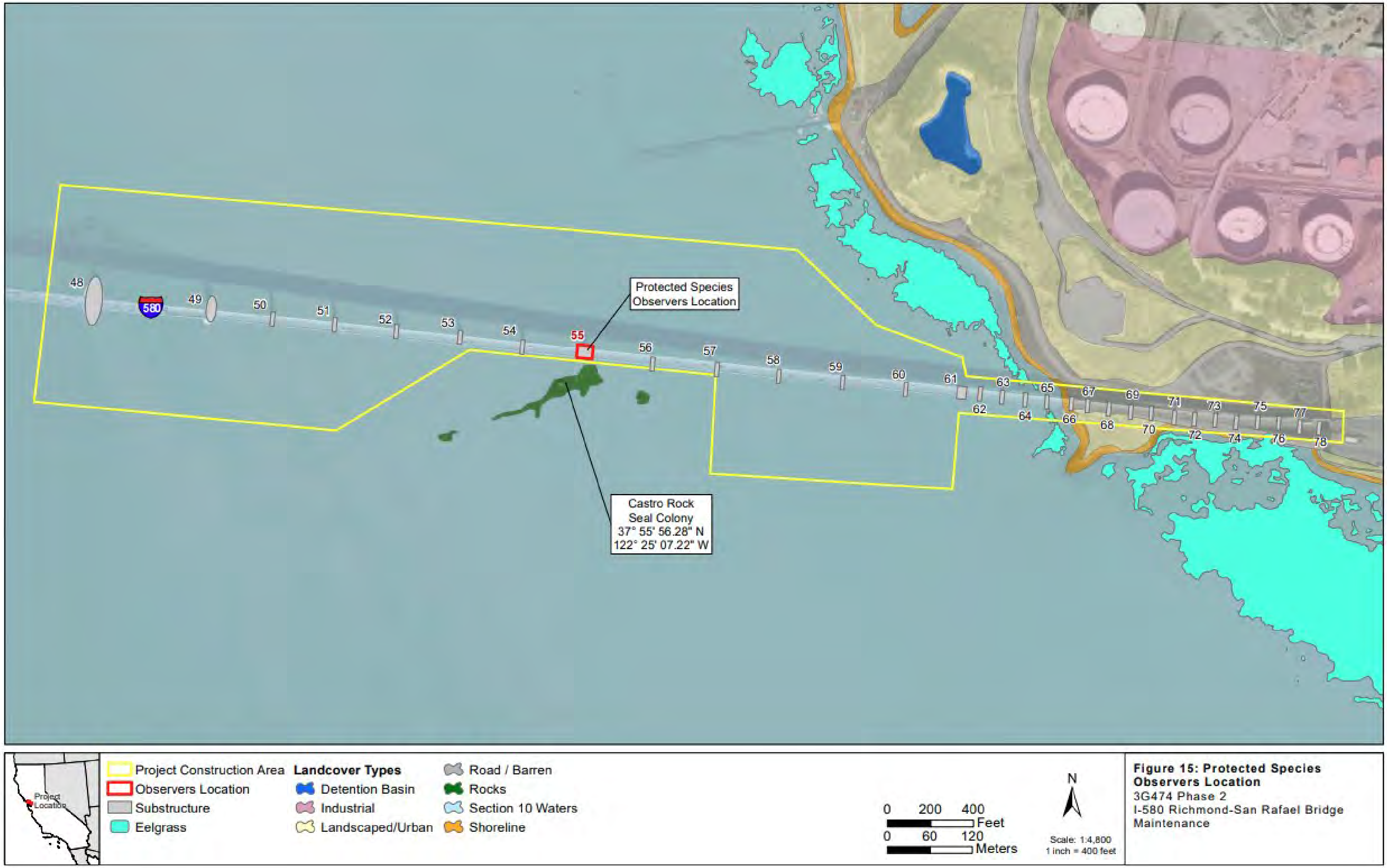
Caltrans will submit the names and qualifications of the Protected Species Observer(s) for NOAA approval prior to initiating construction activities for the Project. The Protected Species Observer will be present as needed, to monitor for the presence and behavior of special-status species. The Protected Species Observer would have the authority to stop work if deemed necessary for any reason to protect the species. The Protected Species Observer will record all instances of take of harbor seals and a detailed description of the potential causes. If at any time work is stopped due to species issues, the Project resident engineer or construction inspector would consult with the Protected Species Observer on how to proceed. Details of visual monitoring protocols will be provided in the marine mammal monitoring plan, and the monitoring plan will be approved by NOAA prior to the start of construction.

An initial monitoring report will be emailed to NOAA within one week after the initial construction activities start. The initial report will include species and numbers of marine mammals observed, time and location of observation, behavior, and other recorded data. In addition, the report will include an estimate of the number of Pacific harbor seals that may have been behaviorally harassed as a result of the start of bridge restoration and painting activities.

Caltrans will provide NOAA with a final report detailing:

- The monitoring protocol
- A summary of the data recorded during monitoring
- An estimate of the numbers of marine mammals that may have been harassed due to the bridge restoration and painting activities

Figure 1-15 Protected Species Observers Location



14 Coordinating Research to Reduce and Evaluate Incidental Take

To reduce the likelihood that impacts will occur to the species, stocks, and subsistence use of marine mammals, construction activities will be conducted in accordance with federal, state and local regulations and the minimization measures proposed in Section 11. Caltrans will coordinate all activities as needed with relevant federal and state agencies. These include, but are not limited to: NOAA, United States Army Corps of Engineers, and the California Department of Fish and Wildlife.

Marine mammal monitoring reports would provide useful information that would influence the design of future projects to reduce incidental take of marine mammals. Caltrans will share field data and behavioral observations of marine mammals that occur in the Project area. Results of each monitoring effort will be provided to NOAA in a summary report at the conclusion of monitoring. This information could be made available to federal, state and local resource agencies, scientists and other interested parties upon written request to NOAA.

15 References

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Appendix A

Richmond-San Rafael Bridge Noise Study

RICHMOND-SAN RAFAEL BRIDGE MAINTENANCE PROJECT CONSTRUCTION NOISE ASSESSMENT

RICHMOND, CALIFORNIA

April 17, 2019

♦ ♦ ♦

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Summary

The project proposes maintenance work, including (1) scaffolding and containment system, (2) barges – equipment, operations, and materials storage, (3) repair, removal, and replacement of steel bridge components, (4) sandblasting, cleaning, and painting, (5) repair of concrete piers, road deck, and expansion joints on the lower deck, and (6) maintenance of seismic bridge components. Noise-generating equipment expected to be used during the noisiest construction phases, including sandblasting and repair phases was considered in this report. Construction noise levels were propagated to the Castro Rocks, which would be as close as 70 feet from the nearest pier where construction activities would occur. The nearest residential buildings are 0.75 miles away from the areas of bridge construction and are not included in this assessment.

The modeled results for L_{max} and L_{eq} for the noisiest task would range from 85 to 96 dBA L_{max} and from 88 to 92 dBA L_{eq} at a distance of 50 feet from the active construction area. Therefore, the Caltrans nighttime threshold of 86 dBA L_{max} may be exceeded when sandblasting occurs at night. Distances to each of the Level B marine mammal thresholds were also calculated from the modeled construction noise levels. The 90 dB behavioral disruption criterion for harbor seals would be exceeded within 65 feet of the active construction work, and the 100 dB behavioral disruption criterion for non-harbor seals would be exceeded within 20 feet, assuming a 6 dB per doubling of the distance fall-off rate.

Based on the modeled results, the A-weighted construction noise levels would not exceed the RMS thresholds for marine mammals at the Castro Rocks, which is 70 feet or more from the active construction work. However, ambient L_{eq} noise levels would be exceeded during daytime hours at distances within about 525 feet during each phase, while the repair phase would also exceed ambient noise levels within 595 feet. During nighttime hours, construction work would exceed ambient L_{eq} conditions within about 1,000 feet during each phase. The L_{max} levels generated during the barge phase would not exceed ambient L_{max} levels during daytime or nighttime hours; however, daytime and nighttime ambient L_{max} levels would be exceeded during the other two noisy phases within 595 feet.

Table of Contents

Chapter 1. Introduction

The California Department of Transportation (Caltrans) proposes the restoration and painting of the Richmond-San Rafael Bridge (Bridge No. 28-0100) on Interstate 580. The Richmond-San Rafael Bridge is 5.5 miles in length and connects the City of Richmond, Contra Costa County to the City of San Rafael, Marin County, California. The proposed restoration work would replace miscellaneous degraded steel bridge components, remove the traveler rail system, replace ladders and platforms, repair laminated concrete on selected piers, repair damaged road deck concrete, and replace expansion joints on the lower deck. Painting of the bridge structure would require the removal of all existing paint through sand blasting and rotary sanding. An enclosed scaffold system would be constructed to ensure complete containment of paint and construction debris. Barges would be used for staging personnel, equipment, and materials.

Chapter 2 of this report provides a more detailed description of the construction activities that will take place in this project. Chapter 3 reviews the fundamentals of environmental noise. Chapter 4 summarizes applicable regulatory criteria. Chapter 5 illustrates the type of existing environment in which the project site is located, the surrounding existing land uses, and the construction noise analysis approach used in this study. A discussion of the ambient noise environment, which was characterized by a noise monitoring survey conducted at the project site and the surrounding area, are included in Chapter 6. Chapter 7 includes the construction noise analysis completed for the proposed project.

Chapter 2. Project Description

The Project is expected to take 1,250 working days. It is anticipated that one to four teams of five to eight individuals will be working simultaneously. Nighttime lane closures outside of commute hours will be required. Materials and personnel will sail from Richmond Harbor via boat to the barge platforms and work areas. Alternatively, materials and personnel will be delivered to the site during nighttime lane closures on the bridge. Work will occur on a 2.4-mile section of the bridge between Pier 1 (postmile [PM] MRN 1.9) and Pier 48 (PM CC 7.3). Work will occur on the main tower of Pier 48 but not on the road deck section between Piers 48 and 49. The Project is comprised of six elements: (1) scaffolding and containment system, (2) barges – equipment, operations, and materials storage, (3) repair, removal, and replacement of steel bridge components, (4) sandblasting, cleaning, and painting, (5) repair of concrete piers, road deck, and expansion joints on the lower deck, and (6) maintenance of seismic bridge components.

2.1. Scaffolding and Containment System

Prior to the start of sand blasting and painting, the contractor will construct a scaffolding system to access the bridge towers and the underside of the bridge deck. The scaffolding system is modular and will be constructed on the concrete bridge piers and towers and hung from the road deck. It is anticipated that the scaffolding system will be installed over a section of three bridge piers at any given time (approximately 650 to 800 feet). Scaffolded areas include concrete piers, bridge towers, the underside of the lower bridge deck, and the first 10 feet above the bottom chord of the lower bridge deck. Conduit for the delivery of power, compressed air, water, and air purification will be constructed into the scaffolding system.

Once the scaffolding is installed it will be enclosed to contain all debris, slurries, and paint generated by the work. A plywood platform will be constructed at the base of each pier to prevent debris falling into the bay. All paint debris associated with sandblasting will be vacuumed to a filtrations system located on barges staged below the work area. Liquid slurries associated with pressure washing will also be captured and pumped to baker tanks located on the barges for full containment. The original paint used on the Richmond-San Rafael bridge was lead-based, and all paint debris will be managed as a hazardous waste and disposed at an approved facility.

There are no specific noise concerns with the installation of these systems, and noise from generators, air compressors, and vacuum systems are addressed for the following activities, specifically.

2.2. Barges – Equipment, Operations, and Materials Storage

It is anticipated that the contractor will employ the use of two floating barges for equipment operations and materials storage. The barges will either be tethered to the concrete bridge piers or anchored adjacent to the work area. It is anticipated that the barge will need to be moved for each bridge pier. The barges will not be moored within the two main shipping channels. No piles will be driven or vibrated to create mooring locations. Equipment operated on the barges may include cranes, generators, air compressors, baker tanks, air purification systems, water pumps, oxy-acetylene welding and cutting tools, concrete pumps, and paint sprayers. Materials stored on the barges may include miscellaneous replacement steel bridge components, sand blasting aggregates, paint and primer, fuel, water, concrete mix, solid paint, and liquid slurry waste. All equipment and materials will receive both primary and secondary containment to ensure that no fuel or hazardous materials enters the waters of the bay. Hazardous materials will be contained in sealed 50-gallon drums and held in a separate containment area on the barges.

2.3. Repair, Removal, and Replacement of Steel Bridge Components

Rusted bolts, nuts, washers, access ladders, drain pipes, platforms, and cable restrainers will be replaced. Existing eye-bar pin caps on the upper truss cord will also be replaced. Holes in the bottom of the existing bottom chord H-beam will be widened from 1.125 to 2 inches to facilitate drainage. The project will also remove the existing travelers and traveler rails on the upper and lower bridge decks.

Non-structural steel areas of the bridge that are rusted may be spot welded prior to painting. Rusted steel bridge components may need to be cut off with an oxy-acetylene torch or ground out using an abrasive grinder. All steel components and debris generated during the cutting, grinding, and removal process will be contained and stored as hazardous waste. Travelers on the lower deck will be removed inside the containment system, while the travelers on the upper deck will be removed during nighttime lane closures. All material that falls on the lower road deck from the removal of the upper deck travelers will be collected and stored as hazardous materials.

For these activities, noise produced on the support barge from compressors, generators, and vacuum systems are addressed. For activities at the point of application on the bridge, noise from sandblasting, torch cutting, welding, and grinding are considered.

2.4. Sandblasting, Cleaning, and Painting

All steel elements will be rotary sanded or sandblasted to remove old paint and expose bare metal prior to painting. Compressed air and sand aggregates will be delivered to the work area through a series of conduits originating from the barges. Another series of return conduit will be used to vacuum all airborne dust and debris to air purification and containment systems located on the barges. All debris generated during the sandblasting process will be collected and stored as hazardous waste. For areas of the bridge that only require pressure washing prior to painting, water and power will be supplied through conduits originating from the barges. All slurries generated during the pressure washing process will be captured and returned to baker tanks located on the barge.

Both primer and paint will be applied to the bridge structure using a pneumatic paint sprayer. Compressed air, primer, and paint will be delivered to the work area through a series of conduits originating from the barges. All painting will occur inside the containment system to avoid paint from entering the water.

For these activities, noise produced by compressors and pumps located on the support barge are addressed in the noise prediction. For activities at the point of application on the bridge, noise from sandblasting is expected to be the dominating noise source.

2.5. Repair of Concrete Piers, Road Deck, and Expansion Joints on the Lower Deck

All delaminated concrete on the column of Pier 19 will be removed. Damaged concrete will be removed using pneumatic air chisels. The work also includes corrosion remediation of the existing reinforcement where needed. All corroded steel will be sandblasted to remove all rust. Additional reinforcement will be placed in structural members to make up for section loss in high tension zones. Structural concrete will be placed to restore the concrete cover. Galvanic anodes (at 4-foot radius) will be installed inside the replaced concrete for corrosion protection. Epoxy injection and a reactive penetrating sealer will be applied to provide a hydrophobic coating. All concrete and structural repair work at Pier 19 will occur within the painting containment system. The noise issues considered for these actitivies pneumatic air chiseling and sandblasting at the point of application and air compressors, generators, and vacuum systems on the barge.

Localized spalled concrete between Piers 1 and 48 will be repaired. Damaged concrete will be removed using pneumatic air chisels. All exposed rebar will be sandblasted prior to placement of new structural concrete in the spalled area. All spalled concrete repair will occur within the painting containment system. The noise issues considered for these actitivies are pneumatic air chiseling and sandblasting at the point of application and air compressors, generators, concrete pumps and vacuum systems on the barge.

A portion of road deck (14 feet wide by 25 feet long) between Piers 8 and 9 on the lower deck will be replaced. The removal of the damaged deck will require saw cutting of the concrete and its removal in sections. Saw cutting and removal of the rock deck will occur during nighttime lane closure on the lower deck. Concrete forms will be placed on the underside of the road deck prior to the pouring of the new deck. Replacement of the road deck will occur when the containment system is installed on the underside of the bridge between Piers 8 and 9. All concrete debris and slurries associated with the road deck replacement will be captured and not allowed to enter the bay waters. The noise issues considered for these actitivies are concrete saw cutting at the point of application and air compressors, generators, concrete pumps and vacuum systems on the barge.

Eighteen bridge joints will be replaced (Piers 20 to 31, 37 to 43, and 45) on the lower deck of the Richmond-San Rafael Bridge. Removal of the old bridge joints requires saw cutting of the last 1.5 feet of deck concrete and removing it in sections. The plate steel joint covers, debris gutters, and supporting frames will be removed. Structural concrete will be poured once concrete forms and steel reinforcements are embedded in the existing bridge deck. Galvanic anodes will be installed inside the replaced concrete for corrosion protection. Rubber joint seals will be added to prevent roadway debris from falling through the road deck. Saw cutting and replacement of the bridge joints will occur during nighttime lane closure on the lower deck. All concrete debris and slurries associated with the bridge joint replacements will be captured and not allowed to enter the bay waters. The noise issues considered for these actitivies are concrete saw cutting, grinding, and torch cutting at the point of application and air compressors, generators, concrete pumps and vacuum systems on the barge.

Chapter 3. Fundamentals of Noise

Noise may be defined as unwanted sound. Noise is usually objectionable because it is disturbing or annoying. The objectionable nature of sound could be caused by its *pitch* or its *loudness*. *Pitch* is the height or depth of a tone or sound, depending on the relative rapidity (*frequency*) of the vibrations by which it is produced. Higher pitched signals sound louder to humans than sounds with a lower pitch. *Loudness* is intensity of sound waves combined with the reception characteristics of the ear. Intensity may be compared with the height of an ocean wave in that it is a measure of the amplitude of the sound wave.

3.1. Noise Measurements and Descriptors

In addition to the concepts of pitch and loudness, there are several noise measurement scales which are used to describe noise in a particular location. A *decibel (dB)* is a unit of measurement which indicates the relative amplitude of a sound. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Sound levels in decibels are calculated on a logarithmic basis. An increase of 10 decibels represents a ten-fold increase in acoustic energy, while 20 decibels is 100 times more intense, 30 decibels is 1,000 times more intense, etc. There is a relationship between the subjective noisiness or loudness of a sound and its intensity. Each 10 decibel increase in sound level is perceived as approximately a doubling of loudness over a fairly wide range of intensities. Technical terms are defined in Table 3-1.

There are several methods of characterizing sound. The most common in California is the *A-weighted sound level (dBA).* This scale gives greater weight to the frequencies of sound to which the human ear is most sensitive. Representative outdoor and indoor noise levels in units of dBA are shown in Table 3-2. Because sound levels can vary markedly over a short period of time, a method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, environmental sounds are described in terms of an average level that has the same acoustical energy as the summation of all the time-varying events. This *energy-equivalent sound/noise descriptor* is called L_{eq}. The most common averaging period is hourly, but L_{eq} can describe any series of noise events of arbitrary duration.

The scientific instrument used to measure noise is the sound level meter. Sound level meters can accurately measure environmental noise levels to within about plus or minus 1 dBA. Various computer models are used to predict environmental noise levels from sources, such as roadways and airports. The accuracy of the predicted models depends upon the distance the receptor is from the noise source. Close to the noise source, the models are accurate to within about plus or minus 1 to 2 dBA.

Since the sensitivity to noise increases during the evening and at night -- because excessive noise interferes with the ability to sleep -- 24-hour descriptors have been developed that incorporate artificial noise penalties added to quiet-time noise events. The *Community Noise Equivalent Level* (*CNEL*) is a measure of the cumulative noise exposure in a community, with a 5 dB penalty added to evening (7:00 pm - 10:00 pm) and a 10 dB addition to nocturnal (10:00 pm - 7:00 am) noise levels. The *Day/Night Average Sound Level* (*DNL* or L_{dn}) is essentially the same as CNEL, with the exception that the evening time period is dropped and all occurrences during this three-hour period are grouped into the daytime period.

3.2. Effects of Noise

Sleep and Speech Interference

The thresholds for speech interference indoors are about 45 dBA if the noise is steady and above 55 dBA if the noise is fluctuating. Outdoors the thresholds are about 15 dBA higher. Steady noises of sufficient intensity (above 35 dBA) and fluctuating noise levels above about 45 dBA have been shown to affect sleep. Interior residential standards for single- and multi-family dwellings are set by the State of California at 45 dBA DNL. Typically, the highest steady traffic noise level during the daytime is about equal to the DNL and nighttime levels are 10 dBA lower. The standard is designed for sleep and speech protection and most jurisdictions apply the same criterion for all residential uses. Typical structural attenuation is 12 to 17 dBA with open windows. With closed windows in good condition, the noise attenuation factor is around 20 dBA for an older structure and 25 dBA for a newer dwelling. Sleep and speech interference is, therefore, possible when exterior noise levels are about 57 to 62 dBA DNL with open windows and 65 to 70 dBA DNL if the windows are closed. Levels of 55 to 60 dBA are common along collector streets and secondary arterials, while 65 to 70 dBA is a typical value for a primary/major arterial. Levels of 75 to 80 dBA are normal noise levels at the first row of development outside a freeway right-of-way. In order to achieve an acceptable interior noise environment, bedrooms facing secondary roadways need to be able to have their windows closed; those facing major roadways and freeways typically need special glass windows.

Annoyance

Attitude surveys are used for measuring the annoyance felt in a community for noises intruding into homes or affecting outdoor activity areas. In these surveys, it was determined that the causes for annoyance include interference with speech, radio and television, house vibrations, and interference with sleep and rest. The DNL as a measure of noise has been found to provide a valid correlation of noise level and the percentage of people annoyed. People have been asked to judge the annoyance caused by aircraft noise and ground transportation noise. There continues to be disagreement about the relative annoyance of these different sources. When measuring the percentage of the population highly annoyed, the threshold for ground vehicle noise is about 50 dBA DNL. At a DNL of about 60 dBA, approximately 12 percent of the population is highly annoyed. When the DNL increases to 70 dBA, the percentage of the population highly annoyed increases to about 25 to 30 percent of the population. There is, therefore, an increase of about 2 percent per dBA between a DNL of 60 to 70 dBA. Between a DNL of 70 to 80 dBA, each decibel increases by about 3 percent the percentage of the population highly annoyed. People appear to respond more adversely to aircraft noise. When the DNL is 60 dBA, approximately 30 to 35 percent of the population is believed to be highly annoyed. Each decibel increase to 70 dBA adds about 3 percentage points to the number of people highly annoyed. Above 70 dBA, each decibel increase results in about a 4 percent increase in the percentage of the population highly annoyed.

Table 3-1. Definition of Acoustical Terms Used in This Report

Term	Definition
Decibel, dB	A unit describing, the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for air is 20 micro Pascals.
Sound Pressure Level	Sound pressure is the sound force per unit area, usually expressed in micro Pascals (or 20 micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressures exerted by the sound to a reference sound pressure (e. g., 20 micro Pascals). Sound pressure level is the quantity that is directly measured by a sound level meter.
Frequency, Hz	The number of complete pressure fluctuations per second above and below atmospheric pressure. Normal human hearing is between 20 Hz and 20,000 Hz. Infrasonic sound are below 20 Hz and Ultrasonic sounds are above 20,000 Hz.
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.
Equivalent Noise Level, L_{eq}	The average A-weighted noise level during the measurement period.
L_{max}, L_{min}	The maximum and minimum A-weighted noise level during the measurement period.
L_{01}, L_{10}, L_{50}, L_{90}	The A-weighted noise levels that are exceeded 1%, 10%, 50%, and 90% of the time during the measurement period.
Day/Night Noise Level, L_{dn} or DNL	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 pm and 7:00 am.
Community Noise Equivalent Level, CNEL	The average A-weighted noise level during a 24-hour day, obtained after addition of 5 decibels in the evening from 7:00 pm to 10:00 pm and after addition of 10 decibels to sound levels measured in the night between 10:00 pm and 7:00 am.
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
Intrusive	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content as well as the prevailing ambient noise level.

Source: Handbook of Acoustical Measurements and Noise Control, Harris, 1998.

Table 3-2. Typical Noise Levels in the Environment

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	110 dBA	Rock band
Jet fly-over at 1,000 feet		
	100 dBA	
Gas lawn mower at 3 feet		
	90 dBA	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	80 dBA	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawn mower, 100 feet	70 dBA	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	60 dBA	
		Large business office
Quiet urban daytime	50 dBA	Dishwasher in next room
Quiet urban nighttime	40 dBA	Theater, large conference room
Quiet suburban nighttime		
	30 dBA	Library
Quiet rural nighttime		Bedroom at night, concert hall (background)
	20 dBA	
		Broadcast/recording studio
	10 dBA	
	0 dBA	

Source: Technical Noise Supplement (TeNS), California Department of Transportation, November 2009.

3.2. Construction Noise

Noise impacts resulting from construction depend upon the noise generated by various pieces of construction equipment, the timing and duration of noise-generating activities, and the distance between construction noise sources and noise-sensitive areas. Construction noise impacts primarily result when construction activities occur during noise-sensitive times of the day (e.g., early morning, evening, or nighttime hours), the construction occurs in areas immediately adjoining noise-sensitive land uses, or when construction lasts over extended periods of time.

Construction noise levels vary on a day-to-day basis, depending on the type and amount of equipment operating on-site and the specific task that is being completed on a particular day. Construction activities generate considerable amounts of noise, especially during earth-moving activities when heavy equipment is used. Table 3-3 summarizes the maximum instantaneous noise levels generated by typical construction equipment that generate either non-impact or impacts sounds at a distance of 50 feet from the noise source.

Construction-generated noise levels drop off at a rate of about 6 dBA per doubling of the distance between the source and receptor. Shielding by buildings or terrain can provide an additional 5 to 10 dBA noise reduction at distant receptors.

Table 3-3. Construction Equipment, 50-foot Noise Emission Limits

Equipment Category	L_{max} Level (dBA)[1,2]	Nature of the Sound: Impact or Non-Impact
Arc Welder	73	Non-Impact
Auger Drill Rig	85	Non-Impact
Backhoe	80	Non-Impact
Bar Bender	80	Non-Impact
Boring Jack Power Unit	80	Non-Impact
Chain Saw	85	Non-Impact
Compressor[3]	70	Non-Impact
Compressor (other)	80	Non-Impact
Concrete Mixer	85	Non-Impact
Concrete Pump	82	Non-Impact
Concrete Saw	90	Non-Impact
Concrete Vibrator	80	Non-Impact
Crane	85	Non-Impact
Dozer	85	Non-Impact
Excavator	85	Non-Impact
Front End Loader	80	Non-Impact
Generator	82	Non-Impact
Generator (25 KVA or less)	70	Non-Impact
Gradall	85	Non-Impact
Grader	85	Non-Impact
Grinder Saw	85	Non-Impact
Horizontal Boring Hydro Jack	80	Non-Impact
Hydra Break Ram	90	Impact
Impact Pile Driver	105	Impact
Insitu Soil Sampling Rig	84	Non-Impact
Jackhammer	85	Impact

Equipment Category	L_{max} Level (dBA)[1,2]	Nature of the Sound: Impact or Non-Impact
Mounted Impact Hammer (hoe ram)	90	Impact
Paver	85	Non-Impact
Pneumatic Tools	85	Non-Impact
Pumps	77	Non-Impact
Rock Drill	85	Non-Impact
Scraper	85	Non-Impact
Slurry Trenching Machine	82	Non-Impact
Soil Mix Drill Rig	80	Non-Impact
Street Sweeper	80	Non-Impact
Tractor	84	Non-Impact
Truck (dump, delivery)	84	Non-Impact
Vacuum Excavator Truck (vac-truck)	85	Non-Impact
Vibratory Compactor	80	Non-Impact
Vibratory Pile Driver	95	Non-Impact
All other equipment with engines larger than 5 HP	85	Non-Impact

Notes: [1] Measured at 50 feet from the construction equipment, with a "slow" (1 sec.) time constant.

[2] Noise limits apply to total noise emitted from equipment and associated components operating at full power while engaged in its intended operation.

[3]Portable Air Compressor rated at 75 cfm or greater and that operates at greater than 50 psi.

Chapter 4. Regulatory Criteria

The proposed project would be subject to noise-related regulations, plans, and policies established within documents prepared by the State of California and National Marine Fisheries Services (NOAA).

Noise associated with construction is controlled by Caltrans Standard Specification Section 14-8.02, "Noise Control," which states the following:

- Do not exceed 86 dBA L_{max} at 50 feet from the job site activities from 9:00 p.m. to 6:00 a.m.[1]
- Equip an internal combustion engine with the manufacturer recommended muffler. Do not operate an internal combustion engine on the job site without the appropriate muffler.

Typically, work taking place within the Caltrans right-of-way is not subject to local noise ordinances; however, Caltrans will work with the contractor to meet local requirements where feasible.

NOAA Fisheries has airborne thresholds for various marine mammals. Table 4-1 summarizes the NOAA Fisheries criteria.

Table 4-1. NOAA Fisheries Current In-Air Acoustic Thresholds

Criterion	Criterion Definition	Threshold
Level A	PTS (injury) conservatively based on TTS	None established.
Level B	Behavioral disruption for harbor seals	90 dB
Level C	Behavioral disruption for non-harbor seal pinnipeds	100 dB

All decibels referenced to 20 micro Pascals (re: 20µPa). Note, all thresholds are based off root-mean-square (RMS) levels.

If construction noise levels are expected to exceed the contract specification criteria or construction noise levels are expected to exceed the ambient (baseline) noise levels, and there are sensitive receptors near the project site, construction noise control measures should be considered. These measures are discussed in Chapter 7.

Chapter 5. Study Methods and Procedures

5.1. Methods for Identifying Land Uses and Selecting Noise Measurement and Modeling Receiver Locations

A field investigation was conducted on April 10th and April 11th, 2019, to quantify the ambient noise environment of the water surrounding the Castro Rocks. The dominating noise source in the project vicinity would be vehicular traffic noise along I-580 located on the Richmond-San Rafael Bridge. The nearest rock of the Castro Rocks would be approximately 70 feet from the edge of the bridge deck. Long- and short-term measurement locations were selected to represent the ambient noise environment at various distances from the bridge deck. Measurement locations are shown in Chapter 6. Photos of the measurement sites are provided in Appendix A.

5.2. Field Measurement Procedures

A field noise study was made with Larson Davis Model 831 Integrating Sound Level Meters (SLMs) set at “slow” response. The sound level meters were equipped with G.R.A.S. Type 40AQ ½-inch random incidence microphones fitted with windscreens. The sound level meters were calibrated prior to the noise measurements using a Larson Davis Model CAL200 or Model CA250 acoustical calibrator. The response of the system was checked after each measurement session and was always found to be within 0.2 dBA. No calibration adjustments were made to the measured sound levels. At the completion of each monitoring event, the measured interval noise level data were obtained from the SLM using the Larson Davis SLM utility software program.

5.2.1. Long -Term Measurements

A long-term (LT) reference noise measurement was made at the base of a pier, approximately 1,700 feet west of the Castro Rocks. This location was selected due to the large pier base, which was sufficient for installing the LT measurement equipment. The measurement (LT-1) captured the diurnal trend in noise levels and established hourly average ambient noise level data during daytime and nighttime hours for a 24-hour period. Additionally, average maximum instantaneous noise level data during daytime and nighttime hours were also determined from the LT measurements. This measurement was taken at a height of about 10 to 12 feet above the base of the pier. This location was selected to isolate typical ambient noise in the Bay along the Richmond Bridge alignment. After the data was downloaded from the sound level meter, the data was reviewed to identify any time periods possibly contaminated by local noise sources. Data points were excluded from the dataset where significant contamination was noted. Table 5-1 summarizes the details of the LT-1 measurement location. The trend in ambient noise levels measured at LT-1 are summarized graphically in Appendix B.

5.2.2. Short-Term Measurements

Four short-term (ST) noise measurements were made south of the Richmond Bridge in the vicinity of the Castro Rocks. Each of the ST measurements were made concurrent to the data collected at the LT measurement sites. This method facilitates a direct comparison between both the ST and LT noise measurements. For highway projects, this method would allow for the identification of the loudest-hour noise levels in the project vicinity where LT measurements were not made, such as at the rocks. The same relationship between the ST and LT measurements that is addressed in the Caltrans Technical Noise Supplement (TeNS) can be used here to correlate the 10-minute ST measurements to hourly average noise measurements. Based on the 10-minute measurement made at LT-1 at the same time as the ST measurement, the difference between the 10-minute measurement and the hourly average measurement calculated for the LT receptor can be applied to the ST receptor to estimate the hourly average noise level at the ST measurement. Further, since the ambient noise levels during both daytime and nighttime hours would be the same traffic sources for the ST receptors and LT-1, the average difference between hourly average daytime and hourly average nighttime noise levels would be equivalent. Therefore, the difference calculated from the daytime and nighttime hourly average ambient noise levels at the LT positions can be used to calculate the hourly average nighttime noise levels at each of the nearby ST receptors.

At each of the ST receptor locations used to represent existing residential land uses, a 10-minute measurement was made. At each of these locations, noise levels were measured from a boat in the water. Table 5-1 summarizes all ST monitoring locations, activities that were observed during each measurement, and distances to edge of the bridge.

Table 5-1. Summary of Monitoring Locations

Noise Measurement Location	Date, Time	Location Description	Pertinent Activities
LT-1	4/10/2019, 10:50- 4/11/2019, 11:30	Base of the nearby pier; ~95 feet from the edge of the bridge deck	Dominated by expressway traffic; traffic noise ~60-75 dBA
ST-1	4/11/2019, 10:16-10:26	Drifted from ~340 to 675 feet from the edge of the bridge deck	Dominated by expressway traffic; traffic noise ~60-70 dBA; light traffic on bottom deck and heavy traffic on top deck, moving slowly
ST-2	4/11/2019, 10:35-10:45	~195 feet from the edge of the bridge deck	Dominated by expressway traffic; traffic noise ~68-72 dBA; heavy truck noise ~70-74 dBA
ST-3	4/11/2019, 10:49-10:59	~485 feet from the edge of the bridge deck	Dominated by expressway traffic; traffic noise ~64-66 dBA
ST-4	4/11/2019, 11:05-11:15	~445 feet from the edge of the bridge deck	Dominated by expressway traffic; Boat passed by, generating noise levels ~69-70 dBA

5.3. Construction Noise Level Prediction Methods

Construction noise would primarily result from the operation of point of application construction equipment and stationary equipment from the barge. Federal Highway Administration's (FHWA's) Roadway Construction Noise Model (RCNM) was used to calculate the maximum and hourly average noise levels anticipated for the worst-case scenario. This construction noise model includes representative sound levels for the most common types of construction equipment and the approximate usage factors of such equipment that were developed based on an extensive database of information gathered during the construction of the Central Artery/Tunnel Project in Boston, Massachusetts (CA/T Project or "Big Dig"). The usage factors represent the percentage of time that the equipment would be operating at full power.

Six major elements are included in the proposed project. These include: (1) scaffolding and containment system, (2) barges – equipment, operations, and materials storage, (3) repair, removal, and replacement of steel bridge components, (4) sandblasting, cleaning, and painting, (5) repair of concrete piers, road deck, and expansion joints on the lower deck, and (6) maintenance of seismic bridge components. It is assumed that the worst-case scenario would be sandblasting, cleaning, and painting, which would require a generator, an air compressor, and a vacuum/purification system operating simultaneously from the barge in addition to the equipment for this task. During the task of repairing the concrete piers, road deck, and expansion joints, equipment such as concrete saws and pneumatic air-chisels would be used, in addition to the equipment on the barge. While the repair, removal, and replacement of steel bridge components task would also be noisy, this task would have similar noise levels to the previously mentioned noisy tasks.

For each these noisy phases, the equipment modeled in RCNM are summarized in Table 5-2, along with the hourly average noise levels and maximum instantaneous noise levels that would be generated by using one piece of all equipment simultaneously, as measured at a distance of 50 feet. Note, for each of the noisy phases modeled here, the equipment from the barge was also assumed to be operating, as indicated in Table 5-2. The hourly average noise level is calculated by an energy summation of the hourly average noise levels for each piece of equipment, while the maximum instantaneous noise levels represents the loudest single piece of equipment for each phase. Therefore, the more equipment operating at once, the combined hourly average noise level may be greater than the maximum instantaneous noise level.

The nearby biological species at the Castro Rocks would be exposed to the highest construction noise levels when activities from each of these tasks would occur at the closest pier. The nearest construction to the rocks would occur at the pier approximately 70 feet from the rocks.

For purposes of modeling the worst-case scenario, the hourly average noise levels and the maximum instantaneous noise levels summarized in Table 5-2 would represent a combined point source of noise when each piece of equipment is operating simultaneously. The exact location of each piece of equipment would likely change over the course of a work day; however, the work would be localized to the same general location, which would be approximately the same distance from the rocks (within a few feet of each other). For modelling the worst-case scenario, each piece of the equipment used in the specific activity was considered to be 50 feet from a reference location. These levels were then combined into single L_{eq} and L_{max} values. These levels from this reference location were then “propagated” out to further distances as a combined source of noise using 6 dB/doubling of distance.

It should be noted that RCNM and other known noise levels for construction equipment are A-weighted values, as shown in Table 5-2. However, the NOAA Fisheries criteria summarized in Table 4-1 are not A-weighted values. Therefore, the comparison between the modeled results and the criteria is difficult. For purposes of this analysis, the criteria in Table 4-1 is treated as A-weighted.

Table 5-2. Summary of Construction Noise Modeling Source Levels at a Distance of 50 feet

Task	Equipment	Quantity[a]	L_{max}[b]	L_{eq}[c]
Barge Equipment	Generator	3	85 dBA	88 dBA
	Crane	1		
	Manlift	1		
	Air Compressor	2		
	Vacuum System	2		
	Water Pump	1		
	Welding & Cutting Tool	1		
	Concrete Pump	1		
	Paint Sprayer	1		
Sandblasting, Cleaning, and Painting	Air Compressor	1	96 dBA	89-91 dBA[e]
	Pump	1		
	Sandblasting	1		
	Generator[d]	3		
	Crane[d]	1		
	Manlift[d]	1		
	Air Compressor[d]	2		
	Vacuum System[d]	2		
Repair of Concrete Piers, Road Deck, and Expansion Joints on the Lower Deck	Concrete Saw	1	96 dBA	90-92 dBA[e]
	Pneumatic Air-Chisel	1		
	Sandblasting	1		
	Torch Cutting	1		
	Generator[d]	3		
	Crane[d]	1		
	Manlift[d]	1		
	Air Compressor[d]	2		
	Vacuum System[d]	2		

[a] Quantities for equipment on the barge were determined by an photograph of the barge (Figure 5-1), while all other quantities were assumed to be 1 for each task.
[b] L_{max} noise levels are the maximum instantaneous noise level for the loudest individual piece of equipment.
[c] L_{eq} noise levels are the hourly average noise level for all combined equipment.
[d] Equipment listed are stationary noise sources located on the barge and could operate simultaneously with the equipment for the specific task.
[e] Range of noise levels represents the specific equipment for the task alone and in combination with the barge equipment that could operate simultaneously.

Figure 5-1. Photograph of Barge to be Used in Construction

Chapter 6. Existing Noise Environment

6.1. Existing Land Uses

The Richmond-San Rafael Bridge connects the City of Richmond and the City of San Rafael via the east-west traveling Interstate 580 (I-580). The project would occur at each pier across the entire span of the bridge. Currently, the Castro Rocks, which are located approximately 70 to 475 feet from the edge of the bridge deck, are at times populated with marine mammals, such as harbor seals. These biological species would be exposed to the existing ambient noise environment dominated by I-580 vehicular traffic. Local boat traffic, as well as occasional aircraft flyovers also contributes to the noise environment.

6.2. Noise Measurement Results

A noise monitoring survey was performed just south of the I-580 in the vicinity of the Castro Rocks, starting on Wednesday, April 10, 2019 and concluding on Thursday, April 11, 2019. The monitoring survey included one long-term measurement and four short-term measurements in the Bay. The locations of each measurement are shown in Figure 6-1.

Figure 6-1. Noise Measurement Locations Near the Castro Rocks, Just South of the Richmond-San Rafael Bridge

Source: Google Earth 2018.

6.2.1. Long-Term Monitoring

LT-1 ran throughout the duration of the noise survey. The purpose of the long-term measurement was to determine the hourly average ambient noise levels during the daytime and nighttime hours and to determine the average maximum instantaneous noise levels during the daytime and nighttime hours. Appendix B shows the daily trend for LT-1.

LT-1 was positioned at the base of a pier along the Richmond Bridge. LT-1 was approximately 95 feet south of the edge of the bridge deck. Table 6-1 summarizes the highest L_{max} and highest hourly L_{eq} values measured at each LT location for the daytime and nighttime hours. The “typical” L_{max} and L_{eq} values are also shown. These are defined such that only 1% of the data points exceed this level.

Table 6-1. Summary of Long-Term Maximum Noise Levels

Receptor ID	Daytime Hours, 6am–9pm		Nighttime Hours, 9pm–6am	
	L_{max}	L_{eq}	L_{max}	L_{eq}
LT-1	Max = 104 dBA Typical = 77 dBA	Max = 75 dBA Typical = 73 dBA	Max = 79 dBA Typical = 75 dBA	Max = 73 dBA Typical = 67 dBA

6.2.2. Short-Term Monitoring

Short-term measurements were made from a boat in the vicinity of the Castro Rocks. Four different measurements were made, in 10-minute durations on Thursday, April 11, 2019, between 10:16 a.m. and 11:15 a.m. Table 6-2 summarizes the A-weighted data and the unweighted L_{eq} data measured from these short-term locations, which are shown in Figure 6-1. Both the A-weighted and the unweighted spectra measured at each location are shown in Appendix C. Each of the short-term measurements ranged from 195 to 675 feet from the edge of the Richmond Bridge deck; however, there really is not much of a fall-off as distance increases.

To estimate the L_{eq} for the daytime and nighttime at each ST location, the difference between the L_{eq} at the ST location and closet LT location for the same 10-minute interval was calculated. This difference was applied to the hourly L_{eq} values measured at the LT location to estimate what the corresponding hourly L_{eq} would have been at the ST locations. The same process was applied to estimate the nighttime L_{max} at the ST location. Table 6-2 shows the estimated L_{eq} and L_{max} values determined in this manner during daytime and nighttime hours.

Table 6-2. Summary of Short-Term Noise Measurements Representing Castro Rocks (dBA)

Receptor ID	10-minute L_{eq}		Daytime Hours, 6am–9pm		Nighttime Hours, 9pm–6am	
	Un-weighted	A-weighted	L_{max}	Estimated L_{eq}[a]	Estimated L_{max}[a]	Estimated L_{eq}[a]
ST-1	88 dB	67 dBA	83 dBA	68 dBA	81 dBA	62 dBA
ST-2	91 dB	70 dBA	74 dBA	70 dBA	72 dBA	64 dBA
ST-3	96 dB	66 dBA	71 dBA	67 dBA	69 dBA	61 dBA

Receptor ID	10-minute L_{eq}		Daytime Hours, 6am–9pm		Nighttime Hours, 9pm–6am	
	Un-weighted	A-weighted	L_{max}	Estimated L_{eq}[a]	Estimated L_{max}[a]	Estimated L_{eq}[a]
ST-4	94 dB	68 dBA	80 dBA	68 dBA	78 dBA	62 dBA

[a] Hourly average noise levels and maximum instantaneous noise levels estimated using the nearby LT measurement data.

Chapter 7. Construction Noise

Noise impacts resulting from construction depend upon the noise generated by various pieces of construction equipment, the timing and duration of noise-generating activities, and the distance between construction noise sources and noise-sensitive areas. Construction noise impacts for marine mammals primarily result when construction activities exceed established thresholds or ambient conditions at known habitable locations for the species.

When there are sensitive receptors near the project site, construction noise control measures should be considered if construction noise is expected to exceed the contract specification criteria or if construction noise levels are expected to exceed the ambient (baseline) noise levels. The modeled results for L_{max} and L_{eq}, which are summarized in Table 5-2 for the worst-case scenario construction noise levels expected for the proposed project during the noisiest tasks, would range from 85 to 96 dBA L_{max} and from 88 to 92 dBA L_{eq} at a distance of 50 feet from the active construction area. Therefore, the Caltrans nighttime threshold of 86 dBA L_{max} may be exceeded when sandblasting occurs at night. Using a 6 dB per doubling of the distance fall-off rate, which is typical for stationary construction equipment, distances to each of the Level B marine mammal thresholds were also calculated from the modeled data of Table 5-2. It should be noted that thresholds are expected to be weighted for marine mammals; however, RCNM only provides L_{max} and hourly average L_{eq} levels that are A-weighted, which is a weighting defined for human mammal. The weighting curves for the marine mammal and human mammals emphasize about the same frequency range in a spectrum; therefore, the A-weighted levels are assumed to be comparable to the marine mammal weighted criteria in Table 5-2. The 90 dB behavioral disruption criterion for harbor seals would be exceeded within 65 feet of the active construction work, and the 100 dB behavioral disruption criterion for non-harbor seals would be exceeded within 20 feet.

The modeled noise levels summarized in Table 5-2 during the noisiest tasks would occur at Piers 1 through 48; however, Castro Rocks would be exposed to the highest construction noise levels when activities occur at the nearest piers, which would be approximately 70 to 450 feet from the nearest piers. Construction work at the nearest pier would represent the worst-case scenario by generating the highest noise levels at Castro Rocks. The following analysis considers the noisiest construction tasks at this pier and shows the propagation curves with respect to distance. All results are tabulated and plotted for each task.

7.1. Estimated Construction Noise Levels

Figure 7-1 shows the locations of the three closest piers to Castro Rocks, as well as the distance used for propagating the construction noise levels. For the stationary equipment operating on the barge, as well as the noisiest two construction tasks discussed above, this section considers the noise levels generated when the loudest construction tasks would occur at the nearest pier to the Castro Rocks, as identified in Figure 7-1.

Figure 7-1. Loudest Construction Noise Source Locations for Castro Rocks Receptors

As shown in Figure 7-1, the biological species that inhabit the Castro Rocks would have direct line-of-sight to the piers and therefore the barge and other construction activities. No shielding from intervening structures would be expected. The following results represent activities occurring at this southernmost location.

Figures 7-2 and 7-3 show the hourly average and maximum instantaneous noise levels, respectively, compared with the daytime and nighttime ambient noise levels when barges – equipment, operations, and materials storage; sandblasting, cleaning, and painting; and repair of concrete piers, road deck, and expansion joints on the lower deck are completed at the nearest pier to the Castro Rocks. Table 7-1 summarizes the estimated construction noise levels for each task, as well as the ambient measurements and RMS thresholds.

As shown in Figure 7-2 and stated above, the A-weighted construction noise levels would not exceed the RMS thresholds for marine mammals at the Castro Rocks, which is 70 feet or more from the active construction work. However, ambient L_{eq} noise levels would be exceeded during daytime hours at distances within about 525 feet during each phase, while the repair phase would also exceed ambient noise levels within 595 feet. During nighttime hours, construction work would exceed ambient L_{eq} conditions within about 1,000 feet during each phase. The L_{max} levels generated during the barge phase would not exceed ambient L_{max} levels during daytime or nighttime hours; however, daytime and nighttime ambient L_{max} levels would be exceeded during the other two noisy phases within 595 feet.

Figure 7-2. Hourly Average L_{eq} Construction Noise Levels at the Castro Rocks When Construction Activities Occur at Each of the Nearest Pier (about 70 feet from the nearest rocks)

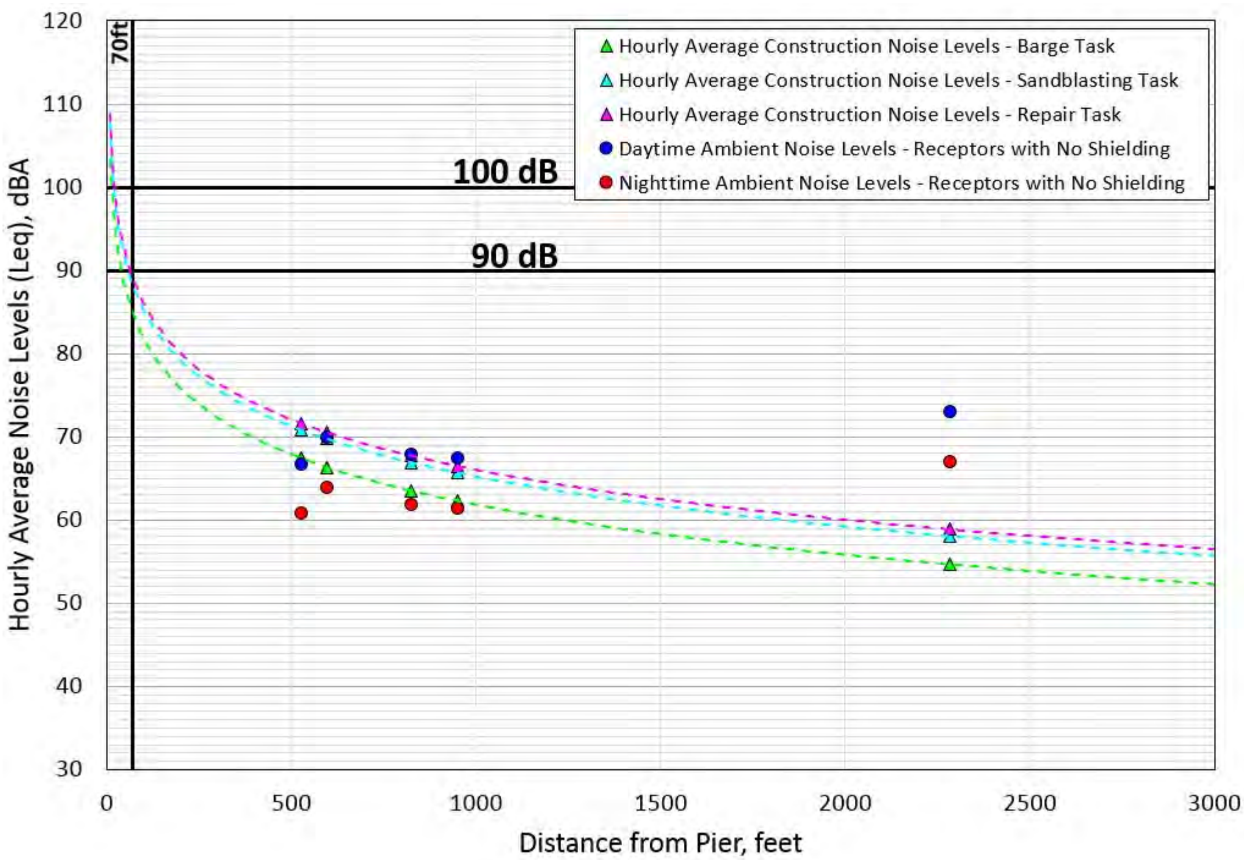


Figure 7-3. L_{max} Construction Noise Levels at the Castro Rocks When Construction Activities Occur at Each of the Nearest Pier (about 70 feet from the nearest rocks)

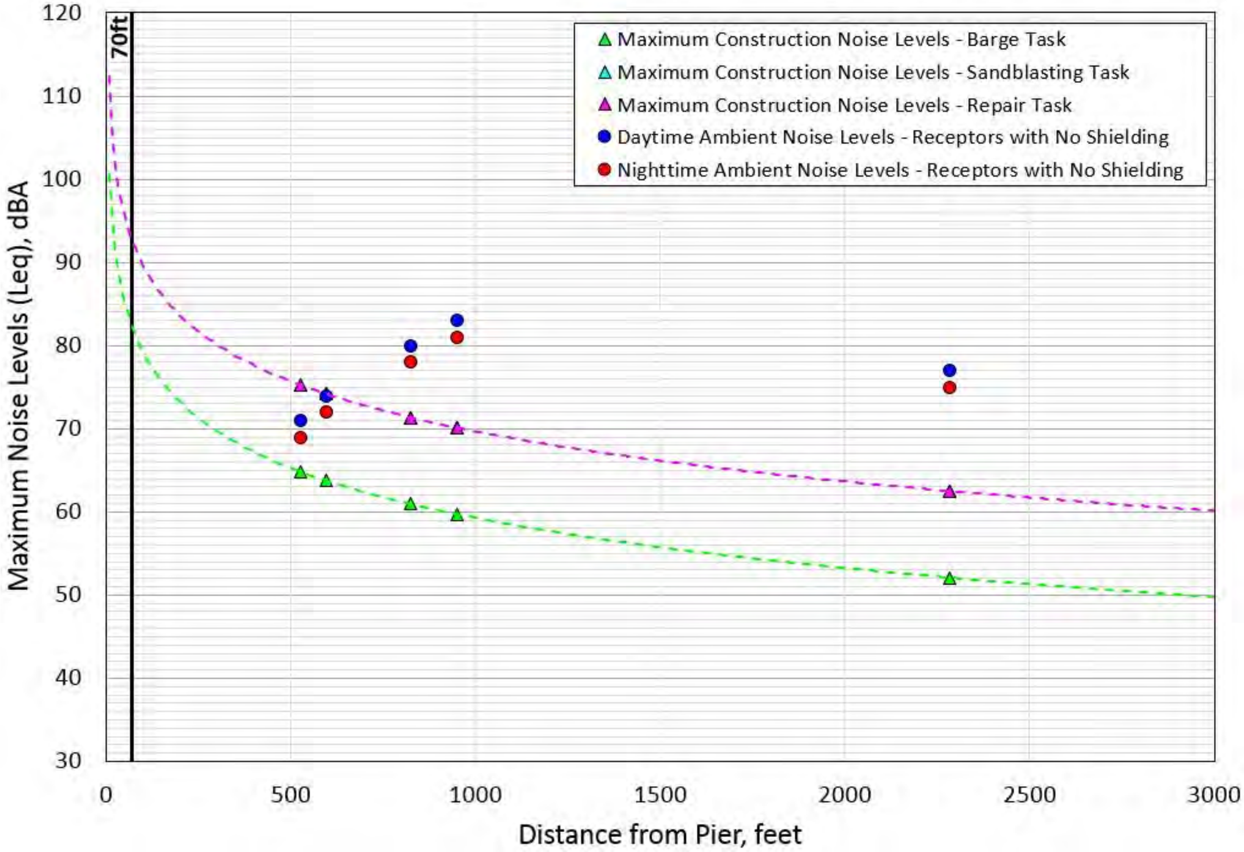


Table 7-1. Summary of Construction Noise Levels at the Castro Rocks When Construction Activities Occur at Each of the Nearest Piers

Pier where Construction Noise Occurs (Distance to Castro Rocks)	Modeled Construction Noise Levels During Barge (only) Task		Modeled Construction Noise Levels During Sandblasting Task		Modeled Construction Noise Levels During Repair Task		Daytime Ambient Noise Levels		Nighttime Ambient Noise Levels	
	L_{eq}	L_{max}	L_{eq}	L_{max}	L_{eq}	L_{max}	L_{eq}	L_{max}	L_{eq}	L_{max}
ST-1 (1,115 feet)	61 dBA	58 dBA	62 to 64 dBA[a]	69 dBA	63 to 65 dBA[b]	69 dBA	68 dBA	83 dBA	62 dBA	81 dBA
ST-2 (485 feet)	68 dBA	66 dBA	70 to 72 dBA[a]	76 dBA	70 to 72 dBA[b]	76 dBA	70 dBA	74 dBA	64 dBA	72 dBA
ST-3 (525 feet)	67 dBA	65 dBA	69 to 71 dBA[a]	75 dBA	70 to 72 dBA[b]	75 dBA	67 dBA	71 dBA	61 dBA	69 dBA
ST-4 (825 feet)	64 dBA	61 dBA	65 to 67 dBA[a]	71 dBA	66 to 68 dBA[b]	71 dBA	68 dBA	80 dBA	62 dBA	78 dBA
LT-1 (2,285 feet)	55 dBA	52 dBA	56 to 58 dBA[a]	63 dBA	57 to 59 dBA[b]	63 dBA	73 dBA	77 dBA	67 dBA	75 dBA

[a] Range represents Sandblasting equipment only and when combined with stationary barge equipment, which could operate simultaneously. Only the combined level is plotted in Figure 7-2.

[b] Range represents Repait equipment only and when combined with stationary barge equipment, which could operate simultaneously. Only the combined level is plotted in Figure 7-3.

7.2. Construction Noise Minimization Measures

To reduce the potential for adverse noise impacts resulting from project construction, the following construction best management measures should be considered during project construction:

- All construction equipment should conform to Section 14-8.02, Noise Control, of the latest Standard Specifications.
- Limit the quantity of equipment used during nighttime hours to reduce noise levels when ambient levels are low.
- The construction activities generating excessive noise should occur during the daytime hours from 6:00 a.m. and 9:00 p.m. when feasible.
- Equip all internal combustion engine driven equipment with manufacturer recommended intake and exhaust mufflers that are in good condition and appropriate for the equipment.
- Maintain all internal combustion engine properly to minimize noise generation or consider using electric powered equipment if feasible.

Appendix A Site Photos

LT-1: Installed at the base of a pier of the Richmond-San Rafael Bridge

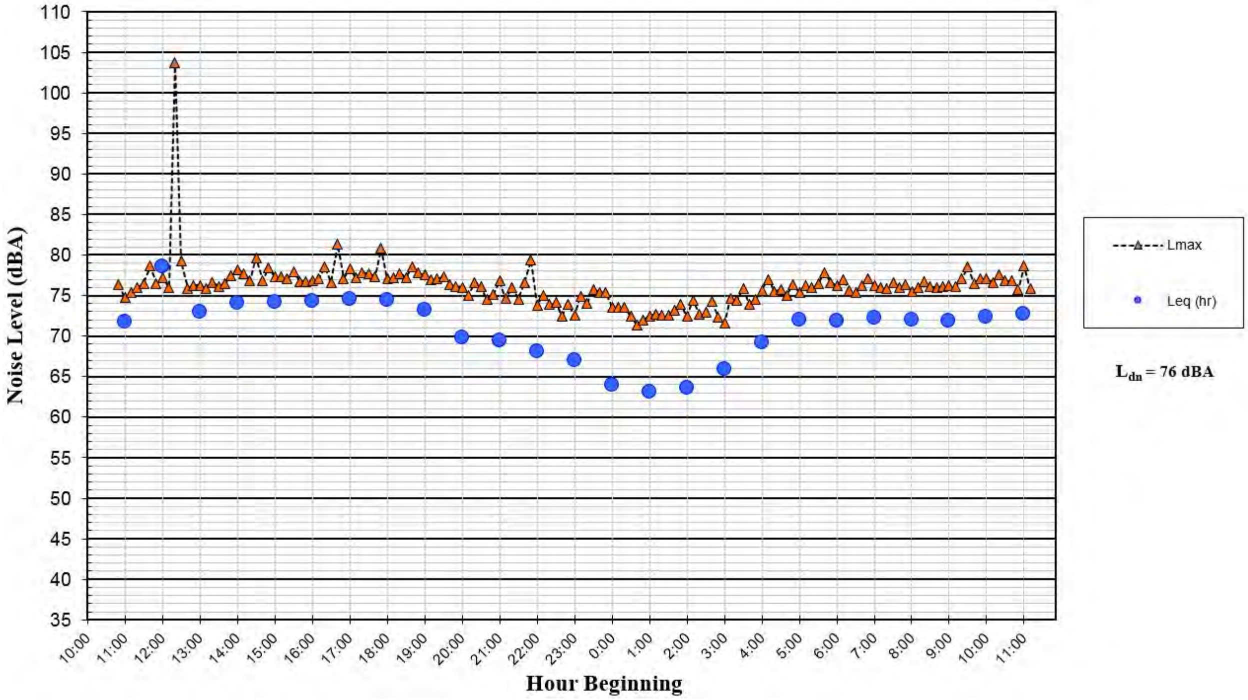
ST-1: Drifted ~340 to 675 feet from the edge of the Richmond-San Rafael Bridge

ST-2: ~195 feet from the edge of the Richmond-San Rafael Bridge

ST-3: ~485 feet from the edge of the Richmond-San Rafael Bridge

Appendix B Long-Term Noise Data

Figure B-1. Daily Trend in Noise Levels at LT-1, Wednesday, April 10, 2019 to Thursday, April 11, 2019



Appendix C Spectral Noise Data

Figure C-1. A-weighted Spectra for All ST Measurement Locations

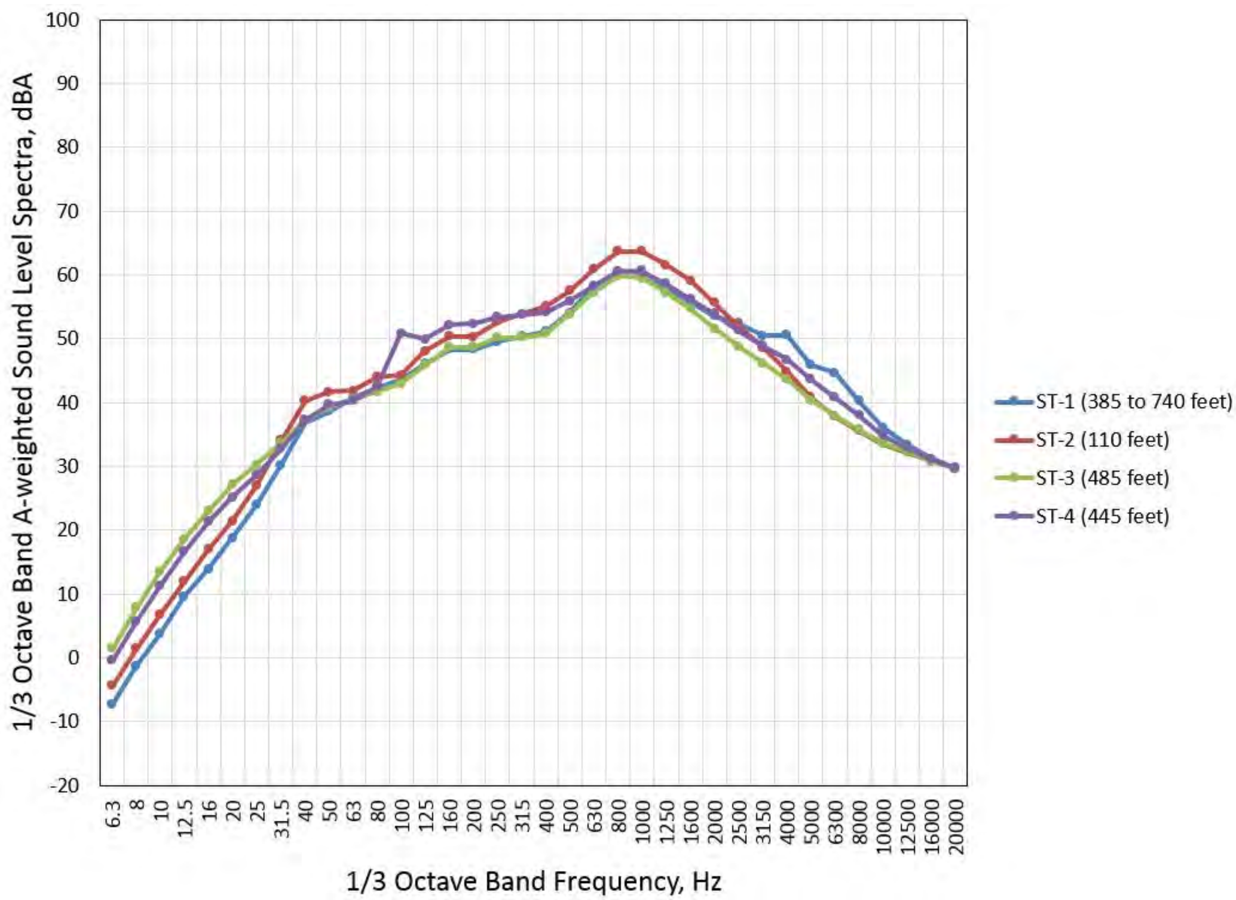
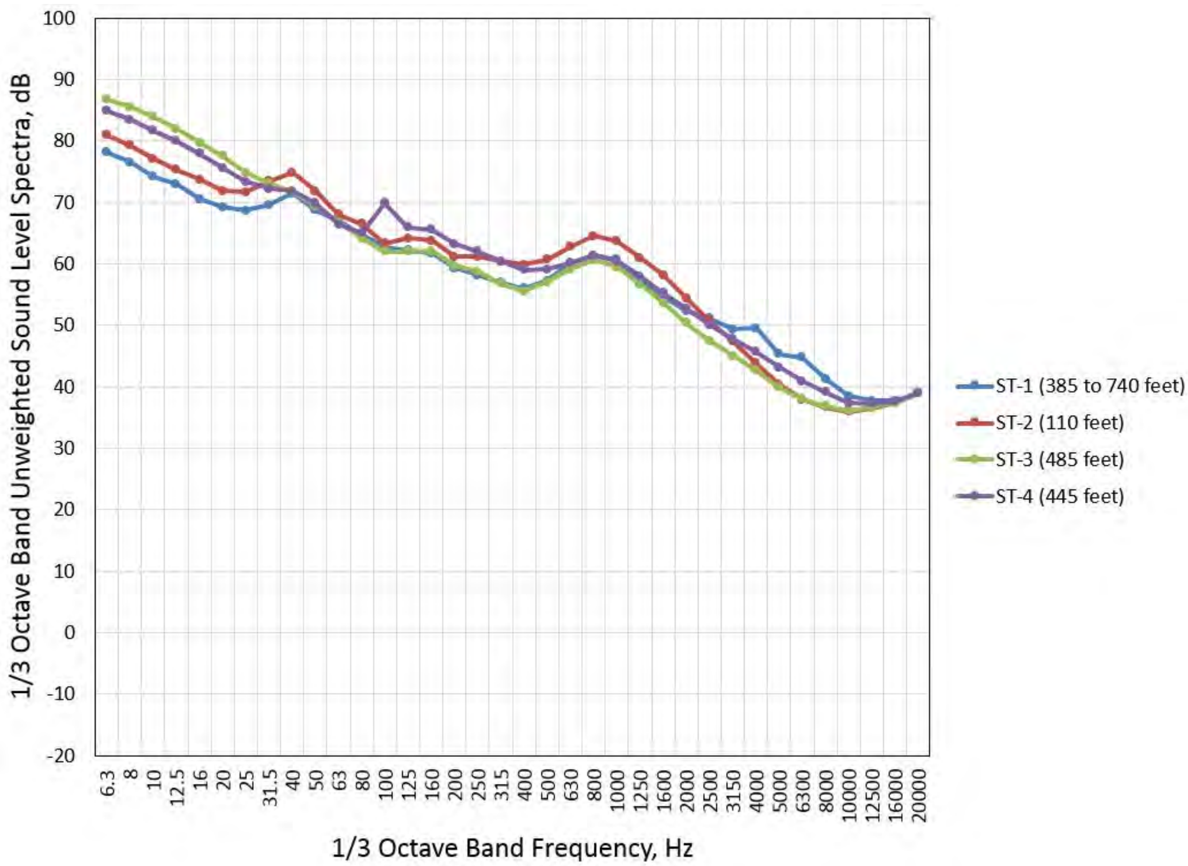


Figure C-2. Unweighted Spectra for All ST Measurement Locations

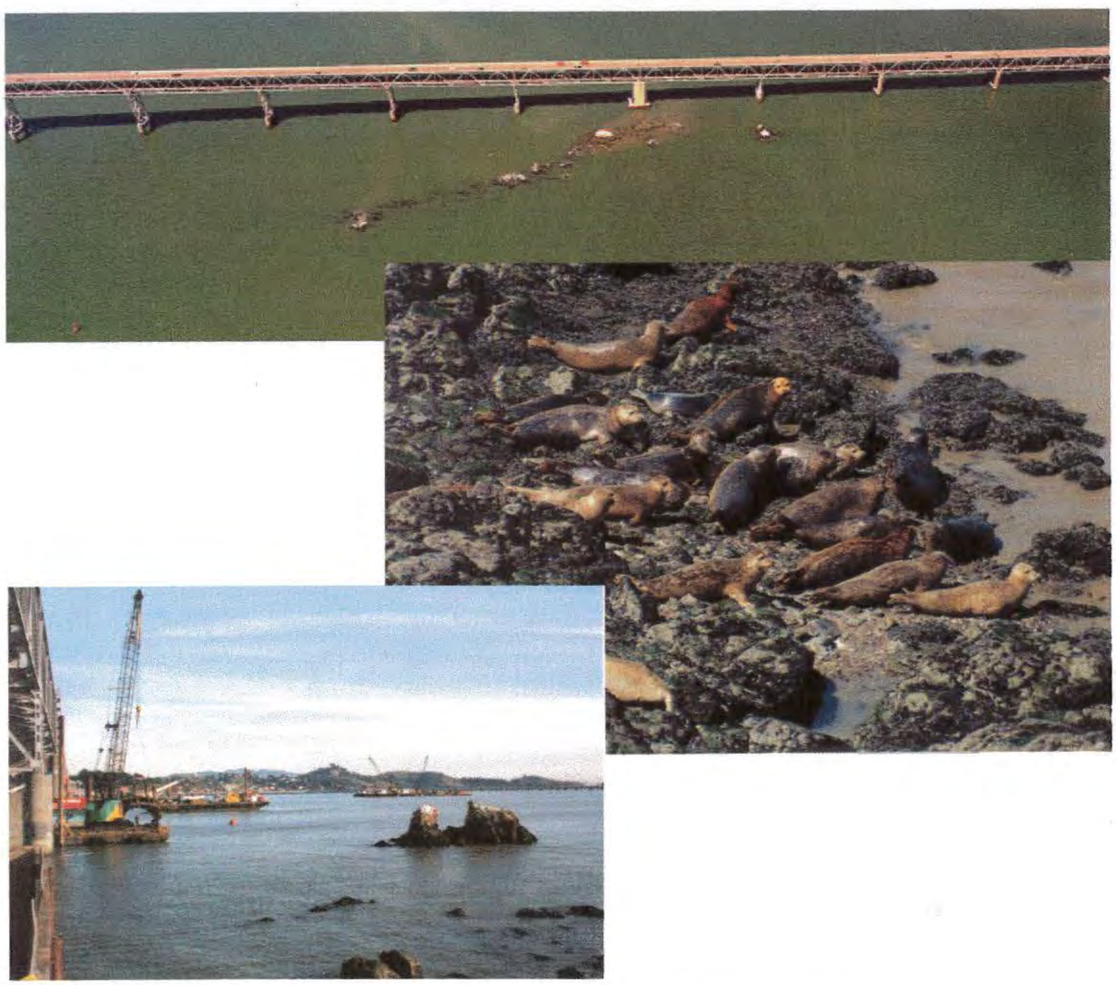


Appendix B

2001 Richmond Bridge Seismic Retrofit Monitoring Report

Monitoring the Potential Impact of the Seismic Retrofit Construction Activities at the Richmond San Rafael Bridge on Harbor Seals (*Phoca vitulina*):

<u>May 1, 1998 – December 31, 2004</u>



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Sarah Allen and Hal Markowitz
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<u>Final Interim Report</u>
IHA 11/19/2003-11/18/2004
November 2004

The following report is submitted in accordance with the requirements of an Incidental Harassment Authorization (IHA) issued by the National Marine Fisheries Service to the California Department of Transportation (Caltrans) for the time period November 19, 2003 through November 18, 2004. This IHA is under the authority of Section 101 (a) (5) (D) of the Marine Mammal Protection Act (16 U.S.C. 1361 *et seq.*), and refers to monitoring of harbor seals during the seismic retrofit construction of the Richmond-San Rafael Bridge, San Francisco Bay, CA. Caltrans provides all funding associated with this project. In addition, this work was approved by the San Francisco State University IACUC (International Animal Care and Use Committee) (# 99-534).

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INTRODUCTION

Harbor seals (*Phoca vitulina*) haul out on rocky shores, mud flats or beaches for a number of reasons. Haul-out sites serve as breeding and resting areas (Allen 1991, Sydeman and Allen 1999), and hauling out may aid in thermoregulation (Feltz and Fay 1966). By hauling out in groups, seals are able to maximize the likelihood of detecting disturbances (Terhune 1985). There is also some speculation that seals haul out to avoid marine predators (Watts 1993). In addition, haul-out sites provide researchers with the means to assess the status of a given population and the maximum number of harbor seals present on a haul-out site provides a means for estimating the local population size.

Haul-out site locations are characterized by ease of access to the water, proximity of food resources, and minimal disturbance levels. Timing of haul-out site use relative to tide varies by location; some sites are used exclusively at low tides, others at mid or high tides, while some show haul out patterns independent of the tide level. Other factors, such as time of day and season, may also affect haul out patterns.

There is considerable evidence that human activities adversely affect behavioral patterns of harbor seals. Primary sources of disturbance for harbor seals in San Francisco Bay (SFB), California include boats, kayaks, jet skis, aircraft, foot traffic and dogs in the vicinity of the haul-out site. Distance between the seals and the disturbance source appears to play a role in the seals' response. Disturbance sources within 100 meters of the seals typically provoke a stronger negative response (Allen *et al.* 1984).

Seals are known to react to visual and acoustic disturbance sources (Richardson *et al.* 1995). Watercraft, particularly those with erratic behavior, are a common source of disturbance to seals. However, boats with quiet engines that maintain a steady, slow speed and have little visible movement onboard elicit less reaction from harbor seals (Hoover 1988, Kopec and Harvey 1995).

In cases of long-term exposure to disturbance, seal responses vary by site and disturbance intensity. In some areas, seals habituate to disturbances near the haul-out site (Bonner 1982, Johnson *et al.* 1989), while in other areas increased levels of disturbance have contributed to the abandonment of a haul-out site (Bartholemew 1949, Paulbitski 1975, Allen 1991). If the frequency and magnitude of disturbances are sufficient, seals may permanently abandon a site. One SFB example of site abandonment due to human disturbance occurred at Strawberry Spit (Paulbitski 1975, Allen 1991). Increased development pressures and human foot traffic beginning in the late 1970's caused a precipitous drop in the number of seals that used this haul out. Seals eventually abandoned this site in the late 1980's (Allen 1991) and no reestablishment has occurred to date.

In addition, disturbances which cause seals to flush into the water often result in the separation of mother/pup pairs (Johnson 1977), and may be a significant source of mortality for seal pups in disturbed areas (Bartholomew 1949, Clifton 1971, Johnson 1977, Calambokidis *et al.* 1978).

When analyzing the impact of disturbance on harbor seals at a given site, a number of factors which may influence the degree of response must be taken into account, including season (i.e. the presence of pups or changes in prey availability), site topography, and the number of seals present on the haul-out site. For example, based on reports of increased vigilance, mothers with pups may be more sensitive to disturbance (Stein 1989). In addition, an increase in the number of seals on a haul-out site fosters an increased ability to detect disturbance, while decreasing the time spent scanning by each individual seal (da Silva and Terhune 1988). Protecting haul out locations is an important measure for protecting populations.

A large-scale seismic retrofit of the Richmond-San Rafael Bridge, located in northern SFB, began in January 2001. A primary SFB harbor seal haul-out site, Castro Rocks, is located next to the southeastern section of the bridge. Monitoring is being conducted at Castro Rocks in order to assess any effects construction may have on harbor seal behavior and productivity.

Disturbances due to construction at the Richmond-San Rafael Bridge may affect where the seals forage around the Richmond-San Rafael Bridge, as well as the number of harbor seals using other haul-out sites within the Bay. Regular monitoring is also being conducted at two alternate haul-out sites in the Bay, Yerba Buena Island (YBI) and Mowry Slough (MS); and during the pupping season at Corte Madera. Castro Rocks, YBI and MS are the three largest harbor seal haul-out sites in SFB.

Wildlife telemetry studies provide valuable information on daily and seasonal animal movements, habitat use, and survival, as well as information useful in population estimation (White and Garrott 1990). For harbor seals in San Francisco Bay, telemetry elucidates both 'normal' daily movements to foraging areas, and larger-scale movements associated with dispersal or displacement. Telemetry allows identification of where seals go when they leave the Castro Rocks haul-out site, other haul-out sites used, and locations of feeding areas. Over the course of the construction work, tracking known individuals may allow us to detect changes in movement, foraging and use areas, and/or haul out patterns not detectable in haul out survey numbers alone. Alternately, telemetry may allow us to demonstrate stability in seal spatial use patterns throughout the construction work.

The objectives of this study are as follows:

1) to study the effects of the seismic retrofit construction of the Richmond-San Rafael Bridge on harbor seal behavior in SFB;

2) to provide information concerning the productivity and distribution of harbor seals in SFB;

3) to recommend procedural changes which may reduce the incidental disturbance of the seals without significantly hindering construction;

4) to provide information on the SFB harbor seal population which will be useful in determining threshold values for disturbances, and may assist in the design of the current and future construction projects situated near harbor seal haul-out sites.

Study Area

SAN FRANCISCO BAY

Located in central California, SFB is surrounded by several major urban areas and is heavily used by commercial and recreational watercraft. Although harbor seals haul out consistently on approximately 12 sites along SFB, three haul-out sites serve as primary sites for harbor seals in SFB; Castro Rocks, Yerba Buena Island, and Mowry Slough.

CASTRO ROCKS

Castro Rocks (CR) is located in northern SFB, near the southeastern edge of the Richmond-San Rafael Bridge (RSRB). It is situated approximately 600 m northwest from the Chevron Long Pier where tankers offload oil. CR is composed of a chain of six rock clusters which stretch approximately 250 m in a southwesterly direction from the RSRB. The rocks span the distance of three bridge piers, beginning approximately 17 m from the bridge (pier 55) and ending approximately 75 m from the bridge (pier 52) (Figure 1).

CR is the largest harbor seal haul-out site in northern SFB and is the second largest pupping site in SFB (Allen *et al.* 1991, Kopec and Harvey 1995). Seals haul out year-round on CR during medium to low tides. Few alternative low tide sites are available within SFB.

The seals at CR have habituated to some sources of human disturbance such as large tanker traffic and the noise from automobile traffic on the bridge, but often flush into the water when small boats maneuver close by or when people work on the bridge (Kopec and Harvey 1995).

YERBA BUENA ISLAND

YBI is located at the midpoint of the San Francisco Oakland Bay Bridge in central SFB, and seals haul out on the southern shoreline of the island. The haul-out site at YBI is a cobble intertidal beach backed by a steep 15-25 m high cliff. Several rocky outcroppings extend into the Bay from the haul-out site and a shallow shelf extends a short distance from the shore before dropping off to depth (Kopec and Harvey 1995).

Harbor seals haul out on YBI year-round. Previous researchers have reported that YBI is the only major SFB haul-out site not used extensively for pupping (Kopec and Harvey 1995, Spencer 1997). However, data gathered by this study indicates YBI is used by a small number of seals as a pupping site. Maximum harbor seal numbers at YBI are found during the winter months (defined here as mid-November through mid-March), when Pacific herring (*Clupea pallasi*) spawn in SFB (Spencer 1997, Kopec and Harvey 1995).

MOWRY SLOUGH

Located on the Don Edwards San Francisco Bay National Wildlife Refuge near Newark, California, Mowry Slough (MS) is the largest of all seal haul-out sites in the SFB, and the largest pupping site in the SFB (Fancher 1987, Kopec and Harvey 1995). Both Newark and Mowry Slough are surrounded by tidal marsh vegetation and are bordered by smooth mudflats. During the pupping season (defined here as mid-March through May), MS is utilized by more seals during low tides, while at other times of the year seal haul out mainly during mid to high tides (Alcorn and Fancher 1980).

CORTE MADERA

The Corte Madera harbor seal haul-out site is located in Marin County between Corte Madera Creek and San Clemente Creek, which drains into SFB. This site is typically used by less than thirty seals during pupping and molting season (Allen *et al.* 1991). Seals haul out on the marsh bank at mid to high tides.

METHODS

We began monitoring harbor seal populations at three haul out locations in SFB in May 1998, during the last month of the pupping season in the Bay. Baseline data were collected until the start of the retrofit construction, which began in January 2001. Construction activities occurred in the area of the haul-out site during January/February 2001, August 2001 – February 14, 2002, July 16, 2002 – February 28, 2003, July 16, 2003 – March 14, 2004, and July 16, 2004 – February 28, 2005 (during the "work period"). This report summarizes data collected thus far (May 1998 – mid March 2005).

FIELD DATA COLLECTION

A combination of data collection techniques were used, including 1. direct observations of seals conducted by trained field biologists and 2. documentation of disturbances to harbor seals. Counts were taken at CR based on six subsites, A through F, which represent the six rock clusters at this site (Figure 1). Surveys at CR and YBI were centered around the low tide, when possible. In addition, beginning in January 2002, we began counting a small number of seals hauling out on two small sunken piers/platforms approximately 750 m north of the RSRB (north of CR). Counts at MS were also taken based on six subsites, five of which are located along or at the mouth of MS itself. The sixth subsite, Newark, is located at the mouth of neighboring Newark Slough. Surveys at MS were taken on a falling tide, with one survey taken at each of the six subsites. Difficulties in accessing MS limited the duration and number of surveys conducted at this site.

During surveys, biologists recorded information concerning 1) demographic data, 2) environmental data, and 3) behavioral data. Demographic data included 1) total count of all seals present on the haul-out site taken once every 30 minutes for CR and YBI, and once per research day at each of six subsites at MS, 2) number of red pelaged seals, and 3) number of each age and sex class, when possible. In addition, biologists recorded pupping season chronology and pup numbers during each pupping season: the number of pups seen with a female and those seen alone. The total number of pups present on a haul-out site was not included in the total count. Due to the distance between subsites at MS, and the time necessary to move between them, each subsite at MS was surveyed at a slightly different time and tide height. However, all six subsites were normally surveyed within approximately 2 hours. Each MS subsite was examined independently for trends in seasonal and tidal haul-out site use. Corte Madera was surveyed sporadically during each pupping season by using a trail located in the Corte Madera Ecological Reserve, and more recently by using a spotting scope at the entrance to San Quentin Prison. The prison is located directly across from the Corte Madera haul-out site (approximately 800 m) and therefore allows biologists to survey the site.

Field biologists collected environmental data including temperature, cloud cover, wind speed, low tide time/level and the presence or absence of rainfall.

Behavioral data included seal response to disturbances, both human and non-human in origin. The same variables that have been used in past studies to measure the response of seals to disturbance were utilized in this study. Responses included seals looking toward the direction of a disturbance source (head alert), seals moving suddenly towards the water (approach water), and seals entering the water (flushing) (Sullivan 1979, Allen 1991). In addition, if a potential disturbance source was noted, but no response was seen from the seals, a behavior of "no response" was recorded. If animals flushed into the water due to a disturbance, additional information was recorded concerning the number of animals that flushed into the water, elapsed time before seals rehauled and the location where seals rehauled. Other data collected were the source of disturbance, the distance from the source to the harbor seals, and the number of seals that remained on the haul-out site. In May 2000, we began triangulating, using a rangefinder and compass, to calculate the distance from a disturbance source to the seals. Prior to triangulating, distances were estimated using a rangefinder and a list of reference distances.

The frequency of research sessions at each location was determined in conjunction with the construction activities scheduled to take place in the vicinity of the haul-out site (Table 1). Harbor seal pupping and molting seasons were taken into account in determining when construction occurs in the vicinity of CR. A "work period", the time of year during which work on the area of the bridge closest to CR is permitted, was originally designated from August 1st through February 14th (later adjusted to 7/16/02-2/28/03, 7/16/03-3/14/04 and 7/16/04-2/28/05). From mid-March through July (during pupping and molting seasons), work is not allowed to take place on the sections of the bridge closest to the harbor seal haul-out site, between Pier 52 and Pier 57 (work "closure period"). A boat exclusion zone (BEZ) was set up in February 2001, which encompasses the CR haul-out site. The southern boundary of the exclusion zone is located 91 m from the southernmost tip of CR, the northern boundary is located 91 m from the northernmost tip of CR, the western boundary is located 91 m from the westernmost tip of CR, and the eastern boundary is located 31 m from the easternmost tip of CR. The eastern boundary was relocated closer to CR in 2003 compared to earlier years in order to allow work at Pier 57 to continue throughout the work closure period that year. Construction boats are not permitted within the BEZ during the work closure period.

Logistical issues exist in accessing all of the study sites. The ability of researchers to survey seals from the viewing platform on the lower deck of the Richmond-San Rafael Bridge at Pier 55, overlooking the haul-out site, is dependent upon weather conditions and construction activities. For safety reasons, researchers are not permitted on the viewing platform during periods of high wind or storms. In addition, during construction work periods, when construction took place within the immediate area of the haul-out site (during all work periods beginning in January 2001), we frequently gathered data from either the upper or lower deck of the Richmond-San Rafael Bridge, from the base of Pier 55, or from a temporary platform on the lower deck of the bridge, when the normal platform at Pier 55 was unavailable. The alternative viewing platforms at CR do not provide as favorable a view as the Pier 55 platform for ease of viewing disturbance sources and construction activities. In addition, following the completion of the 2003/2004 work period on March 14, 2004, access to the regular monitoring platform at Pier 55 was not possible. Therefore, during the 2004 closure period, we monitored Castro Rocks from a temporary wooden construction platform located adjacent to the Pier 55 platform. Visibility from this platform was not optimal because views to the north and east were partially obstructed, but visibility was better than the temporary platform on the lower deck which was used during the 2003/2004 work period.

The YBI observation site is located at a private residence on U.S. Coast Guard (USCG) land and requires an access permit from the USCG. In 1999, the USCG requested that data collection at YBI be conducted only during the weekdays, and only during daylight hours. Access to MS is limited by weather. Researchers are not permitted to drive on the levees that provide access to the observation points in wet weather, or on the days immediately following wet weather. Access to MS is also dependent on yearly access permits from the Cargill Salt Company and the Don Edwards San Francisco Bay National Wildlife Refuge.

AIR ACOUSTIC DATA LOGGER

A Larson-Davis Model 820 Air Acoustics Data Logger was set up on subsite A of Castro Rocks in November 2000. The logger records the decibel level (A-weighted) of sounds surrounding the haul-out site. The L_{eq}, the level of a constant sound over a specific time period that has the same sound energy as the actual (unsteady) sound over the same period, is recorded every 30-minutes, 24 hours a day.

RADIO- AND SATELLITE-LINKED TELEMETRY

On January 7-9, 2001, a pilot study was initiated to determine the feasibility of capturing seals at CR for radio- and satellite-linked telemetry work. Eight harbor seals were captured at CR for tagging (NMFS Research Permit # 373-1575 issued to Sarah Allen, Point Reyes Bird Observatory). Individuals experienced in tagging harbor seals were recruited to carry out the seal captures (Steve Jeffries, Washington Department of Fish & Game, and Jim Harvey, Moss Landing Marine Laboratory). In addition, a marine mammal veterinarian was present during the captures and tagging to monitor animal well-being (Frances Gulland, DVM, The Marine Mammal Center, Sausalito, CA). Due to the rocky substrate surrounding CR, a "tangle net" method was utilized for seal capture. Nets which were approximately 20-40 m in length and approximately 5 m in depth were set to the south of CR, and seals were passively caught as they became tangled in the net. Once captured, seals were weighed, sexed, and blood and tissue samples were taken. Three seals were fitted with headmount VHF (very high frequency) radiotags (Advanced Telemetry Systems, model #MM350), and one seal was fitted with a dorsally-mounted satellite-linked Platform Terminal Transmitter (PTT) (Telonics ST-18, model #A-800). Tags were attached to the seals' pelage using Loctite 422 cyanoacrylate adhesive (radiotags) or Devcon 5-minute epoxy (PTT's). The PTT's were first glued to a small (approximately 15 cm x 22 cm) square of mesh to increase the surface area for tag attachment; this mesh was then glued to the seal's pelage. A similar procedure was used for the radiotags, only instead of mesh a thin piece of rubber was used (~2 mm), and the tags were additionally cable-tied to the rubber before attachment on the seal. All seals captured were also flipper-tagged on both rear flippers to allow for later identification in the field.

From July 15 through 19, 2001, 13 additional seals were captured and tagged at CR. Of those seals captured, five were tagged with satellite PTT's and two with VHF radiotags. One radiotag (seal 320) was mounted on the top of the head, as with the January seals; one radiotag (seal 611) was mounted dorsally, just behind the head. All satellite tags were mounted dorsally, as in the January capture. Seals were captured using similar methodologies to the January capture, and data were collected on weight, sex, etc. as with the January seals. On one occasion, two seal handlers were able to quietly approach one seal from behind and net the animal on CR (subsite A). Further attempts to use this 'sneak approach' were unsuccessful, however.

On January 24, 2002, six more seals were captured and tagged at CR, using methods as described for earlier captures. Five radiotags were deployed at this time, and one PTT. As three PTT's from the July 2001 capture were lost prematurely due to attachment failure, the January 2002 PTT was fitted with a mesh 'harness', completely enclosing the tag and securely attached to the attachment mesh, before being epoxied to the seal's pelage.

On August 12-13, 2002, 15 additional seals were captured and tagged at CR; nine radiotags were deployed, and six satellite-linked PTT's. Methods of capture and tag attachment were as described above, including the use of a mesh 'harness' for the satellite PTT's.

On August 28-30, 2003, 5 seals were captured and tagged at CR. Two Wildlife Computers SPOT3 location-only satellite-linked tags were deployed; these tags are small enough to mount on the top of the head, using the mesh harness method, with

Loctite 422 used to glue the tag/harness to the hair on the head. Headmount tags maximize the amount of time that the tag remains above the water's surface, thereby maximizing the amount of locational data collected and transmitted. In addition, two satellite-linked time-depth recorders (Wildlife Computers SDR-T16) were deployed, mounted dorsally using the mesh harness method and Devcon 5-minute epoxy. A fifth seal, a small juvenile male, was flipper-tagged and released.

DATA ANALYSIS

Certain assumptions were made in summarizing the data collected to date. In discussing patterns of haul-out site use by the seals, an even distribution of age and sex classes was assumed. In addition, we assumed that data were collected consistently by all field researchers and any bias was minimized by pairing observers in the field.

Trends in harbor seal counts at each of the three haul out locations were examined at each 30 minute survey in relation to both the tide height and time of day. In examining counts by time of day, only those counts taken during surveys when the tide height was ≤2 ft (~0.61 m) were used, since this is the tide height when we tend to see the greatest number of seals on the haul-out sites (except at Mowry Slough, where use was examined independent of tide height). Data are shown for the entire study period, as well as by season. Seasons have been defined to coincide with those used by D. Kopec (pers. comm. 1999), in order to allow for comparisons between the present data and data collected by Kopec at each of the three research sites from April 1995 to November 1997. The four seasons were identified by Kopec as; pupping (March 15th – May 31st), molting (June 1st – August 15th), fall (August 16th – November 15th) and winter (November 16th – March 14th) (Kopec and Harvey 1995). In analyzing average seal haul out numbers, a daily average count was calculated (using only those surveys with a survey tide height of ≤ 2 ft) which was then used for yearly and seasonal analyses.

Trends in harbor seal counts during the "work period" were examined and compared to average and maximum harbor seal counts during past years. In addition, seasonal subsite use at CR was examined.

Analyses of harbor seal counts at each haul-out site were done using non-parametric tests such as Mann-Whitney U and Kruskal-Wallis (non-parametric ANOVA), which do not assume a normal distribution of the data. A Mann-Whitney U test ranks data samples from two groups to determine if the parameters they are estimating differ from each other, represented by the statistic U. A Kruskal-Wallis is similar to the Mann-Whitney U test, except that it is used to compare samples from three or more groups. For example, a Mann-Whitney U can be used to compare seal counts between two seasons, whereas a Kruskal-Wallis test can be used to compare seal counts across all four seasons. In presenting statistical results, degrees of freedom (df) and probability (p) are calculated. Degrees of freedom provides a representation of the sample size used for the statistic (with a larger number meaning that more samples were used). The p value represents the probability that the results are due to chance alone, with typically a probability of less than 5%, or 0.05 used as a standard for accepting a difference between two or more groups.

The proportion of red-pelaged harbor seals present at CR and YBI was calculated using the maximum harbor seal count per day with its corresponding number of red coats. The proportion of red coats at MS was calculated using the sum count of all six subsites that was collected at each research survey (only one per day). Since the greatest number of red coats are typically present just before molting season (June-mid August), the proportion of red coats present at each site was calculated using red pelage numbers recorded during pupping season (mid March – May). In order to avoid any bias due to a low number of seals hauled out, only surveys that had a minimum of 5 seals present on the haul-out site were used in calculating the proportion of red-pelaged seals present.

Comparisons were made between the data collected during this study (1998-2003) and data collected by D. Kopec during the previous three years (1995-1997). Seasonal maximum harbor seal counts taken at each of our research locations were compared to maximum counts collected at the same sites by Kopec (D. Kopec pers comm.).

Patterns in disturbances at the three study sites were also examined. Predominant disturbance sources at each location were identified and the frequency of disturbances per hour of field time was analyzed. T-tests were used to examine the frequency of disturbances per hour of field time at CR and YBI, as well as differences in the distance from seals to watercraft disturbance sources at each site. ANOVAs were used to examine disturbances per hour of field time between work periods at CR. In addition, trends in disturbances during preconstruction core sampling (conducted close to the haul-out site from January 24, 2001 – February 15, 2001) and the "work periods" were analyzed and compared to the same time periods in past years. The end date of the "work period" was extended by 2 weeks, from the initial end time of mid-February in 2002, to February 28th in 2003, to March 14th in 2004 and back again to February 28th in 2005.

Trends in air acoustic dBA levels throughout the course of the day during the work and closure periods were examined and differences in daytime and nighttime dBA levels were analyzed using a Mann-Whitney U test. Due to technical difficulties in maintaining the air acoustics equipment, there is very limited data available during the time period from December 2002 - March 2003 and no data available from October 2004-February 2005.

The August 2002 tagged seals were tracked by Richmond Bridge Harbor Seal Survey (RBHSS) biologists; all tracking of the August 2002 VHF seals was done from land. Location estimates for radio-tagged seals were obtained using a biangulation method during land-based tracking and with a handheld GPS (Global Positioning System) receiver (after visual confirmation) during boat-based tracking. Much of the location data, distance and depth calculations for the January 2001 through January 2002 radio-tagged seals was provided by Barry Nickel, a graduate student at San Francisco State University working on the project in conjunction with his Master's thesis (Nickel, 2003).

The August 2002 seals were tracked by RBHSS biologists; all tracking of the August 2002 VHF seals was done from land.

Location readings for seals tagged with satellite-linked PTT's were provided by Service Argos, Inc. Satellite location readings were filtered to remove unlikely or impossible readings (for example, points that fell inland or represented an unrealistic travel speed between two successive locations for an individual seal, and isolated points – i.e. not corroborated by other spatially similar points for the same seal – that fell outside the study area). For this report, the study area was defined by Point Reyes Headlands (37° 59' 44" N, 123° 01' 34" W) to the north, the Farallon Islands (37° 45' 54" N, 123° 07' 13" W) to the west, Pillar Point (37° 29' 39" N, 122° 29' 54" W) to the south, and Suisun Bay (38° 03' 45" N, 121° 58' 01" W) to the east. Location accuracy ratings, assigned to each point location by Argos, were also used in evaluating suspect locations, and all points with very low Argos accuracy ratings (LC=B) were removed. According to Argos, estimated accuracy of locations ranges from <150 m to >1000 m, and varies with the LC rating. Although we believe that mean accuracy of seal point locations is considerably improved through the filtering process, caution should be used when drawing conclusions about fine-scale habitat use patterns based on the satellite tag data summarized in this report. Marine mammals are considered to be good study animals for satellite-linked telemetry, as time at the surface to breathe allows sufficient time for a location reading to be established by the satellites.

Haul-out sites used by radio- and PTT-tagged seals were noted, and mean distance from CR (when CR was being used as the primary haul-out site) was calculated for each seal. Rather than calculating straight line distances from CR (which would sometimes involve unrealistic travel paths for the seals, such as across land), a cost-weighted distance grid of SFB and coastal waters was created in ArcGIS 8.3, with each grid cell assigned a least-cost across-water distance from CR. Distances from CR for all seal locations were taken from this grid. In order to evaluate the stability of seal habitat use patterns over the course of the construction work (2001-2004), we used a Kruskal-Wallis test to compare the mean distances from CR of seal locations by year. In order to ensure comparability of data across years, only data from PTT-tagged seals was used for these statistical comparisons of distance from CR. To minimize variation due to individual seal haul-out site preferences, only distances from CR when CR was being used as the primary haul-out site were examined. For this analysis, PTT-tagged seals were considered to be using CR as a primary haul-out site when their movements remained within 10 km (across water) from the CR haul-out site; once a seal moved >10 km from CR, it was determined that it was no longer using CR as the primary haul-out site. This 10 km boundary was based on the lack of alternate major haul-out sites within the 10 km area, repeated recorded presence of the seals at CR during the study period, and recorded tendencies of harbor seals in SFB to forage in close proximity to the haul-out site (Torok 1994, Kopec and Harvey 1995). Although smaller haul-out sites exist within 10 km of CR (e.g., Brooks Island, 8.7 km, and Corte Madera Marsh, 7.6 km), the closest major haul-out site considered as a potential alternate site by this study is YBI, located 14.7 km from CR. We used a Kruskal-Wallis test to compare the mean distances from CR of seal locations by year, 2001-2004 (males and females combined).

Male and female seals may differ in the distances of use areas from the haul-out site (Thompson *et al.* 1998), and season can influence the distances to which harbor seals travel from the haul-out site to forage (Hanan 1996, Thompson *et al.* 1998). Given these potential differences between individuals, we then used a conservative approach and only analyzed locational data for adult/subadult females, August-February (the dataset for which we had consistent data across years, 2001-2004). A Kruskal-Wallis test was used to compare distances of seals from CR, during August-February. The months of August through February fall in the Work Period, when work is allowed on the sections of the bridge closest to the CR site, and fall outside of the pupping season. Locations collected while the animal was hauled out at CR, and data from animals with low sample size ($n \leq 20$), were removed from the analysis.

In analyzing data for all tagged seals, depth information was obtained for each animal location using the ArcView GIS (Geographical Information System) v. 3.3 Spatial Analyst Extension. Note that seal "depth" does not refer to the depth to which the seal was known to dive, but the water depth over which the seal was located. Bathymetry data for SFB and for the coast was obtained from a California Department of Fish and Game 200 m bathymetry grid, compiled by the Teale Data Center from 75 mosaicked original Digital Elevation Models (DEM's). Spatial data analysis and mapping were done in ArcView GIS v. 3.3 and ArcGIS 8.3 (ESRI, Inc. 1999-2002).

In addition, "use areas" for the tagged seals were computed and mapped using the Animal Movement Extension for ArcView v. 2.0 (Hooge et al. 1999). "Use areas" are an estimate of the area used by the seals during the period of tag attachment, and are based on the fixed kernel home range utilization distribution (Worton1989), 50% and 95% probability contour polygons (the 50% probability contour polygon represents that portion of the 95% "use area" used most heavily by the seal, during the time of tag attachment). These "use areas" are intended to be a tool to help visualize areas used by the seal, but are limited by the number of location readings used to create the "use area" estimates – as the contours are designed to map probability of locating an animal in a given area based on the point locations available, low point location sample size will result in a probable overestimate of the areal extent of the "use area". For this report, "use areas" were calculated only for seals with >10 location readings; however, "use areas" based on <25 readings are identified and should be viewed with caution.

In August 2002, seven of the nine seals radiotagged were weaned pups; dates of dispersal away from the CR haul-out site, based on a stationary radioreceiver/datalogger (ATS scanning receiver model #R4000, ATS datalogger model #5041) located at CR, are noted. In addition, again using the radioreceiver/datalogger, haul out time and site attendance at CR were calculated for each radiotagged seal. Haul out time was defined as the number of hours per day the seals spent on the CR haul-out site, on days when they were recorded as present on the site. Site attendance was defined as number of hours per day the seals spent on the CR site as long as the tag was functional (i.e. including days on which the tagged seal was not recorded using CR).

Results and Discussion

A combined total of almost 15,000 hours of field data was collected at the three study sites from May 1998 – mid-March 2005. Coverage was greatest at CR, with ~3/4 of the field hours spent at this site (Table 2).

HARBOR SEAL SURVEYS

In examining years when a full year of data was available (January 1999 – December 2004), the daily average harbor seal count at both CR and YBI was greatest at tide heights ≤ 2 ft (Figure 2). However, harbor seals appear to utilize CR and YBI at tide heights up to 4 ft and 7 ft, respectively. The majority of the CR haul-out site is submerged at tide heights above 4 ft, and is therefore unavailable as a seal haul-out site. Since CR and YBI are predominantly used at tide heights ≤ 2 ft, only those surveys taken under these tidal limits were considered in examining use of each haul-out site by time of day and season.

Castro Rocks – Overall Counts

During the daytime, the daily average number of seals using CR was slightly greater at higher tides during the pupping season (Figure 3) compared to all other seasons. During the pupping season, females nursing pups tend to stay on the haul out for longer periods of time, including higher tides.

When examining the overall study period, the average number of harbor seals at CR was slightly lower during the mid morning hours and increased in the afternoon and nighttime, particularly between 1900 hr and 0300 hr. (Figure 4). A similar trend was seen during the fall season, with seal numbers lowest during midday (Figure 5). Seal numbers during the molting season remained fairly stable throughout the course of the day, while numbers during the winter season were lowest from early morning until noon.

During the pupping season, haul out numbers were greatest in the mid to late afternoon, with numbers dropping off during the nighttime. The higher daytime seal counts recorded during the pupping season may be related to the fact that the nighttime tide heights were significantly higher than daytime tide heights during this season ($U=51810.0$, $p< 0.0001$). This same trend was documented in past interim reports for this project (Green *et al.* 2004).

In comparing daily average seasonal haul out numbers, counts at CR (day) remained fairly consistent throughout the entire study period, with an increase over time (Figure 6), while nighttime counts were greater during the molting and fall seasons compared to the pupping and winter seasons. Similarly, maximum seasonal counts at Castro Rocks during the day were relatively stable throughout all seasons, with an increase over time, particularly in 2003 and 2004. Nighttime maximum counts were greatest during the fall season, but with a notable increase in numbers during the winters in 2001-2004 (Figure 7).

In comparing average haul out numbers during years where a full year of data was available (1999 - 2004), there was a significant difference in the daily average number of seals hauled out at CR during the daytime when the tide height was $\leq$2 ft (H=213.57, df=5, p<0.0001). The daily average counts increased considerably during 2002 (93.79 $\pm$ 3.60 SE), 2003 (118.70 $\pm$ 3.87 SE) and 2004 (138.31 $\pm$ 5.21 SE) compared to the first three full years of data collection (1999: 70.55 $\pm$ 2.36 SE; 2000: 78.60 $\pm$ 2.49 SE; 2001: 77.95 $\pm$ 2.77 SE). Similarly, there was a significant difference in the daily average number of seals hauled out on CR during the nighttime (H=97.20, df=5, p<0.0001). As with the daytime counts, nighttime counts during 2002-2004 (2002: 123.72 $\pm$ 5.84 SE, 2003: 161.70 $\pm$ 6.55 SE, 2004: 166.60 $\pm$ 10.1 SE) were considerably greater than daily average counts during 1999-2001 (1999: 86.18 $\pm$ 6.04 SE; 2000: 99.63 $\pm$ 5.44 SE; 2001: 94.33 $\pm$ 5.67 SE).

In addition, when comparing seasonal counts between years (1999 – 2004), the daily average number of seals hauled out at CR was significantly different at CR (day) by season, across years (pupping: H=133.78, df=5, p<0.0001; molting: H=97.09, df=6, p<0.0001; fall: H=30.50, df=6, p<0.0001; winter: H=94.08, df=6, p<0.0001). There was an increasing trend in counts during the pupping, molting and fall seasons. During the winter, the daily average number of seals during 2000/2001 was lower than all other years, and there was a large increase in seal numbers during the 2004/2005 winter season (Figure 6).

There was a significant difference in the daily average number of seals hauled out during the nighttime within each season across years (1998-2004); pupping: (H=17.30, df=5, p<0.01), molting: (H=37.51, df=6, p<0.0001), fall: (H=87.64, df=6, p<0.0001) and winter: (H=56.64, df=6, p<0.0001) (Figure 6). There was a general increasing trend in counts during all seasons, except for a slight decrease during the 2000 pupping season.

Castro Rocks – Subsite Use

Daytime

Use of the six subsites at CR during the daytime fluctuated depending on the season. There was a significant difference in the average number of seals hauled out on each subsite between the four seasons (across all years) when the tide height was $\leq$2 ft (Subsite A: H=281.78, df=3, p<0.0001; Subsite B: H=126.47, df=3, p<0.0001; Subsite C: H=105.49, df=3, p<0.0001; Subsite D: H=20.90, df=3, p<0.0001; Subsite E: H=13.08, df=3, p<0.005, and Subsite F: H=87.14, df=3, p<0.0001). Seals hauled out on subsite A, the largest subsite which is exposed for longer than other subsites and is located closest to the bridge compared to other subsites, in greater numbers during the pupping and molting seasons, whereas subsites B and C were used more during the fall and winter seasons. In addition, seals hauled out on subsites D and E, the smallest subsites, in greater numbers during the molting and winter seasons (though daily average count <5 seals) and subsite F (located farthest from the bridge) was used more during the molting and fall seasons (Figure 8).

When examining individual subsite use at Castro Rocks during the daytime within season, across years, there was a significant difference in the daily average number of seals hauling out on each subsite during at least two seasons (Figure 8). During the pupping season (1998-2004), there was a significant difference in the average number of seals hauling out on each subsite (A: H=84.10, df=6, $p<0.0001$, B: H=24.90, df=6, $p<0.0005$, C: H=14.47, df=6, $p<0.05$, D: H=31.27, df=6, $p<0.0001$, E: H=35.08, df=6, $p<0.0001$, and F: H=67.47, df=6, $p<0.0001$). Following a slight decrease on subsite A during the 1999 and 2000 pupping seasons, counts on subsite A increased steadily each year. Fewer seals hauled out on subsite B in 2001 and 2002. There was a general increasing trend in the average number of seals hauling out on subsites C, D, E, and F.

During the molting season, there was a significant difference in the average number of seals hauling out on subsites B-F (B: H=34.49, df=6, $p<0.0001$, C: H=51.73, df=6, $p<0.0001$, D: H=50.10, df=6, $p<0.0001$, E: H=53.55, df=6, $p<0.0001$, and F: H=82.21, df=6, $p<0.0001$). Counts on subsite B increased by 50% during the 2004 molting season. There was a slight increasing trend in seal numbers on subsite C over the years during the molting season. Though used by very few seals (average < 5), counts on subsites D and E were relatively stable during the molting season, with the exception of a decrease in the 1999 molting season. Beginning with the 2000 molting season, seal numbers greatly increased on subsite F, with a 100% increase from 1999 to 2000. However, there was a decrease in counts on subsite F during the 2004 molting season (Figure 8).

During the fall season, there was a significant difference in the daily average number of seals hauling out on all subsites *except* subsite B (A: H=35.76, df=6, $p<0.0001$; C: H=17.47, df=6, $p<0.01$; D: H=33.26, df=6, $p<0.0001$; E: H=33.63, df=6, $p<0.0001$; F: H=44.15, df=6, $p<0.0001$). The daily average number of seals hauling out on subsite A decreased in 2001 (the first fall season with construction in the area of the haul-out site) and 2002 compared to all other years, but increased ~100% in 2003 and 2004. Subsites C-F displayed a general increase in the average number of seals hauling out, with the most notable increase on subsite F. This shift of subsite use from areas close to the bridge (subsite A) to those farther away (subsite C-F) may be related to construction activities underway during the fall season within the area of the CR haul-out site in the absence of the BEZ. However, as mentioned above, daily average haul out numbers on subsite A in Fall 2003 increased in recent years. This increase may be related to the location of construction activities. Potentially, less work in the area of subsite A, may have fostered greater use of subsite A (Figure 8).

There was a significant difference in the daily average number of seals hauling out during the winter season across years on all subsites *except* subsite C, where numbers remained stable across all years (A: H=131.28, df=6, $p<0.0001$; B: H=34.44, df=6, $p<0.0001$; D: H=39.55, df=6, $p<0.0001$; E: H=61.26, df=6, $p<0.0001$, and F: H=102.84, df=6, $p<0.0001$). During the 2000/2001 winter season (preconstruction core sampling occurred in January/February 2001) and 2001/2002 winter season (the first full winter season of construction activity), there was a decline in the daily average number of seals hauling out on subsites A and B. This was followed by a 2x increase in average seal numbers on subsite A in 2002, and another 2x increase in average seal numbers on subsite A in 2004. Average counts on subsite B returned to numbers comparable to the 1998 and 1999 winter seasons, and have remained stable. The daily average number of seals hauling out on subsite F increased >2x in the 2001/2002 winter season compared to the winter 2000/2001 season, and numbers on F have continued to show a slight increasing trend since the 2001/2002 winter. The increase in the daily average number of seals hauling out on subsite F during the winter may be at least partially attributed to an increase in herring spawning in the areas around the Richmond-San Rafael Bridge during the winter (D. Watters, California Dept. of Fish & Game, pers. comm.). In addition, given that construction activities are ongoing during the winter season in the immediate area of the haul-out site, some seals may preferentially haul out on subsite F since it is located farther from the bridge, and therefore farther from construction activity (Figure 8).

Overall, during the daytime, there was a significant difference in the daily average number of seals hauling out on subsite A during all seasons except the molting season. On subsite A, there was a general increasing trend during pupping season, whereas both the fall and winter seasons displayed a decrease in the daily average number of seals hauling out during the first two years of construction activities (2001 and 2002 during the fall season, and the 2000/2001 and 2001/2002 winter seasons). Haul out numbers on subsite C were significantly different across years during the pupping, molting and fall seasons, with a general increase in haul out numbers over the last three years. There was a significant difference in the daily average number of seals hauling out on subsites D-F across years during all seasons. All three subsites (D-F) had an increasing trend in numbers across years, with the greatest increase noted on subsite F, which is located farthest from the bridge, and is the largest of these three subsites.

Nighttime

As was found during the daytime, the average number of seals hauled out on each subsite between seasons (across all years) during the nighttime was significantly different for all subsites (Subsite A: $H=91.55$, $df=3$, $p<0.0001$; Subsite B: $H=118.64$, $df=3$, $p<0.0001$; Subsite C: $H=140.45$, $df=3$, $p<0.0001$; Subsite D: $H=34.26$, $df=3$, $p<0.0001$; Subsite E: $H=20.98$, $df=3$, $p<0.0001$; and Subsite F: $H=126.36$, $df=3$, $p<0.0001$; Figure 8). Subsite A was used by more seals during molting and fall season. Similar to daytime numbers, the number of seals hauling on subsites B and C was greatest during the fall and winter seasons, as was subsite F. Both subsites D and E were used by very few seals throughout the year, though slightly more during the fall and winter seasons.

In addition, during the nighttime, there were significant differences in the nightly average number of seals hauling out on each subsite within each season, across years (Figure 8). Similar to CR daytime during pupping season, the number of seals hauling on subsites A ($H=17.25$, $df=5$, $p<0.005$) and F ($H=12.84$, $df=5$, $p<0.05$) was significantly different across years, with a general decrease in numbers on A from 1999 to 2000, followed by increasing numbers during the 2001-2004 pupping seasons. There was an increasing trend in the nightly average number of seals on subsite F. There was no significant difference in seal numbers across years during pupping season on subsites B – E.

Seal numbers during the molting season were significantly different across years on subsite B, E, and F ($H=17.41$, $df=6$, $p<0.01$; $H=18.18$, $df=6$, $p<0.01$; and $H=20.63$, $df=6$, $p<0.005$, respectively), with the greatest nightly average count on each subsite documented in 2003 (though subsite E was used by very few seals; nightly average count < 2).

During the fall, there was a significant difference in the nightly average number of seals hauling out on the 4 largest subsites (A,B,C, and F) across all years: A ($H=52.00$, $df=6$, $p<0.001$), B ($H=20.46$, $df=6$, $p<0.005$), C ($H=27.95$, $df=6$, $p<0.001$) and F ($H=68.04$, $df=6$, $p<0.001$). Fall 2001 was the first fall season when construction activities occurred within the area of the haul-out site. Similar to daily average counts at CR during the daytime during the fall, during the fall 2001, there was a decrease in use of subsite A (closest to the bridge) and an increase in seal use of subsites C and F during the nighttime at CR. In 2002-2004, the nightly average number of seals on subsite A increased 1.4-2.5x (Figure 8), exceeding all prior year nightly average counts, and numbers on subsites B, C and F remained at an elevated level compared to years prior to construction activity.

There was a significant difference in the nightly average number of seals hauling out on all six subsites across winter seasons (A: $H=66.41$, $df=6$, $p<0.0001$; B: $H=26.19$, $df=6$, $p<0.001$; C: $H=14.22$, $df=6$, $p<0.05$; D: $H=16.26$, $df=6$, $p<0.05$; E: $H=15.18$, $df=6$, $p<0.01$; F: $H=50.65$, $df=6$, $p<0.0001$). Average counts on subsite A increased 2-3x during the 2002/2003, 2003/2004 and 2004/2005 winter seasons, while all other subsites showed a less dramatic increasing trend across years (Figure 8).

Castro Rocks - Work Period (August 1st – February 14th; all years)

Although the time period for the 2002/2003, 2003/2004 and 2004/2005 work periods was altered (7/16/02-2/28/03, 7/16/03-3/14/04, and 7/16/04-2/28/05 respectively), the original work period (August 1st – February 14th) was used for all years in order to allow for comparable analyses of haul out numbers between years.

Overall, the daily average number of seals hauled out on CR during the daytime was significantly different across all years (1998-2004) during the work period, with a general increasing trend in daily average seal numbers beginning with the 2001/2002 work period ($H=104.36$, $df=6$, $p<0.001$) (Figure 9). The increase in seal numbers over the past three work periods may be related to an increase in herring spawning closer to the RSRB (D. Watters, California Dept. of Fish & Game, pers. comm.), thereby influencing an increase in seal numbers at CR due to its close proximity to the food source. Although there was a decrease in subsite use of subsites A and B during the first 1-2 years of construction activity in the fall/winter, by the 2003 work period seal numbers on subsites A and B returned to preconstruction levels (or greater) (Figure 8). The shift in subsite use in the beginning of construction work may be related to subsite locations in relation to the bridge (and therefore bridge work); subsite F is located farther from the bridge (~75 m) and may therefore be a preferred haul out location during the work period compared to subsite A which is located much closer to the bridge (~17 m).

As with the daytime average counts, there was a significant difference in the nightly average number of seals hauling out during the nighttime across all work periods ($H=118.90$, $df=6$, $p<0.001$), with a ~1.5x increase in seal numbers noted during the 2002/2003, 2003/2004 and 2004/2005 work periods compared to past years during the same time period (Figure 9). Again, as with the daytime counts, this increase in nighttime haul out numbers may be related to an increase in herring spawning in the area south of the Richmond-San Rafael Bridge during recent winter seasons (D. Watters, California Dept. of Fish & Game, pers.comm.). Biologists monitoring CR frequently observe harbor seals hauling out with herring eggs on their face during the winter season (this is also observed at YBI during the winter season).

North of Richmond-San Rafael Bridge

We began documenting seals hauling out on two small sunken barges/piers located north of CR/RSRB in January 2002. Since that time, we routinely documented use of this area by harbor seals (maximum count = 15 adults/immatures and 2 pups). Use of this area has also been seen in previous years (Allen, pers comm.).

Yerba Buena Island

Seals used YBI year-round and at higher tides during the winter season (Figure 3). Historically, herring spawn during the winter within the vicinity of the YBI haul-out site (Spratt 1981). Given that harbor seals are opportunistic feeders (Allen *et al.* 1984), it seems likely that the seals would take advantage of this nearby and seasonally abundant food source (Spencer 1997). During the winter, we routinely documented harbor seals with herring roe on their faces when hauled out at YBI.

Regardless of season at YBI, there was a large drop in the average harbor seal count beginning at 0900 until 1300, followed by an increase in numbers through the late afternoon (Figure 4). The same drop in numbers in the morning was seen in all four seasons at YBI (Figure 5). This decline in numbers of seals on the haul-out site may be due to high daytime disturbance levels at YBI (see disturbances section of results). The greatest average number of seals at YBI was seen in the winter season (Figure 6).

In comparing daily average counts between years (1999-2004), there was no difference in the number of seals hauled out at YBI when the tide height was ≤ 2 ft. In comparing average seasonal counts across all seasons, there was a significant difference in the average number of seals hauling out on YBI ($H=10.67$, $df=3$, $p<0.05$), with more seals hauling out during the molting and winter seasons. In addition, within season comparisons (across years) revealed a significant difference in the daily average number of seals hauling out on YBI during the fall ($H=36.01$, $df=6$, $p<0.001$), with fewer seals on the site during the fall season of 1998 compared to 1999 – 2002, and an increase in the daily average number of seals hauled out during the 2003 and 2004 fall season. There was no significant difference in haul out numbers during the pupping, molting or winter season.

From November 7, 2002 until December 8, 2002, a 250 m long dry dock blocked harbor seal access to the YBI haul-out site. The dry dock was pushed ashore on YBI after it broke loose from a pier along the SF shoreline during a storm. During this one month time period, we recorded no seals using the YBI haul-out site. However, several seals continued to haul out on rocks located immediately southeast of the site, along the YBI shoreline/cliffs, and seals were routinely seen in the waters within 200m of the shoreline. Within 2 weeks after the dry dock was removed from the site, seals resumed normal use of this site.

Short-term access to YBI during the nighttime allowed us to collect preliminary data concerning nighttime haul out patterns of seals at this site. Three nighttime surveys were conducted at YBI in July and August 2001. The maximum number of seals hauled out during each survey was 26 (survey tide height = 1 ft), 161 (survey tide height = -0.6), and 248 (survey tide height = 1.3). The average number of seals hauled out at YBI during the nighttime was 137.3 ± 24.1 SE.

<u>Mowry Slough – Overall Counts</u>

In comparing daily counts between years (1999-2004), there was a significant difference in the number of seals hauled out at MS ($H=16.96$, $df=5$, $p<0.01$), with a slight increase in 2001-2004. In comparing average seasonal counts across all seasons, there was a significant difference in the average number of seals hauling out on MS ($H=471.28$, $df=3$, $p<0.001$), with more seals hauling out during the pupping and molting seasons (Figure 6). In addition, within season comparisons (across years) revealed a significant difference in the daily average number of seals hauling out on MS during each season (pupping: $H=23.40$, $df=5$, $p<0.001$; molting: $H=25.12$, $df=6$, $p<0.001$; fall: $H=34.81$, $df=6$, $p<0.001$; and winter: $H=15.99$, $df=6$, $p<0.05$). Numbers during pupping and molting season increased in recent years, while numbers during the fall and winter season have remained fairly stable (Figure 6).

<u>Mowry Slough – Subsite Use</u>

The maximum number of harbor seals at each MS subsite occurred during pupping or molting seasons (Figure 10). Newark (NW), South Salt Pile (SSP), Mowry Slough North (MSN), Mowry Slough South (MSS) and Mud Flats (MF) were used regularly throughout the year. North Salt Pile (NSP) was used during the pupping and winter seasons. The maximum count at each MS subsite is probably a more reliable indicator of when seals utilize each subsite (i.e. during which season and under what tidal range each subsite is used) than the average count, due to variability in the tide height when surveys were taken.

The lower counts reported at MS during the fall and winter months may be related to the increased use of this site by coastal seals during the pupping/molting seasons, and their subsequent return to the coast by the fall season. In addition, the onset of duck hunting season (mid-October to mid-January) at the Don Edwards San Francisco Bay National Wildlife Refuge may also contribute to a decreased use of MS during the fall/winter seasons. Duck hunters have been seen on several occasions in the area of the SSP and in boats around NW. Furthermore, harbor seal numbers at the SSP in the fall 1998 may have been influenced by work conducted by a private landowner to build up a portion of the levees located nearby. Levee construction began in early October 1998 and extended through mid-November 1998. Numbers at Newark were likely impacted by watercraft launching from a site upstream from the seal haul-out site, thereby necessitating that watercraft pass by the seals on their way to the Bay.

Corte Madera
A maximum of 15 harbor seals (May 1999) and two pups (April 1999) were documented at Corte Madera since 1999 (Bohorquez, 2002). In 2000, a maximum of 8 harbor seals and 1 pup was seen at Corte Madera during the pupping season. In 2002, only 3 adult/immature seals were counted during the pupping season at Corte Madera (8 recorded just prior to pupping in early March). Eleven adults/immatures and 3 pups were recorded during the 2003 pupping season, and only 1 adult and 1 pup were recorded during the 2004 pupping season. Due to its location, the Corte Madera site cannot accommodate many seals and access may be limited due to expanding mudflat (Allen *et. al* 2002).

PUP COUNTS
Timing of Pupping
The first pups born each pupping season at CR were seen in mid to late March (3/17/99, 3/24/00, 3/24/01, 3/16/02, 3/17/03, 3/19/04). A pup was seen earlier in both 1999 and 2000, but did not survive. The pup seen in 1999 was born on 2/24/99, but the mother did not interact with the pup and we believe that the pup did not survive. In 2001, a pup was seen on 2/28/01 with its mother. However, by 3/2/01, the pup had died and the mother was carrying the dead pup with her.

The first pups at YBI were seen later in the season compared to CR in 1999 (4/17/99), 2001 (4/9/01), 2002 (4/4/02), 2003 (4/1/03) and 2004 (3/30/04), but at approximately the same time in 2000 (3/22/00). The first pups of the season at MS were seen at approximately the same time as CR for all years except 2004, when the first pup at MS was documented earlier than CR (3/31/99, 3/22/00 and 3/27/01, 3/25/02, 3/15/03, 3/3/04).

The maximum number of pups hauled out at CR during the day increased over the past 7 years; 9 in 1998 (this count was influenced by the fact that data was only collected during May and this was an El Niño year), 21 in 1999, 27 in 2000, 35 in 2001, 44 in 2002, 48 in 2003 and 56 in 2004 (these numbers only represent the maximum number of pups hauled out at once; Table 3). Total pup numbers were estimated at 35 in 1999, 40 in 2000, and 40 in 2001 by A. Bohorquez, a graduate student at San Francisco State University who studied mother/pup pairs at CR for her Master's thesis (Bohorquez, pers. comm.). This information was based on monitoring individual mother/pup pairs by coat patterns and may represent a more accurate estimate of the total number of pups born at CR each pupping season. Maximum pup numbers have also increased over the last three years at MS, from 78 in 1999, 90 in 2000, 102 in 2001 and 144 in both 2002 and 2003, but dropped slightly in 2004 (127). Although not considered a significant pupping site, up to 9 pups have been seen at once on the YBI haul-out site (during the 2001 pupping season). Although no births have been witnessed at YBI, mother/pup pairs have repeatedly been seen at this site. In addition, afterbirth and several dead pups have been documented at YBI.

A maximum of 3 pups was documented at Corte Madera during the 1999 and 2003 pupping seasons, and only one was recorded during the 2000, 2001 and 2004 pupping seasons.

Of the total number of pups documented at these 4 haul-out sites within SFB (CR, MS, YBI, Corte Madera) during the 2000 (n=126), 2001 (n=146), 2002 (n=193), 2003 (n=197) and 2004 (n=191) pupping seasons, the number of pups at CR represents 20-30% of the pups in SFB. The number of pups documented at MS represents 65-75% of the pups in SFB during these years. However, there are several other small haul-out sites used by harbor seals which may serve as pupping sites, such as Point Bonita and Brooks Island.

Pups are typically seen on all haul-out sites until early to mid-June. Lone pups are seen on the haul-out site in greater numbers as the pupping season progresses and females wean their pups.

Mother/Pup Site Use of Castro Rocks

In examining all pupping seasons (1999-2004), the majority of the pups were located on Subsite A at Castro Rocks during both the daytime and nighttime (Daytime: 86.5%, Nighttime: 98.8%; Table 3). 3-4.7% of pups hauled out on subsites B, C, and F during the daytime, but less than 1% of the pups used a subsite other than subsite A during the nighttime. There was little fluctuation across pupping seasons in the proportion of pups hauling out on each subsite (Table 3). Several factors likely contribute to subsite A as the preferred pupping subsite: 1) Subsite A is the largest subsite at CR, 2) Due to the tidal dependency of the CR site, subsite A remains exposed for the longest period of time, 3. In addition to rocky areas, subsite A also has a small sandy area which mother/pup pairs are commonly seen resting on, and 4. Subsite A is at the farthest eastern end of CR, and is therefore farthest from the shipping channel and potential watercraft disturbances.

PROPORTION OF RED PELAGED SEALS

Using the maximum daily count (with its corresponding red coat count), the average proportion of red-pelage seals present at CR across all pupping seasons was 30.7% (1999-2004). The average proportion of red-pelage seals at YBI during pupping season (18.9%) was less than at CR, while the proportion of red-pelaged seals at MS (33.1%) was similar to the proportion of red-pelaged animals at CR. However, since seals are often covered with mud at MS and the observer to seal distance is much greater at MS than at CR and YBI (~200-300 m compared to ~30-150 m), identifying red-pelaged seals is more difficult. Therefore, this may be a conservative calculation of the proportion of red-pelaged seals present at MS. As noted earlier, in order to avoid a bias due to a low number of seals present on each haul-out site, only surveys with at least 5 seals present on each haul-out site were used to analyze the proportion of red-pelaged seals at each site.

COMPARISONS TO PAST DATA

Comparisons between data collected by D. Kopec (1995-1997) and this study (1998-2004) were limited because a final report was never received from D. Kopec. Therefore, we had to rely on summary data provided by D. Kopec in making comparisons (Table 6). In addition, the limited number of surveys conducted by D. Kopec at all sites and the lack of information concerning yearly seasonal counts at YBI and Newark Slough made comparisons difficult.

Castro Rocks

The maximum seal count recorded at CR during the pupping season was 271 in 2004. 2003 (max count = 248) was the first year this project recorded a pupping season count which exceeded the maximum count recorded by Kopec (187) (Table 4). The smaller number of seals counted in the 1998 pupping season (121) may be largely due to the fact that 1998 was an El Niño year and conditions associated with El Niño are believed to have an adverse effect on seal populations. Similar declines were seen at Point Reyes, California (Delong *et al.* 1999, Sydeman and Allen 1999, Allen *et al.* 2002). The present study has recorded a greater maximum number of seals hauled out at CR during molting, fall and winter compared to Kopec's reports from 1995-1997, with the overall maximum counts recorded in 2003 for the molting season (max count = 248), and in 2004 for the fall (max count = 336) and winter(max count = 594) seasons. The 2004 winter season maximum count represents the greatest increase in seal numbers within a season over two years. We speculate that this dramatic increase is related to the proximity of herring spawning in the Bay near CR.

Yerba Buena Island

Although yearly seasonal maximum counts were not available at YBI from 1995-1997, the number of seals using the haul-out site during the pupping season showed an increasing trend across all years until 2003, with a maximum of 180 in 2003, followed by a decline to 129 seals in pupping 2004 (Table 4). Molting season counts were relatively comparable across all years. Fall season numbers declined substantially in comparison to the 236 recorded in 1995 (D. Kopec, pers. comm. 1999), but increased back up to a maximum of 208 in the fall 2003. Maximum counts during the winter season varied greatly year to year, ranging from 193 in 1999 to 343 in 2003.

Mowry and Newark Sloughs

Due to differences in data analysis methods between D. Kopec and the present study, Newark Slough was considered separately from the five subsites at MS for the purposes of this comparison. Yearly maximum counts at MS occur in pupping and molting seasons (Table 4). The extremely low maximum count recorded at MS in 1998 during pupping was likely due to the fact that: 1) only two surveys were conducted in 1998 and both were late in the pupping season, and 2) 1998 was an El Niño year. In addition, the low number of seals recorded during the 1998 molting season may be related to El Niño's effect. There was a general increase in counts during the pupping and molting seasons at MS. Across all years, seal numbers at MS declined sharply during both the fall and winter seasons compared to pupping and molting.

As with YBI, detailed yearly information was not available for Newark Slough 1995-1997. In comparing seasonal counts between years, pupping season numbers increased slightly through 2002, and then declined in 2003 and 2004 (Table 4). The molting and fall season counts declined over the years, while the winter counts remained fairly stable across all years at Newark Slough.

DISTURBANCES

The frequency of disturbances (including those which caused head alerts, approaches to the water or flushes) at the three study sites varied (Table 5). YBI had the most disturbances reported per hour of field time, followed by CR day, CR night and MS. However, if only those disturbances that caused seals to flush into the water were considered, CR Day had the highest frequency of flushes/hour, followed by YBI, CR night and MS. Only those disturbances that caused seals to flush into the water will be analyzed for the remainder of this report unless otherwise noted.

Castro Rocks

Of all flush disturbances recorded at CR during the day (n=1889), the major sources were watercraft (0.097 flushes/hr field time; e.g. motorboats, sailboats, tankers, kayaks and jet skis), "other man-made" (0.073 flushes/hr field time; e.g. debris, workmen on the bridge), and wildlife (0.066 flushes/hr field time; e.g. seals and birds) (Figure 11). Of the 279 disturbances due to wildlife, 64 were due to birds, and 215 were due to seals. Sixty-four of the seal disturbances were due to either 1) a seal tagged with a time depth recorder seen at Castro Rocks in June 1998 (n=2), or 2) seals tagged with radiotags or a satellite tag in 2001-2005 (n=62). The majority of the tagged seal disturbances (n=54) occurred during the first 2 months after the first tagging event this project completed (2001). Very few disturbances were recorded in future years after a tagging event (n=8). The frequency of disturbances of unknown origin occurred 0.190 flushes /hr field time of all recorded disturbances. Major sources of "other man-made" disturbances were construction activities (0.034 flushes/hr field time), debris (0.019 flushes/hr field time) and other people (0.016 flushes/hr field time; Figure 12). Examples of construction activities include jackhammering, cranes moving, hammering, and sounds from hydraulic machinery. In addition, many of the disturbances due to "other people" were associated with construction workers in the area of the haul-out site (detailed further in a later section of this report).

Few disturbances caused a flush during the Castro Rocks night surveys (n=158). Causes of nighttime disturbances were "other man-made" (0.033 flushes/hr field time), watercraft (0.022 flushes/hr of field time), wildlife (0.021 flushes/hr field time), researchers (0.016 flushes/hr field time) and disturbances of unknown origin (0.071 flushes/hr field time; Figure 11). Traffic noise on the bridge is greatly reduced at night and the seals are more able to hear the researchers descending onto the observation platform. In addition, the lack of available light makes detecting the source of many disturbances difficult. Disturbances due to watercraft, which are common during the daytime, are greatly reduced at night. However, watercraft disturbances recently increased during the nighttime due to construction activities occurring at night. Primary sources of "other man-made" sources were construction activities (0.022 flushes/hr field time) and other people (0.009 flushes/hr field time). Construction activities include activities such as hammering and lights flashing on the haul-out site. As with the daytime disturbances, many of the flushes due to "other people" were due to construction workers (detailed further in a later section of this report).

Yerba Buena Island

The majority of the disturbances at YBI (n=562) were caused by watercraft (0.139 flushes/hr field time; Figure 11). "Other man-made" sources caused 0.042 flushes/hr field time of the recorded disturbances, wildlife caused 0.027 flushes/hr field time, researchers caused 0.021flushes/hr field time, aircraft caused 0.017 flushes/hr field time, and automobiles caused 0.004 flushes/hr field time. Primary sources of "other man-made" disturbance sources included debris (0.017 flushes/hr field time), other nonconstruction (0.012 flushes/hr field time) and other people (0.008 flushes/hr field time; Figure 12). Other people at YBI typically were Coast Guard personnel or researchers conducting harbor seal monitoring for the San Francisco-Oakland Bay Bridge construction project in the fall 2000. Disturbances of unknown origin occurred 0.116 flushes/hr field time.

Mowry Slough

Disturbances were infrequent at MS (n=99), due to the relative inaccessibility of this site to the public and the method of data collection at this site. Much of this site is located on U.S. Fish and Wildlife Service land that is not open to the general public; the remainder is accessed through private lands and requires a permit from the landholder (Cargill Salt Company). In addition, since field biologists do not remain at each subsite for an extended period of time (like at CR and YBI), disturbance sources common at this location, such as small aircraft in the area, are not recorded as often as they would be at the other research sites. Therefore, the number of disturbances at Mowry Slough likely represents an underestimate of the actual disturbances at this site. Of the 99 disturbances causing seals to flush at this site, 49 (0.032 flushes/hr field time) of these were caused by researchers (Figure 11). Aircraft caused 0.014 flushes/hr field time, 0.004 flushes/hr field time were due to watercraft, and wildlife accounted for 0.002 flushes/hr field time. 0.006 flushes/hr field time were attributed to unknown sources. The infrequency of human activity at this site may result in seals being more sensitive to human actions. In addition, since biologists do not remain at each subsite for a long period of time, researcher disturbances are more likely to be recorded than other disturbance sources.

Watercraft Disturbance Sources

Watercraft were a major source of disturbance at CR and YBI during the daytime. The average distance at which watercraft caused a flush at Castro Rocks (Mean = 163.8 m ± 5.12 SE) was significantly less than the average distance at which watercraft elicited a head alert or approach water response (Mean = 219.6 m ± 2.49 SE; $t=9.80$, $df=616$, $p<0.0001$). Similarly, the average distance at which watercraft caused a flush at YBI

(Mean = 137.6 m ± 8.03 SE) was significantly less than the average distance at which watercraft elicited a head alert or approach water response (Mean = 281.0 m ± 2.80 SE; $t=16.86$, $df = 247$, $p<0.0001$).

Overall, the average distance of watercraft which caused a flush at CR (163.8 m) was significantly larger compared to watercraft at YBI (137.6 m; $t=2.75$, $df = 360$, $p<0.01$) (Table 6). Except for the watercraft category "construction other boat", all watercraft elicited a flush response at a greater distance from seals at CR compared to seals at YBI (Table 6). The reason watercraft in the "construction other boat" category caused a flush reaction at a closer distance at CR is likely due to the fact that construction boats were working in the immediate area of the harbor seal haul-out site, whereas construction boats near YBI pass by the site within or close to the shipping channel which maintains a greater distance from the seals.

Caution should be used in interpreting disturbance data for several reasons. Depending upon the nature and behavior of the watercraft, the distance at which seals react can vary widely. For example, watercraft with erratic behavior, such as sudden changes in speed or direction, were more likely to cause a disturbance, whereas tankers maneuvering to the Chevron Pier located approximately 600 m from CR typically do not cause a disturbance. In addition, the distance at which seals were able to perceive watercraft varied due to obstructions and angle of approach at each site. For example, watercraft approaching from the north at CR, or from the east at YBI, are frequently not noticed until they were close to the haul-out site.

Construction-Related Disturbances

Overview of disturbances

At tide heights of ≤2 ft, a total of 402 construction-related flush disturbances were recorded during the daytime at CR since the inception of construction work in January 2001. 38.8% of flushes were due to construction activities (e.g. jackhammering, rivet work, banging and crane activity), 26.9% were due to "construction-related other boats" (mainly pushboats and crewboats), 21.6% were due to construction motorboats, and 11.0% were due to construction workers moving around and/or talking loudly near the haul-out site (Figure 13). On five occasions, construction-related debris in the water elicited a flush reaction from the seals. Construction-related items which have caused a flush include a hard hat, BEZ buoy washing ashore at the haul-out site, and scaffolding material floating in the water. The average distance at which "construction-related other boats" elicited a flush was 173.8 m ± 9.33 SE, while construction motorboats elicited a flush at an average distance of 129.7 m ± 7.14 SE. Flush disturbances due to construction activities (e.g. jackhammering, rivet work, banging and crane activity, 38.8%, n=156) were due to activities in the area between Pier 50 and Pier 57, with the majority of these disturbances associated with activities near Pier 54 (19.9%), Pier 55 (49.4%) and Pier 57 (9.6%).

During the nighttime, construction work caused a total of 49 flush disturbances, predominantly due to construction activities (38.8%) (e.g. crane activity and lights shining) and "construction other boats" (34.7%). The average distance to flush due to "construction other boats" was 188.3 m ± 32.59 SE. There was no significant difference in the average distance "construction other boats" caused a disturbance during the daytime and nighttime. Of all construction activity flush disturbances (n=19), 73.7% (n=14) were due to work activity by Pier 55, and 10.5% were due to work by Pier 56 (n=2).

Construction activities were permitted an additional 2 weeks longer in the area of the haul-out site during the work period encompassing July 15, 2003 – March 14, 2004 compared to the prior year, and therefore work continued until the start of pupping season (March 15, 2004). While construction work was occurring in the area of Pier 55 during this additional two week time period, a pup was born on Subsite A (located closest to the bridge, and immediately adjacent to Pier 55). Within 5 minutes of the birth, there was a flush due to construction activities (lowering equipment via rope/bucket) which caused ~30 seals to enter the water near the mother/pup pair. In the course of the disturbance, the monitors lost sight of the mother/pup pair. The mother/pup pair was not seen again by monitors during the week following the disturbance. It is possible that the mother/pup pair moved to a different location instead of utilizing Castro Rocks. However, given that the disturbance occurred immediately following the birth, it is also possible the mother/pup pair became separated and the pup did not survive.

Preconstruction Core Sampling (PCCS)

We recorded a total of 147 disturbances between January 24, 2001 and February 14, 2001, while preconstruction core samples were taken between piers 52 and 57 (includes both construction and non-construction-related sources). We recorded all disturbances when the tide height was ≤2 ft and all responses to disturbance sources (head alert, approach water, flush and wash off from wakes). Of those disturbances, 29.3% (43) were attributed to activities related to construction. Of the construction-related disturbances, watercraft in the area around the haul-out site were responsible for most disturbances (60.5%), followed by sounds related to construction (30.2%), and boat wakes (9.3%). Two boats were seen most often during the PCCS: a tugboat with 2 6-cylinder Cummins engines ("Mudcat"), and a Crew-boat with 2 12V71 Detroit engines ("Pegasus").

Of the watercraft disturbances, 32.1% (n=9) resulted in seal flushes. Watercraft activity associated with flushes were movement within close proximity of the haul-out site (of one or more boats), accelerations in boat speed, and boat work related to the set up of the boat exclusion zone around the haul-out site. The average distance from the haul-out site at which construction watercraft caused a disturbance (including flushes) was 233.0 m ± 23.1 SE. In comparison, the average distance for other construction activities, such as jackhammering, that caused a disturbance was 172.9 m ±14.7 SE. In comparing disturbance data from the preconstruction core sampling to past years, the overall frequency of flushes per hour of field time was significantly higher during the preconstruction core sampling than during the same time period in 1999 and 2000 ($F=5.73$, $df=46$, $p<0.01$) (Figure 14).

Castro Rocks Work Period (August 1st – February 14th)
During the daytime, when considering all disturbances (both construction-related and non-construction-related) which occurred at tide heights of ≤2ft during the work periods, there was a significant difference across all years (1998-2005) in both the average number of disturbances/hr field time ($F=37.56$, $df=701$, $p<0.0001$), and the average number of flushes/hr field time ($F=6.34$, $df=701$, $p<0.0001$) (Figure 15). The average number of disturbances/hr increased approximately 4-fold during the 2001-2002, 2002-2003, and 2003/2004 work periods and 2 ½ fold during the 2004-2005 work period compared to past years (Figure 15).

In comparing only construction-related disturbances recorded during the past four work periods (2001/2002, 2002/2003, 2003/2004 and 2004/2005), there was a significant difference in the average number of disturbances/hr field time ($F=4.52$, $df=382$, $p<0.01$), with fewer construction-related disturbances recorded during the 2004/2005 work period compared to the prior three work periods. In addition, there was a difference in the average number of flushes/hr field time ($t=3.23$, $df=382$, $p<0.05$), with a decrease in average flushes/hr of field time in 2002/2003 (0.164 flushes/hr) and 2004/2005 (0.173 flushes/hr), and increases in flushes/hr in 2001/2002 (0.363 flushes/hr) and in 2003/2004 (0.270 flushes/hr). This difference in the frequency of disturbances and flushes/hr of field time during each work period may be related to the amount and type of construction activity occurring each work period.

In addition, the frequency of construction-related flushes/hr decreased during work closure periods compared to work periods ($t=6.70$, $df=493$, $p<0.0001$), with more flushes/hr recorded during the work period (mean=0.245 ± 0.030 SE) compared to the closure period (mean=0.061 ± 0.010 SE) (Figure 15).

During the nighttime, when considering all work period disturbances (both construction-related and non construction-related) which occurred at tide heights of ≤2ft, there was a significant difference across years (1998-2004) in the daily average disturbances/hr field time ($F=11.66$, $df=453$, $p<0.0001$). There was a greater number of disturbances during the 2002/2003, 2003/2004 and 2004/2005 work periods, with approximately a 2-fold increase in the 2004/2005 work period compared to the prior to work periods (Figure 16). This increase in disturbances during the last three work periods may be related to an increase in nighttime construction work at night. In addition, there was a significant difference across all work period years in the daily average flushes/hr field time ($F=2.19$, $df=453$, $p<0.05$), with the greatest flushes/hr of field time documented during the 2004/2005 work period (Figure 16).

In comparing only construction-related disturbances recorded during the past three work periods (2001/2002, 2002/2003, 2003/2004 and 2004/2005) during the nighttime at CR, there was a significant difference in the daily average number of construction-related disturbances/hr field time ($F=6.38$, $df=280$, $p<0.0001$), with more than a 2-fold increase in construction-related disturbances/hr during the 2004/2005 work period. No significant difference was found in the frequency of construction flush/hr field time. In addition, as with the daytime construction-related flushes/hr, the frequency of construction-related flushes/hr during the work periods (mean = 0.105± 0.027 SE) was greater than during the work closure periods (mean = 0.020 ± 0.015 SE) ($t=2.73$, $df=353$, $p<0.01$).

Based on observations made by field staff, disturbances due to watercraft were most likely caused by factors such as; 1) moving at varying speeds, 2) changing course, and 3) remaining within close proximity to the haul-out site. In addition, when construction watercraft were traveling either close to the haul-out site or at high speeds, the wake that was created washed over the haul-out site and sometimes forced seals off of the rocks. Also, construction watercraft shining spotlights across the water during the nighttime typically caused a flush disturbance.

Several factors should be considered in evaluating the disturbance information. The frequency of construction-related disturbances recorded at each pier is dependent upon the amount of time and type of work conducted at each location. For example, if more time is spent conducting work at Pier 55 during a particular work period, and less time is spent at Pier 53, the fact that more disturbances may be recorded associated with work at Pier 55 may just be due to the fact that Pier 55 was worked on longer. In addition, due to difficulties in accessing the normal survey platform at Pier 55, some surveys were conducted from locations that did not provide good visibility of the work area at all times. Different viewing platforms resulted in obstructed views of construction activities, and therefore may have led to undetermined disturbance sources.

AIR ACOUSTICS MONITORING

The L_{eq} noise levels (the average A-weighted noise level during the measurement period) taken every 30-min during the daytime over all work periods (January/February 2001, August 1, 2001-February 14, 2002, July 16, 2002 – February 28, 2003, July 16, 2003 – March 14, 2004 and July 16, 2004 – February 28, 2005) ranged from 71.51-72.65 dBA (maximum noise levels ranged from 76.80-87.70 dBA) (Figure 17). In contrast, the hourly nighttime average L_{eq} noise levels during the work periods ranged from 64.74-71.57 dBA (maximum noise levels ranged from 78.80-96.10 dBA). There was a significant difference in the daytime and nighttime average L_{eq} levels during the work periods at Castro Rocks, with the average daytime L_{eq} (median = 72.51 dBA) significantly greater than the nighttime average L_{eq} (median = 68.14 dBA) ($U=899$, $p<0.001$).

During the work closure periods (February 15, 2001 – July 31, 2001, February 15, 2002 – July 16, 2002, March 1, 2003 – July 15, 2003, March 15, 2004 – July 15, 2004), the daytime average L_{eq} levels ranged from 71.92-73.04 dBA (maximum noise levels ranged from 76.00-79.50 dBA). Nighttime average L_{eq} levels during the work closure period ranged from 65.18-72.10 dBA (maximum noise levels ranged from 72.40-78.50 dBA). As with the work period, daytime L_{eq} levels during the work closure period (median = 72.58 dBA) were significantly greater than nighttime average L_{eq} levels (median = 68.56 dBA) during the work closure period ($U=898$, $p<0.001$).

In comparing work period versus work closure period average L_{eq} levels, there was a significant difference in the daytime sound levels ($U=529$, $p<0.05$), with work closure period L_{eq} levels slightly greater than the work period L_{eq} levels. There was no significant difference in nighttime average L_{eq} levels between the work and closure periods. Although the average L_{eq} levels were greater during the work closure period, the maximum daytime and nighttime L_{eq} levels during the work period (median: daytime=80.70, nighttime=82.20) were significantly greater than L_{eq} levels during the work closure period (median: daytime=77.20, nighttime=74.70) (daytime: $U=891.5$, $p<0.001$, nighttime: $U=802.5$, $p<0.0001$). Average L_{eq} levels during the work period may be lower than the work closure period due to wooden scaffolding structures which are erected around piers in order to work on the bridge. These scaffolding structures may aid in attenuating sound levels. However, as seen when examining the maximum L_{eq} levels, work period sound levels exceed work closure sound levels.

The drop in decibel levels at night during both the work period and work closure periods is likely due to decreased automobile traffic on the RSRB. This may be biologically, as well as statistically meaningful, since decibels are based on a logarithmic scale; each one decibel increase representing a more substantial increase than if measured on a standard numerical scale.

RADIO- AND SATELLITE-LINKED TELEMETRY

A total of 47 seals were captured at CR in January 2001 – August 2003. All seals captured were tagged on both rear flippers with lime green rototags. Of the 47 seals captured, 36 were tagged with telemetry tags: 19 seals were deployed with VHF radiotags, and 17 with satellite-linked PTT's. Prior to August 2002, no pups were affixed with radio or satellite tags, but were flipper-tagged. In order to examine dispersal dates and movement patterns of pups born at CR, 7 weaned pups were tagged in August 2002 with VHF radiotags (given the date of tagging relative to the pupping season at CR, peaking in May, we assumed that these pups were born at CR). Data for the 36 seals tagged with VHF- or satellite-linked telemetry tags are summarized in Table 7: Table 7(A) summarizes data for the VHF-radiotagged seals, and Table 7(B) summarizes results from the PTT-tagged seals.

Harbor seal haul-out sites in SFB and along the adjacent coastline are shown (Figure 18). Of seals tagged at CR through August 2003, most (25 of 36) used more than one haul-out site in and around SFB (Table 7, Figure 19-20). Ten seals (1/3 of tagged seals) appeared to use CR exclusively, although short tag duration or low point location sample sizes for some seals (PTT 15440; VHF 8.020, 8.142, and 8.891) should be considered when drawing conclusions about haul-out site use for these animals. All seals except four (PTT 15437 and 10278; VHF 1.652 and 8.950) used CR as a primary haul-out site during at least part of the study period. Corte Madera Marsh, a small haul-out site located west of CR, was used by four (1/9)of the tagged seals. Small haul-out sites on Angel Island State Park (e.g. Pt. Blunt) in central SFB were used by a number of CR seals. Ryer Island, a relatively new haul-out site in Suisun Bay, was used extensively by one adult male seal. A number of seals used the Sausalito Boatworks haul-out site, or another small site in Richardson Bay (Peninsula Point, Belvedere), perhaps related to seasonal presence of herring in that area (D. Watters, California Dept. of Fish and Game, pers. comm.). Four of the five seals which used the

Richardson Bay sites were tagged in July/August, indicating their use of that area in the fall/winter season, when herring spawn in SFB. Mean depths utilized by seals in SFB ranged from three to 18 m (Table 7). Many seals appeared to use consistent feeding areas within and outside the SFB (Figures 19-20).

When seals used CR as their primary haul-out site, mean in-water distances from the haul-out site generally ranged from two to eight km (with one outlier, at 33 km, for radiotagged seal 1.631); mean distances for most seals (26 of 30) were ≤ 5 km (Table 7), indicating that "use areas" of CR seals tend be located close to the CR haul-out site. Maximum distance from CR recorded for seals tagged at CR was 72 km (PTT seal 15437) (Table 7).

There was a significant difference by year in distances of seals from the CR haul-out site (all age classes, males and females combined, and including haul-out site data) ($H=46.33$, $df=3$, $p<0.001$, adjusted for ties) (Table 8). Seals tended to be located closer to the haul-out site in 2003, and further from the haul-out site in 2004.

In the comparison of adult/subadult females during the fall/winter season (August through February, haul out data excluded), a significant difference was seen in in-water distances of seals from CR by year ($H=342.38$, $df=2$, $p<0.0001$, adjusted for ties) (Table 8). In a pattern similar to that seen in the combined dataset, above, seals tended to be located closer to the haul-out site in 2002-2003, and further from the site in 2003-2004.

Data from yearling females were not included in the more conservative analysis, as a Mann-Whitney U test revealed a significant difference between distances from CR for yearlings vs. other age classes, with yearlings generally found closer to the CR haul-out site (yearling median: 3.0 km, adult/subadult median: 4.5 km; $U=737116.5$, $p<0.0001$). Males and females also differed in median distances from CR, again based on a Mann-Whitney U test, with males generally located in water areas further from the CR site (males median: 5.0 km, females median: 4.2 km; $U=1863337.5$, $p<0.005$).

The reason for the differences in distance from CR between years is not clear, but may be related to:

1) Construction-related increases in disturbance levels at CR (and on the RSRB as a whole). However, if the shifts in distances from CR across years are due to construction, the trend is not clear. Disturbances/hr and flushes/hr related to construction work were lower in fall/winter 2002-2003, corresponding with seals using areas closer to the bridge, and increased again in fall/winter 2003-2004, when seal locations were further from the bridge (this report). However, the trend does not hold for 2001-2002, the first fall/winter season of construction at the RSRB. In fall/winter 2001-2002, seals were located at intermediate distances from the CR site, despite the highest recorded levels of disturbances/hr and flushes/hr for the three seasons compared. Generally, seals tagged for this study in SFB were located at mean distances within 5 km of the CR haul-out site, when CR was being used as the primary haul-out site (Table 7, for both VHF-

and PTT-tagged seals). This tendency of SFB seals to use areas close to the primary haul-out site has been noted in other studies: within 24-hour tracking surveys, Torok (1994) noted that most seals appeared to use one to two specific foraging areas and remained within 5 km of the primary haul-out site.

2) Similarly, a difference in the type of construction work underway during each time period could potentially impact seal responses and seal tendency to use waters further from the work. Given the many types of work underway simultaneously on the bridge, and the shifts in construction work location along the bridge (sometimes occurring on a daily basis), investigating relationships between type of work underway and seal in-water distances from the bridge would be problematic. Relationships between type of work and seal response are best investigated using the behavioral (disturbance) data set.
3) Individual differences in foraging/use areas used by seals tagged in different years, differences which may be exacerbated by the small sample size of this analysis. One example of this can be seen in the 2003-2004 data, which contains data from seal number 42527, a seal who spent a considerable amount of time near the small Pt. Blunt haul-out site (Figure 19b). However, this seal did not shift primary haul-out site use away from CR during this period; instead, she moved regularly between the two sites in both 2003 and 2004.
4) Shifts in food resources (e.g. herring) to waters near CR, as seen in fall/winter 2002/2003, may have resulted in an increased use of these areas by seals. Alternately, shifts of prey resources away from CR (to Richardson Bay, for example) may have resulted in greater distances used in 2004, and may also explain the high use of sites near Richardson Bay by 2004 seals.

Most tagged seals have shown strong fidelity to haul-out sites and foraging areas within SFB and the adjacent coast (Figures 19-20). The weaned pups tagged in August 2002 were an exception to this rule, dispersing out from CR to the outer coast. Other studies have noted that a large proportion (up to 30-48%, depending on study) of harbor seal pups appear to migrate away from the site of their birth, sometimes to considerable distances (Bonner and Witthames 1974, Thompson 1989, Lander *et al.* 2002). Once the VHF radiotagged seals leave SFB and our study area, they are much more difficult to track, and complete information on haul-outs used by radiotagged seals while on the coast is not available. Dispersal dates away from CR for six of the weaned pups are as follows: 8/14/03 (8.371 female), 8/21/02 (8.950 male), 9/7/02 (8.828 female), 9/10/02 (8.142 male), 9/13/02 (8.292 female), and 9/14/02 (8.020 female). The seventh (8.891 female) moved between the bay and coast repeatedly between 8/13/02 and 9/2/02, and was sighted back on the CR haul-out site repeatedly after 9/3/02. Five of the dispersing seals were heard on the coast following dispersal from CR; one (8.020) lost its radiotag antenna and was not heard following its departure from CR. One (8.950) was heard (by a RBHSS biologist surveying from Pt. Reyes) and sighted (by biologists stationed onsite) on the Farallon Islands in mid-February 2003. One seal (8.828) was heard back in SFB by 12/5/02, following time spent on the outer coast. In summary, our data on the August 2002 pups suggest that most pups born at CR do not remain there for long after weaning (weaning occurs ~4 weeks after birth).

Haul out time and site attendance for CR for the radiotagged seals varied widely, but 41.2% (7 of 12) of seals who retained their tag for >25 days used CR on more than 50% of days tagged, and 23.5% of these seals used CR on more than 90% of days tagged (Table 9).

Some of the harbor seals tagged at CR used haul-out sites outside SFB, as far west as the Farallon Islands (37°42'04"N, 123°00'30"W), as far south as Pillar Point (37°29'43"N, 122°30'15"W) and as far north as Point Reyes Headland (38°01'42"N, 122°56'27"W) (Table 7; Figures 18-20). Excluding use of haul-out sites located at the mouth of SFB (Land's End and Point Bonita; Figure 18), eight seals (1/4th), ranging in age from weaned pup to adult, regularly used sites outside of SFB (Table 7). At least two seals made >1 trip between the Farallon Islands and the California coast, and at least one seal (PTT 15437) used a consistent feeding area between the coast and the Farallones (Figures 19-20). For example, one seal (PTT 19582) traveled to the Farallon Islands, remained at the Farallones for nine days, then returned to Duxbury Reef for two days, and then moved back to the Farallones. This seal lost its PTT four days later, while still at the Farallones, but has since been resighted at CR. The Farallon Islands are located 45 km west of the entrance to SFB, in the Gulf of the Farallones National Marine Sanctuary, and serve as a haul-out and breeding location for a number of pinniped species. Duxbury Reef is the closest point of land to the Farallones and is a harbor seal haul-out site (Allen *et al.* 2002; Figure 18). Three tagged seals (1.652, 15437 and 10278) also periodically used YBI, the closest major SFB haul-out site to the mouth of SFB.

Interestingly, few seals tagged at CR used haul-out sites in southern SFB, for example Mowry (MS) or Newark Sloughs (Figure 18), despite ranging considerable distances and using both central SFB and coastal haul-out sites. Of all seals tagged at CR, only two (adult female 1.310, adult female 42527) used sites in south SFB. Three possible explanations of this lack of extensive movement by seals from the northern to southern reaches of SFB exist:

1) timing of tag attachment: seal numbers at MS rise sharply for the pupping and molting seasons, and fall again during the winter and fall; the fact that much of our data was collected during the fall/winter means that we cannot eliminate the possibility that some of these seals spend pupping and molting season in the south bay; or
2) spatial segregation of south and north bay seals: seals that use the northern reaches of SFB, particularly the north bay rookery site CR, may not use the southern reaches of SFB to the extent that these areas are utilized by seals using the south bay rookery, MS. Of 39 seals captured in the south SFB and radiotracked in the pupping and fall seasons, 1990-1992, only five used sites in the central SFB, and only one used CR (Harvey and Torok 1994).
3) individual variation (of use area size, degree of movement between sites) between seals

Initially, problems with tag attachment meant shorter tag attachment durations for some seals. The refined attachment technique for the PTT's, used beginning in January 2002, has resulted in an increase in tag duration. Difference with timing of tag attachment relative to the seals' molting season (June-August) may also play a role in duration of tag attachment.

OTHER MARINE MAMMAL SIGHTINGS

Other marine mammal sightings were periodically documented while monitoring the three harbor seal haul-out sites in SFB. Since the start of monitoring in May 1998, observers noted 14 gray whale (*Eschrichtius robustus*) sightings within the Bay (12 live and 2 dead). Nine of the live whale sightings were from the RSRB, two from YBI and one was seen off of Tiburon. Both dead whale sightings were from the RSRB. Whale sightings occurred during the months of April (n=10), May (n=2), and one sighting in the months of June and October. In addition, at least 90 California sea lions (*Zalophus californianus*) have been seen near the RSRB and at least 57 were seen in the waters off of YBI. One dead sea lion was seen onshore at YBI, approximately 200 m northwest of the YBI haul-out site, and another was seen on Red Rock; located just west of CR. Sea lions are sighted throughout the year at the research sites. One sea otter (*Enhydra lutris*) was seen in March 2001 near YBI, and at least 1 harbor porpoise (*Phocoena phocoena*) was seen in May 2000 off of YBI.

SUMMARY

POPULATION

- Castro Rocks serves as an important harbor seal haul-out site within SFB, utilized during low to medium low tides.

- Castro Rocks is also particularly important as a nighttime haul-out site, with average nighttime counts surpassing daytime counts during the molting and fall seasons.

- During pupping season, subsite A at CR remains preferred by females with pups, regardless of year (including construction years), with 85% using subsite A during the daytime, 98% using subsite A during the nighttime.

- During the four "work periods" of the construction activity within the area of the Castro Rocks haul-out site (August 2001 – February 14, 2002 and July 16, 2002-February 2003, July 16, 2003-March 14,2004 and July 16, 2004 – February 28, 2005):
  - The total number of seals hauling out on Castro Rocks did not decrease compared to past years. However, we noted a shift in the pattern of subsite use at Castro Rocks compared to past years.
  - There was a trend toward an increase in the number of seals hauling out on subsites C-F, which are located farther from the bridge, and a decrease in the number of seals hauling out on subsite A, located closest to the bridge during earlier work periods (2001-2002). However, seal numbers on subsite A during the most recent work period

exhibited levels comparable to, or exceeding, levels recorded prior to the onset of construction activities.

- Recent work shows that YBI is an important site year round, particularly during molting and winter season (Green *et al.* 1999, Galloway 2000).

- Although YBI is not historically identified as a pupping site, data gathered over the past 5 years reveals that YBI serves as a small pupping site in the Bay.

- MS is historically identified as an important pupping site and our data support that fact. MS also appears to be an important haul-out site during the molting season.

- Based on direct counts this project has gathered (no correction factor used to adjust count), we estimate the Bay population to be >500 seals.

- The number of seals using CR, as well as YBI and MS, represent a substantial proportion of the seals in SFB, and all three sites serve as important sites for mother/pup pairs during the pupping season (and possibly a slight increase in overall seal numbers over the years).

- CR is an important harbor seal haul-out site in SFB, and protecting this site is important for the preservation of the harbor seal population in SFB.

DISTURBANCE

- It appears that the BEZ provides adequate protection to harbor seals during the pupping and molting seasons, sensitive times of year when access to a haul-out site is particularly important. Prior to the onset of construction-related activities, the number of pups born at CR each year was increasing slightly. This increasing trend continued during construction.

- Construction-related disturbances at Castro Rocks were attributed to two main factors; watercraft in the area of the haul-out site and construction activities such as jackhammering, rivet work, hammering and the movement of cranes on barges near the haul-out site.

- Overall, during the daytime, 49% of construction-related flushes were due to watercraft activities in the area of the haul-out site, and 39% were due to construction activities (e.g. jackhammering, rivet work, crane activity, and banging).

- Flushes due to construction watercraft are likely due to the increase in the number of watercraft in the area and the frequency of watercraft traveling to/from the launching dock located at the southeastern end of the bridge. The close proximity of watercraft to the haul-out site compared to watercraft which typically pass by the site in the shipping channel, in addition to erratic movements and directionality, contribute to disturbances at Castro Rocks.

- During the daytime, construction-related motorboats elicited a flush reaction at an average distance of 130 m, whereas construction-related other boats (e.g. pushboats and crewboats) elicited seals to flush into the water at an average distance of 174 m.

- Flush disturbances due to construction activities during the daytime and nighttime were associated with work in the area between Piers 52-57, with 49% (daytime) and 74% (nighttime) of construction activity flush disturbances associated with work activities in the immediate area of Pier 55.

- Kayaks account for 15% of watercraft flush disturbances at CRD and 20% of watercraft flush disturbances at YBI. Kayaks tend to approach closer to haul-out sites than motorized watercraft at both CR and YBI, 153 m and 91 m respectively.

- Higher daytime sound levels at CR compared to nighttime sound levels may have some impact on haul out number. Average nighttime haul out numbers exceed daytime counts during all seasons except pupping season.

TELEMETRY

- Telemetry studies of harbor seals tagged at CR have provided important information about the spatial distribution of seals which use this site, and evidence of the importance of the Castro Rocks haul-out site.

- Foraging/use areas of many tagged seals were located in close proximity to the CR haul-out site (generally <5 km).

- Many tagged seals displayed strong site fidelity to the CR haul-out site for the duration of tag attachment.

- Although preliminary, analysis of the mean distance from CR as a potential indicator of shifts away from the RSBR construction site revealed no consistent trend toward use of in-water areas farther from the bridge, at least while CR was being used as the primary haul-out site by the seals.

- Telemetry allows tracking of seals that use smaller or new haul-out sites in the Bay and/or leave the Bay, and allows us to document the movements and haul-out patterns of individual seals.

- Telemetry provides additional data on other research questions useful in evaluating shifts in seal numbers at CR and other SFB haul-out sites. For example, how many of the Bay's seals are resident, spending much of their year within SFB, and how many are sporadic or seasonal visitors?

- Given differences in habitat use between sex and age classes of harbor seals, data from additional future taggings would help to clarify trends in light of seasonal, age- and sex-related differences in seal spatial distribution.

RECOMMENDATIONS

Continued monitoring of the Castro Rocks harbor seal haul-out site throughout the retrofit work on the Richmond-San Rafael Bridge is important in order to properly assess what impacts the retrofit work has on the SFB harbor seal population. Currently, we have only documented a temporary shift in subsite use at Castro Rocks, to areas farther from the bridge; no decline has been documented in overall seal numbers at this site (at survey tide heights of ≤ 2ft). In light of the results gathered to date by this project, we recommend the following actions:

- Monitoring should be continued in order to examine the effects as retrofit work progresses through the year 2005. As per the power analysis summarized in the letter dated August 4, 2003 (see Appendix B), depending on the level of detection desired in a change in site use at CR, it may be possible to decrease the frequency of monitoring at CR. However, if significant changes are made to the timing of the construction work period in the area of the CR haul-out site, decreases in monitoring may not be advisable.

- As discussed in previous interim reports, in order to alleviate watercraft-related disturbances during construction:

    - Whenever possible, watercraft should maintain a slow steady speed when passing by the haul-out site to avoid disturbances associated with boat wakes, and, unless necessary, boats should not travel close to the haul-out site. We recommend watercraft maintain a minimum distance of 100 m from the haul-out site.
    - When traveling within the area of the haul-out site, watercraft will likely elicit fewer disturbances if they travel parallel to the haul-out site rather than toward the haul-out site.
    - The use of spotlights from watercraft during the nighttime should be limited in order to alleviate flush disturbances. If it is necessary to use spotlights from watercraft during the nighttime, avoiding directing the light at the Castro Rocks haul-out site may help alleviate some of the disturbances related to watercraft spotlights.

- Continued tagging will allow us to monitor spatial shifts (or stability) in seal distributions around the retrofit site and around SFB. Additional telemetry data are needed, particularly for the months prior to pupping season and during the pupping season itself, in order to understand how seal movements around SFB vary by season. Given that external telemetry tags are naturally shed by seals each year during the molt, and given the difficulty of capturing seals at CR (and resulting small sample sizes), we recommend that seal captures and tracking continue throughout the retrofit work.

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	Work Closure Period 1998 - 2005		Work Period 1998-2005	
	2/15-7/24	7/25-7/31	8/1-8/31	9/1-2/14*
CRD	3 until 3/99 - currently 4	5	5-7	5-7
CRN	2	2	2	2
YBI	2	5 until 9/99 - currently 2	5 until 9/99 - currently 2	3 until 9/99 - currently 2
MS	3	3	7	3

Table 1. Number of days/week surveys were taken at each location during each time period. *Please note: The work period was extended during the 2002/2003 and 2003/2004 work periods. Monitoring continued 7days/wk until the end of each work period each year; February 28, 2003 and March 14, 2004. CRD – Castro Rocks Day; CRN – Castro Rocks Night; YBI – Yerba Buena Island; MS – Mowry Slough.

		CRD	CRN	YBI	MS
Pup 1998 (May Only)	Time in Field hrs(#Surveys)	96(174)	9.47(21)	26.83(60)	5(2)
	# Surveys -Tide Height ≤2'	117	12	52	N/A
Molt 1998	Time in Field hrs(#Surveys)	311.6(615)	29.47(56)	136(299)	129(32)
	# Surveys -Tide Height ≤2'	244	45	143	N/A
Fall 1998	Time in Field hrs(#Surveys)	631(1322)	64.92(148)	184(414)	168(42)
	# Surveys -Tide Height ≤2'	261	141	114	N/A
Winter 1998	Time in Field hrs(#Surveys)	661(1410)	59.48(147)	187.5(416)	149.22(37)
	# Surveys -Tide Height ≤2'	438	84	208	N/A
Pup 1999	Time in Field hrs(#Surveys)	314.33(675)	30.95(77)	72(161)	99.42(27)
	# Surveys -Tide Height ≤2'	457	41	137	N/A
Molt 1999	Time in Field hrs(#Surveys)	361.75(775)	32.97(80)	120(270)	160.55(42)
	# Surveys -Tide Height ≤2'	352	50	140	N/A
Fall 1999	Time in Field hrs(#Surveys)	587.5(1264)	26.43(123)	166.00(374)	209.22(54)
	# Surveys -Tide Height ≤2'	230	122	106	N/A
Winter 1999	Time in Field hrs(#Surveys)	595.00(1268)	63.00(162)	132.00(289)	120.07(32)
	# Surveys -Tide Height ≤2'	452	75	125	N/A
Pup 2000	Time in Field hrs(#Surveys)	308.27(666)	37.12(74)	87.5(195)	124.68(33)
	# Surveys -Tide Height ≤2'	464	24	161	N/A
Molt 2000	Time in Field hrs(#Surveys)	359.25(772)	29.50(78)	79.00(177)	158.78(43)
	# Surveys -Tide Height ≤2'	376	50	113	N/A

Table 2. Field Summary by research location; May 1998 – mid-March 2005. Fewer surveys were conducted at Mowry Slough alternate site compared to YBI; only one survey per day can be conducted at Mowry Slough (to cover all 6 subsites), while 9 surveys are typically conducted per day at YBI. (Continued on next page.)

		CRD	CRN	YBI	MS
Fall 2000	Time in Field hrs(#Surveys)	606.50(1301)	45.5(118)	106.5(240)	157.2(41)
	# Surveys -Tide Height ≤2'	252	112	72	N/A
Winter 2000	Time in Field hrs(#Surveys)	646.2(1380)	70.7(180)	123.0(277)	111.9(34)
	# Surveys -Tide Height ≤2'	488	112	93	N/A
Pup 2001	Time in Field hrs(#Surveys)	283.0(666)	31.0(82)	91.0(206)	84.7(25)
	# Surveys -Tide Height ≤2'	448	43	171	N/A
Molt 2001	Time in Field hrs(#Surveys)	371.0(795)	32.0(84)	94.0(205)	106.5(30)
	# Surveys -Tide Height ≤2'	372	53	107	N/A
Fall 2001	Time in Field hrs(#Surveys)	537.08(1149)	20.75(123)	99.5(214)	57.75(33)
	# Surveys -Tide Height ≤2'	219	121	57	N/A
Winter 2001	Time in Field hrs(#Surveys)	509.38(1096)	87.50(212)	143.50(323)	45.00(29)
	# Surveys -Tide Height ≤2'	398	137	185	N/A
Pup 2002	Time in Field hrs(#Surveys)	264.00(572)	29.50(77)	99.00(223)	40.00(23)
	# Surveys -Tide Height ≤2'	411	31	205	N/A
Molt 2002	Time in Field hrs(#Surveys)	312.25(671)	22.00(57)	78.50(177)	49.33(25)
	# Surveys -Tide Height ≤2'	325	36	118	N/A
Fall 2002	Time in Field hrs(#Surveys)	548.50(1179)	49.50(131)	78.50(209)	59.68(36)
	# Surveys -Tide Height ≤2'	205	129	37	N/A
Winter 2002	Time in Field hrs(#Surveys)	587.25(1261)	98.00(236)	128.67(296)	64.75(42)
	# Surveys -Tide Height ≤2'	489	163	174	N/A

Table 2 (continued). Field Summary by research location; May 1998 – mid March 2005. Fewer surveys were conducted at Mowry Slough alternate site compared to YBI; only one survey per day can be conducted at Mowry Slough (to cover all 6 subsites), while 9 surveys are typically conducted per day at YBI.

		CRD	CRN	YBI	MS
Pup 2003	Time in Field hrs(#Surveys)	290.00(653)	32.98(84)	88.00(198)	51.10(30)
	# Surveys -Tide Height ≤2'	471	34	158	N/A
Molt 2003	Time in Field hrs(#Surveys)	362.75(778)	31.50(83)	47.50(197)	43.00(28)
	# Surveys -Tide Height ≤2'	362	48	128	N/A
Fall 2003	Time in Field hrs(#Surveys)	415.50(888)	66.00(168)	98.50(222)	55.53(36)
	# Surveys -Tide Height ≤2'	176	164	40	N/A
Winter 2003	Time in Field hrs(#Surveys)	485.92(1044)	104(266)	112(234)	57.23(48)
	# Surveys -Tide Height ≤2'	505	167	197	N/A
Pup 2004	Time in Field hrs(#Surveys)	284.25(611)	30.00(76)	80.00(180)	52.36(31)
	# Surveys -Tide Height ≤2'	467	26	176	N/A
Molt 2004	Time in Field hrs(#Surveys)	301.00(646)	29.00(73)	79.50(172)	44.55(30)
	# Surveys -Tide Height ≤2'	291	48	87	N/A
Fall 2004	Time in Field hrs(#Surveys)	310.90(668)	37.50(94)	86.00(195)	56.47(34)
	# Surveys -Tide Height ≤2'	127	92	63	N/A
Winter 2004	Time in Field hrs(#Surveys)	360.30(779)	68.33(179)	127.00(283)	59.95(38)
	# Surveys -Tide Height ≤2'	403	119	181	N/A

Table 2 (continued). Field Summary by research location; May 1998 – mid March 2005. Fewer surveys were conducted at Mowry Slough alternate site compared to YBI; only one survey per day can be conducted at Mowry Slough (to cover all 6 subsites), while 9 surveys are typically conducted per day at YBI.

A.

	CRD		CRN	YBI	MS
	Max # pups hauled out	Estimated # of mother/pup pairs	Max # pups hauled out	Max # pups hauled out	Max # pups hauled out
Pup 1998	9*	--	6	6	6
Pup 1999	21	35	13	7	78
Pup 2000	27	40	15	8	90
Construction Activities Began January 2001					
Pup 2001	35	40	34	9	102
Pup 2002	44	N/A	35	5	144
Pup 2003	48	N/A	43	2	144
Pup 2004	56	N/A	41	7	127

B.

	Daytime Subsites							Nighttime Subsites					
	A	B	C	D	E	F		A	B	C	D	E	F
'99-'04 Pup	86.5%	4.6%	3.0%	0.8%	0.4%	4.7%	**'99-'04** Pup	98.8%	0.6%	0.3%	0.0%	0.0%	0.3%
Pup 1999	89.4%	4.2%	2.5%	0.4%	0.0%	3.4%	Pup 1999	97.5%	1.1%	0.0%	0.0%	0.0%	1.4%
Pup 2000	82.5%	7.6%	2.3%	1.2%	0.3%	6.0%	Pup 2000	99.1%	0.9%	0.0%	0.0%	0.0%	0.0%
Pup 2001	83.4%	5.3%	2.8%	1.3%	0.6%	6.7%	Pup 2001	99.3%	0.3%	0.4%	0.0%	0.0%	0.0%
Pup 2002	82.6%	3.1%	4.6%	1.2%	0.6%	7.9%	Pup 2002	98.1%	0.6%	0.8%	0.0%	0.0%	0.6%
Pup 2003	88.0%	4.7%	2.9%	0.2%	0.9%	3.3%	Pup 2003	99.3%	0.5%	0.1%	0.0%	0.0%	0.0%
Pup 2004	93.0%	2.5%	2.7%	0.6%	0.3%	1.0%	Pup 2004	99.3%	0.5%	0.2%	0.0%	0.0%	0.0%

Table 3. Pupping season information, including A. Summary of the number of pups seen each season at each research site (*Two factors likely contributed to the low pup count this year: 1. data was only collected during the last month of pupping season, and 2. 1998 was an El Nino year. Estimate of total number of mother/pup pairs provided by A. Bohorquez (Bohorquez, pers. comm. 2001) and B. Summary of the percentage of pups on each subsite during each pupping season.

Yearly Maximum Counts

CRD	1995	1996	1997	1998	1999	2000	**2001**	**2002**	**2003**	**2004**
Pupping	89	119	187	121	150	161	172	166	248	271
Molting	161	96	113	125	141	155	172	187	248	238
Fall	98	69	88	136	154	201	205	180	213	336
Winter	128	106	--	160	179	156	225	296	388	594

YBI	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Pupping	117*			129	136	128	156	163	180	129
Molting	230*			213	198	204	184	226	214	177
Fall	236*		--	98	141	151	135	98	208	164
Winter	242*		--	296	193	231	238	206	343	217

MS	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Pupping	117	63	239	52**	201	273	270	367	295	290
Molting	199	158	168	105	177	302	213	221	257	236
Fall	29	26	--	26	60	31	53	60	49	55
Winter	70	26	--	60	69	87	112	106	90	139

NW	1995-1997	1998	1999	2000	2001	2002	2003	2004
Pupping	53*	25**	47	45	59	77	29	23
Molting	69*	51	62	33	34	26	28	24
Fall	35*	41	32	24	31	14	20	16
Winter	34*	26	18	23	22	22	30	13

Table 4. Maximum harbor seal count during each season from 1995 – mid-March 2005 at Castro Rocks (day) (CRD), Yerba Buena Island (YBI), Mowry Slough (MS) and Newark Slough (NW). Years listed in bold under Castro Rocks represent years with construction activity. *Not all of the data provided by D. Kopec could be broken down by year. **Only two counts were taken during the 1998 pupping season at Mowry/Newark Sloughs.

Location	Total # Disturbance/Flush *	Average Disturbances/Flushes Per Hr Field Time *	Total # Construction Related Disturbances/Flushes	Average Construction-Related Disturbances/Flushes Per Hr Field Time
Castro Rocks (day)	13993/1889	3.22/0.49	6084/402	2.54/0.16
Castro Rocks (night)	1195/158	1.27/0.18	579/49	0.96/0.08
Yerba Buena Island	9891/562	6.35/0.39	---	---
Mowry Slough	414/99	0.33/0.10	---	---

Table 5. Summary of the total disturbances and flushes recorded at each research site. In addition, the frequency of disturbances and flushes per hour of field time (May 1998 – mid-March 2005) provided. Only those disturbances which took place when the tide height was ≤ 2 ft are included (except at Mowry Slough, where all disturbances were included). Construction-related disturbances include disturbances recorded since the start of construction work in January 2001, and only include disturbances recorded when the tide height was ≤ 2 ft. * Totals include disturbances related to construction activities.

Watercraft Disturbances

	Castro Rocks Day				YBI			
Type	n	Proportion Overall Sources	Average Distance (m)	Distance Range (m)	n	Proportion Overall Sources	Average Distance (m)	Distance Range (m)
Jet Ski	4	0.01	156.9	105-150	6	0.03	86.8	25-201
Kayak/Canoe	56	0.14	153.0	10-500	39	0.20	90.5	5-258
Sailboat	14	0.03	223.9	70-444	21	0.11	141.1	30-310
Motorboat	125	0.31	169.0	20-536	111	0.56	136.5	15-550
Construction Motorboat	90	0.22	127.0	20-362	2	0.01	103.0	100-106
Other Boat	9	0.02	329.0	150-510	14	0.07	220.4	30-959
Construction "Other Boat"	106	0.26	173.9	9-511	5	0.02	199.3	151-264
Overall	404		163.8	9-536	198		137.6	5-959

Table 6. Summary of the watercraft disturbances that caused seals to flush from the haul-out site at Castro Rocks Day and YBI (May 1998 – mid-March 2005). Only those disturbances that took place when the tide height was ≤ 2 ft are included in order to make comparisons between the two sites. The category "other boats" includes larger watercraft such as tugboats, pushboats, ferries, tankers and Bay tour boats. Construction "other boats" includes larger construction boats such as tugboats and crewboats.

Seal ID	Date tagged (mm/dd/yy)	Tag duration (days)	Season of tag attachment	Age class	Sex	Haul-out sites used	Maximum distance from CR (km)	Mean distance ± SE from CR[a] (km)	Mean depth ± SE used in SFB (m)	Mean depth ± SE used outside of SFB (m)
1.310	01/07/01	43	Winter	A	F	CR, MS, BI	59.6	3.2 ± 2.3	6 ± 4	N/A
1.652	01/08/01	13	Winter	SA	F	YB		--[b]		
1.221	01/08/01	122	Winter/Pup	SA	F	CR	10.6	3.3 ± 2.1	11 ± 6	N/A
0.320	07/15/01	124	Molt/Fall	SA	F	CR, PB, LE	25.6	3.2 ± 1.7	15 ± 9	N/A
1.611	07/15/01	98	Molt/Fall	SA	M	CR, CM, PB	8.7	4.9 ± 0.6	18 ± 6	N/A
1.361	01/24/02	116	Winter/Pup	Y	F	CR	5.5	3.5 ± 1.1	8 ± 4	N/A
1.371	01/24/02	112	Winter/Pup	Y	F	CR, RR	5.3	2.5 ± 1.2	9 ± 3	N/A
1.631	01/24/02	108	Winter/Pup	Y	M	CR, FI, LE	60.2	33.4 ± 12.6	14 ± 10	44 ± 13
1.641	01/24/02	116	Winter/Pup	Y	M	CR	6.1	3.5 ± 1.2	8 ± 2	N/A
1.727	01/24/02	123	Winter/Pup	Y	F	CR, PB, DR, DP, PP	56.1	3.3 ± 1.1	8 ± 3	17 ± 13
8.950	8/12/2002	199	Molt/Fall/ Winter	WP	M	CR, PT, FI	64.2	N/A[c]	--[d]	8 ± 2
8.020	8/12/2002	33	Molt/Fall	WP	F	CR	27.1	2.7 ± 0.6	9 ± 2	24 ± 2
8.891	8/12/2002	155	Molt/Fall/ Winter	WP	F	CR	38.3	2.7 ± 0.4	11 ± 2	19 ± 5
8.142	8/12/2002	99	Molt/Fall	WP	M	CR	60.0	3.4 ± 0.5	8 ± 1	43 ± 13
9.101	8/12/2002	128	Molt/Fall/ Winter	Y	F	CR, PB	29.3	3.9 ± 0.9	10 ± 1	N/A
8.828	8/12/2002	163	Molt/Fall/ Winter	WP	F	CR, BF, PB	24.2	5.3 ± 0.8	11 ± 1	N/A
8.371	8/13/2002	43	Molt/Fall	WP	F	CR, PB		--[b]		
8.292	8/13/2002	70	Molt/Fall	WP	F	CR, PT	21.2	3.1 ± 0.7	12 ± 3	39 ± 12
8.451	8/13/2002	213	Molt/Fall/ Winter/pre-Pup	SA	F	CR, PB	16.9	4.0 ± 0.3	12 ± 1	N/A

[a]when CR was being used as the primary haul-out site
[b]insufficient data was collected on this seal due to early tag loss; mean depth etc. could not be evaluated
[c]seal did not use CR as a major haul-out site, or only used CR briefly
[d]one SFB location only, on haul-out site – depths for SFB not calculated

Haul-out sites, with distances (across water) from Castro Rocks (tagging site) in km (see also map, Figure 18):

BE = Peninsula Pt., Belvedere (9.0)
BI = Brooks Island (7.0)
BL = Bolinas Lagoon (38.5)
BF = Bluff Point, Tiburon (6.0)
CM = Corte Madera Marsh (7.5)
CP = Coyote Point (39.3)
CR = Castro Rocks (--)
DB = Dumbarton Point (55.6)
DE = Drake's Estero (64.4)
DP = Double Point (48.3)
DR = Duxbury Reef (39.0)
FI = Farallon Islands (65.0)
LE = Land's End (21.2)
MS = Mowry Slough (64.4)
PB = Point Blunt, Angel Island (8.7)
PI = Point Ione, Angel Island (7.4)
PP = Pillar Point (58.5)
PT = Point Bonita (20.7)
RR = Red Rock (1.4)
RY = Ryer Island, Suisun Bay (46.0)
SB = Sausalito Boatdocks (12.8)
YB = Yerba Buena Island (15.7)

Table 7. Summary information on harbor seals tagged in San Francisco Bay, CA, Jan 2001 – March 2004. (A) VHF radiotagged harbor seals. (continued on following page)

Seal ID	Date tagged (mm/dd/yy)	Tag days	Season of tag attachment	Age class	Sex	Haul-out sites used	Maximum distance from CR (km)	Median distance from CR[a] (km)	Mean distance ± SE from CR[a] (km)	Mean depth ± SE used in SFB (m)	Mean depth ± SE used outside of SFB (m)
15345	01/09/01	153	Winter/Pup	A	M	CR	34.7	3.4	3.9 ± 0.2	7 ± 1	N/A
15440	07/15/01	34	Molt/Fall	SA	F	CR	17.1	2.5	3.7 ± 0.5	8 ± 2	N/A
15436	07/16/01	31	Molt/Fall	SA	F	CR, CM, BI	7.5	2.4	3.0 ± 0.3	8 ± 1	N/A
19580	07/16/01	233	Molt/Fall/ Winter	A	F	CR, CM, BI, SB	36.5	5.1	5.0 ± 0.1	6 ± 1	18 ± 3
19582	07/17/01	22	Molt	A	M	CR, DR, FI	71.1	--[b]	--[b]	11 ± 3	37 ± 3
15439	07/19/01	69	Molt/Fall	A	F	CR	18.2	1.6	2.1 ± 0.2	9 ± 1	N/A
15437	01/24/02	126	Winter/Pup	A	M	DE, DP, BL, PT, YB, SB, PB	72.4	--[b]	--[b]	14 ± 2	23 ± 2
10024	8/12/2002	158	Molt/Fall/ Winter	A	F	CR, SB	27.5	1.8	2.4 ± 0.1	8 ± 1	N/A
10279	8/12/2002	97	Molt/Fall/ Winter	A	M	CR, SB	34.9	1.8	2.3 ± 0.2	7 ± 1	N/A
10278	8/12/2002	85	Molt/Fall	A	M	PB, YB	17.5	N/A	N/A	15 ± 3	N/A
10280	8/13/2002	229	Molt/Fall/ Winter	A	M	CR, RY	52.2	2.2	3.5 ± 0.3	3 ± 1	N/A
10297	8/13/2002	215	Molt/Fall/ Winter	SA	M	CR, PB, BI, SB	18.3	6.9	6.2 ± 0.1	10 ± 1	N/A
10863	8/13/2002	190	Molt/Fall/ Winter	SA	F	CR, BF, DP, DR, BE	47.0	2.7	3.2 ± 0.1	9 ± 1	5 ± 2[c]
42526	8/28/2003	141	Fall/Winter	SA	F	CR, BL, CM	47.9	2.2	2.6 ± 0.1	10 ± 1	5 ± 3
42527	8/28/2003	204	Fall/Winter/pre-Pupping	A	F	CR, BF, CP, DB, MS	64.4	8.9	7.8 ± 0.1	12 ± 1	N/A
42529	8/29/2003	107	Fall/Winter	Y	F	CR	12.5	3.3	3.4 ±0.1	8 ± 1	N/A
42530	8/29/2003	123	Fall/Winter	Y	F	CR, BE, BF, BL, DE, PI	72.2	2.2	3.3 ± 0.2	10 ± 1	13 ± 3

[a]when within 10km (across water) of the CR haul-out site
[b]CR not used as a primary haul-out site, or only used for a brief time
[c]few coastal location points, all near haul-out sites
[d]tag is still on seal at time of this report

Table 7. (continued) Summary information on harbor seals tagged in San Francisco Bay, CA, Jan 2001 – March 2004. (B) satellite-linked PTT-tagged harbor seals.

A.

Year	n (locations)	n (seals)	Median distance from CR (km)	Mean distance from CR (km) ± SEM
2001	945	6	2.5	3.2 ± 0.084
2002	1412	18	2.0	3.2 ± 0.078
2003	2180	12	1.6	2.9 ± 0.063
2004	222	2	4.4	4.7 ± 0.251

B.

Year (Aug-Feb)	n (locations)	n (seals)	Median distance from CR (km)	Mean distance (km) ± SEM
2001-2002	555	2	5.0	4.9 ± 0.093
2002-2003	561	2	2.5	3.1 ± 0.076
2003-2004	543	2	8.1	6.4 ± 0.133

Table 8. Distance from the CR haul-out site for tagged seals, by year, 2001-2004 (A) and during the fall/winter (non-pupping) season, 2001-2004 (B).

Tag Frequency	Sex	Age Class	Study Period days	Days at CR	Mean haul out time (hrs/day) at CR (±SE)	Mean site attendance (hrs/day) at CR (±SE)	% attendance at CR
1.310	F	A	19	9	4.38 ± 0.59	2.08 ± 0.58	47.4
1.652	F	SA	--*				
1.221	F	SA	99	89	4.97 ± 0.20	4.47 ± 0.23	89.9
0.320	F	SA	125	2	1.69 ± 0.87	0.03 ± 0.02	1.6
1.611	M	SA	102	35	4.39 ± 0.47	1.51 ± 0.26	34.3
1.361	F	Y	114	107	5.28 ± 0.19	4.95 ± 0.21	93.9
1.371	F	Y	124	119	5.98 ± 0.20	5.74 ± 0.22	96.0
1.631	M	Y	116	106	5.78 ± 0.28	5.28 ± 0.29	91.4
1.641	M	Y	108	45	9.68 ± 0.72	4.03 ± 0.55	41.7
1.727	F	Y	118	25	5.31 ± 0.62	1.13 ± 0.24	21.2
8.950	M	WP	199	7	4.63 ± 3.32	0.15 ± 0.08	3.5
8.020	F	WP	33	26	5.45 ± 0.55	4.30 ± 0.09	78.8
8.891	F	WP	103	42	6.03 ± 1.72	2.27 ± 0.10	40.8
8.142	M	WP	99	15	3.28 ± 1.65	0.48 ± 0.05	15.2
9.101	F	Y	128	121	5.35 ± 2.13	5.07 ± 0.09	94.5
8.828	F	WP	163	26	4.17 ± 2.72	0.65 ± 0.07	16.0
8.371	F	WP	--*				
8.292	F	WP	28	11	3.42 ± 0.47	1.33 ± 0.06	39.3
8.451	F	SA	140	97	4.97 ± 2.33	3.15 ± 0.08	69.3

*due to early tag loss or malfunction, data from seals 1.652 and 8.371 were not included here

Table 9. Time spent on the CR haul-out site (hrs/day) on days when CR used as a haul-out site (haul out time), based on data from the stationary radioreceiver/datalogger located at CR, and average time spent at CR (hrs/day) throughout the study period (site attendance). Study period is equal to tag duration, minus days when logger malfunctioned.

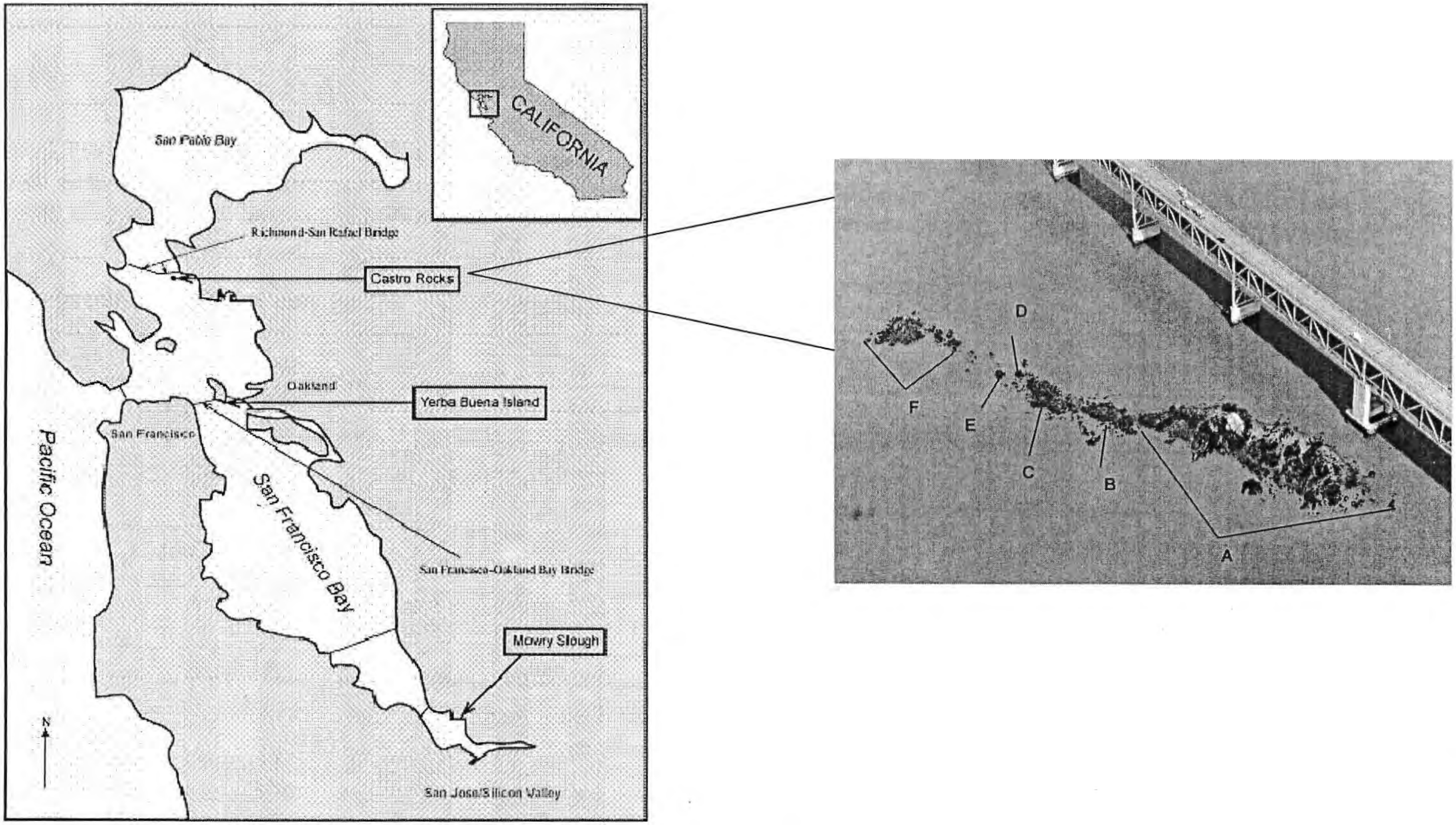


Figure 1. Map of study sites: Castro Rocks, Yerba Buena Island and Mowry Slough, with additional mapping of subsites A-F at Castro Rocks, Richmond-San Rafael Bridge (San Francisco Bay, CA).

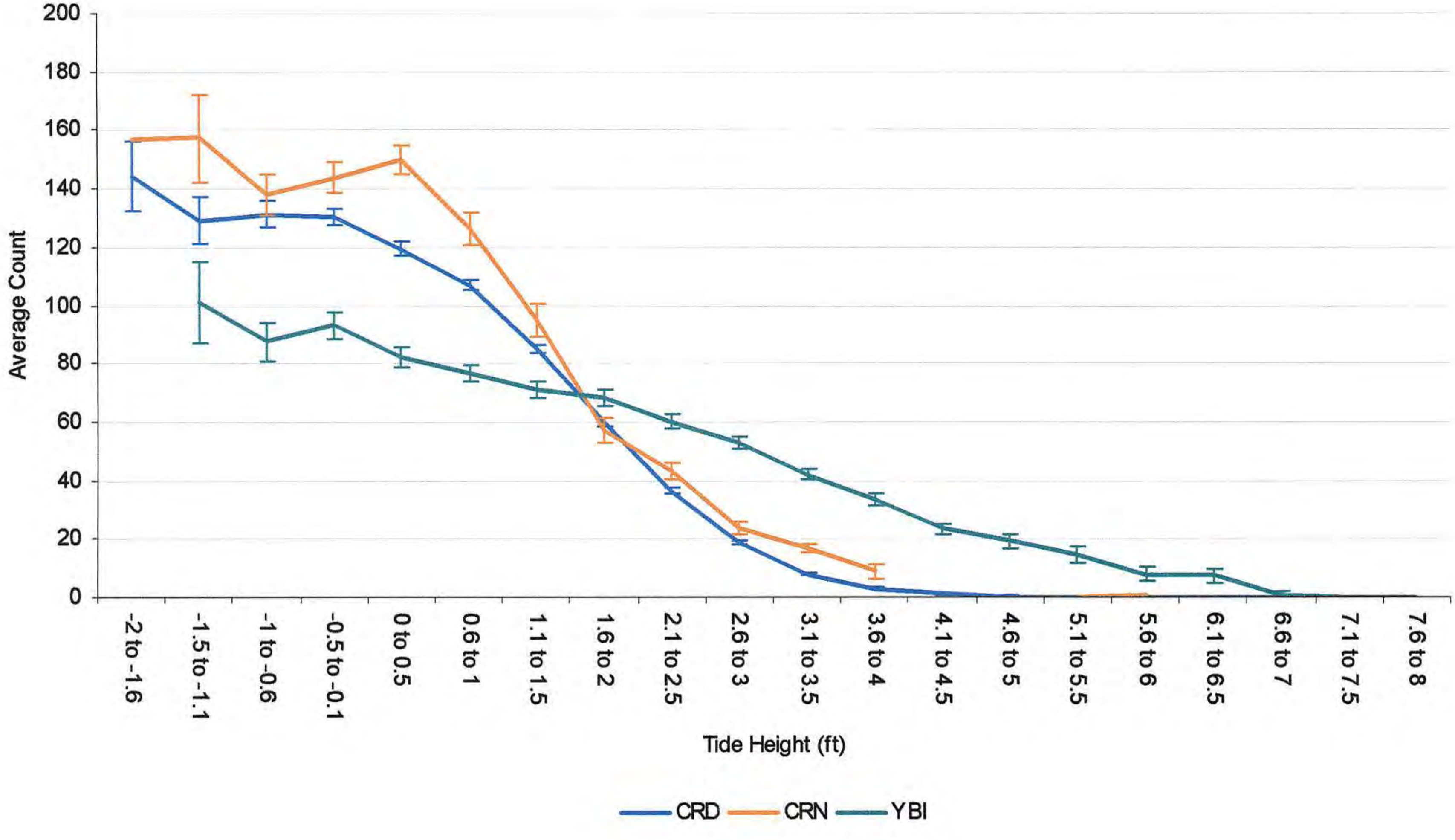


Figure 2. Average count (±SE) at each survey tide height for Castro Rocks Day (CRD), Castro Rocks Night (CRN) and Yerba Buena Island (YBI): May 1998 – December 2004

CRD

CRN

YBI

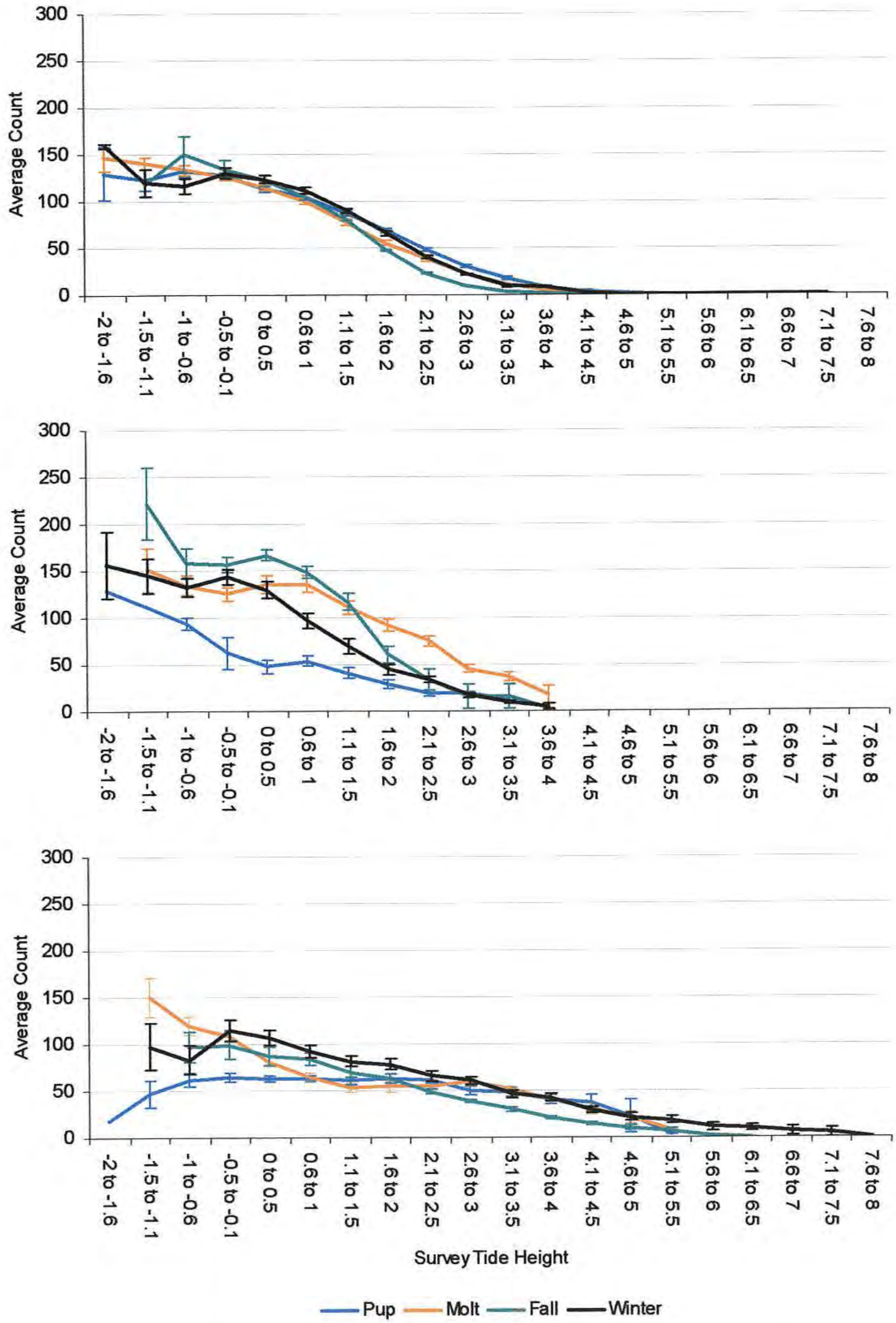


Figure 3. Average count (±SE) by survey tide height at Castro Rocks Day (CRD), Castro Rocks Night (CRN) and Yerba Buena Island (YBI) during the pupping, molting, fall and winter seasons: May 1998 – December 2004.

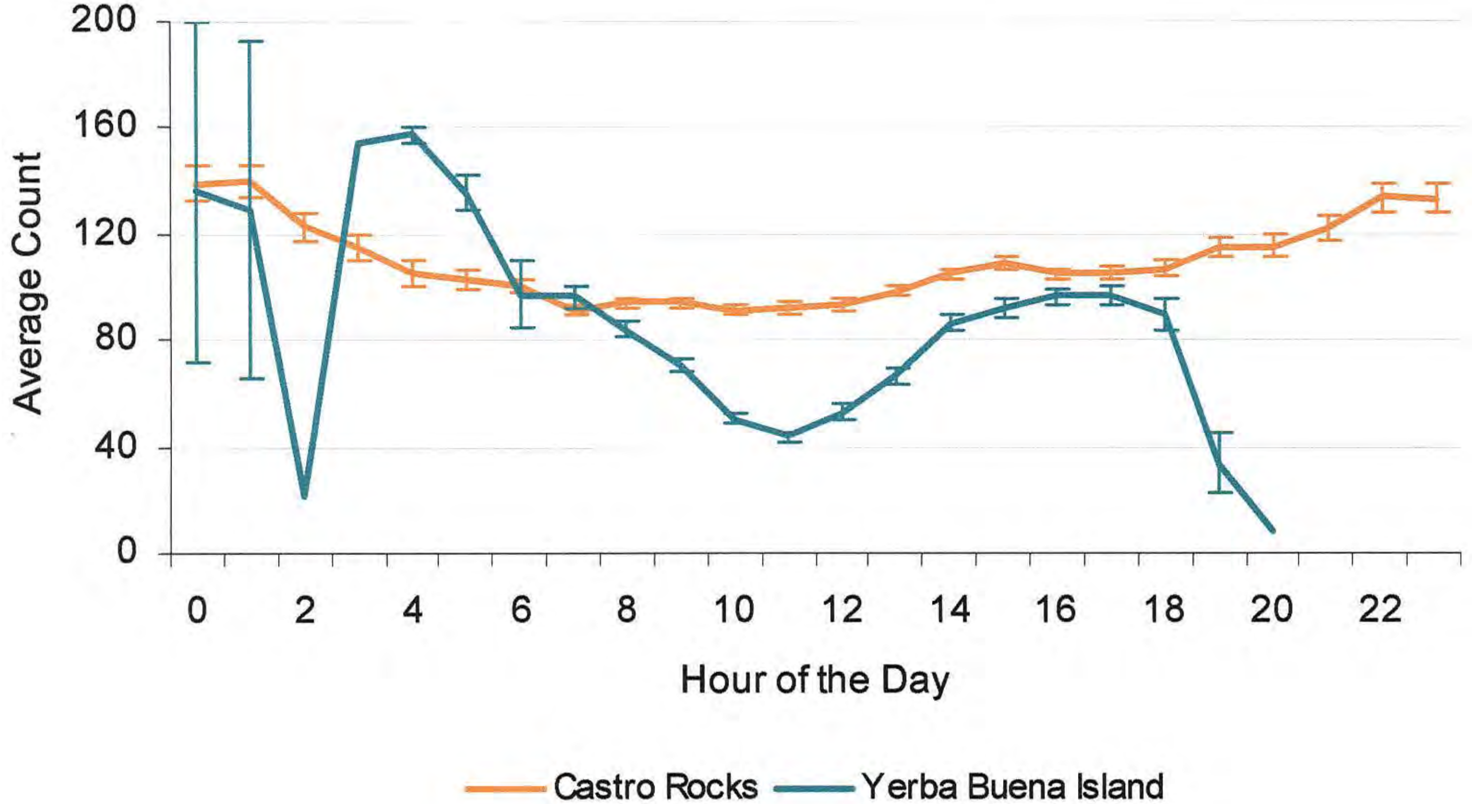
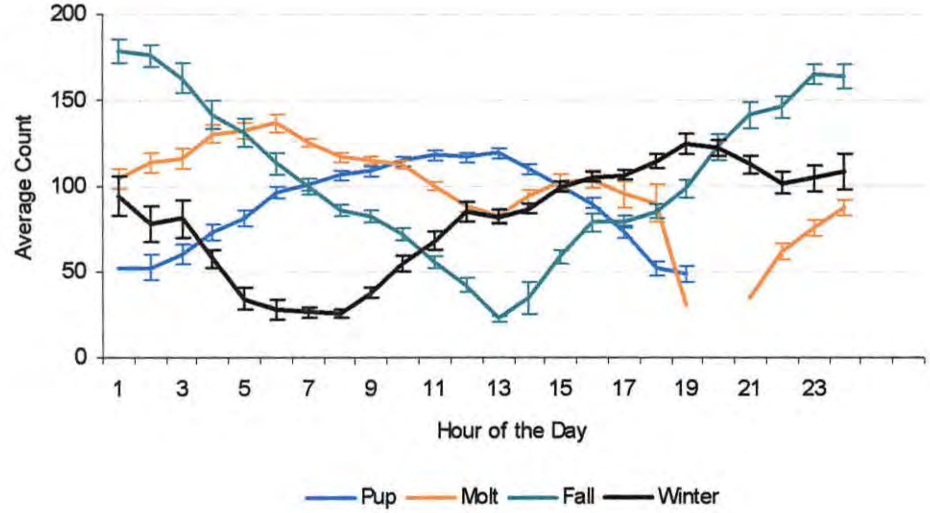


Figure 4. Average count (±SE) by hour of the day (May 1998 – December 2004) at Castro Rocks and Yerba Buena Island. Only those surveys taken at tides heights of ≤ 2 ft were used. NOTE: Only a few night counts at YBI have been possible, which greatly contribute to the large SE at night at YBI.

Castro Rocks



Yerba Buena Island

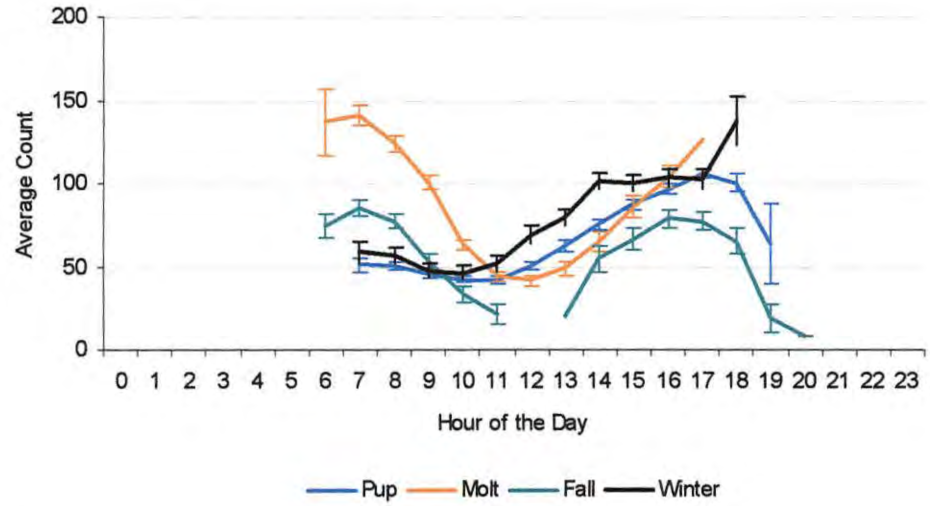


Figure 5. Average count (±SE) by hour of the day at Castro Rocks and Yerba Buena Island during the pupping, molting, fall and winter seasons: May 1998- December 2004. Only those surveys taken with a tide height of ≤ 2 ft were used.

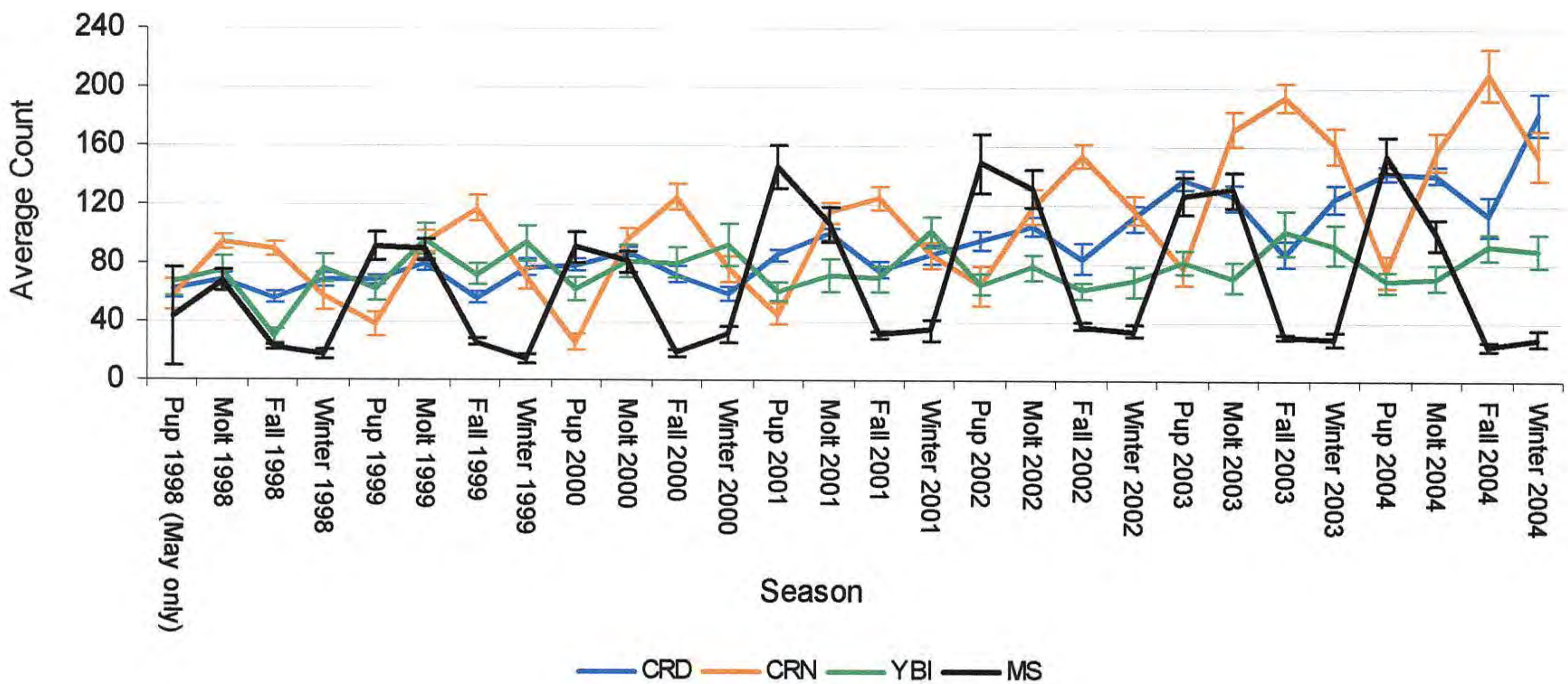


Figure 6. Average seasonal count (±SE) at Castro Rocks Day (CRD), Castro Rocks Night (CRN), Yerba Buena Island (YBI), and Mowry Slough (MS). Only those surveys taken when the survey tide height was ≤2 ft were used. Averages for MS were calculated regardless of tide height.

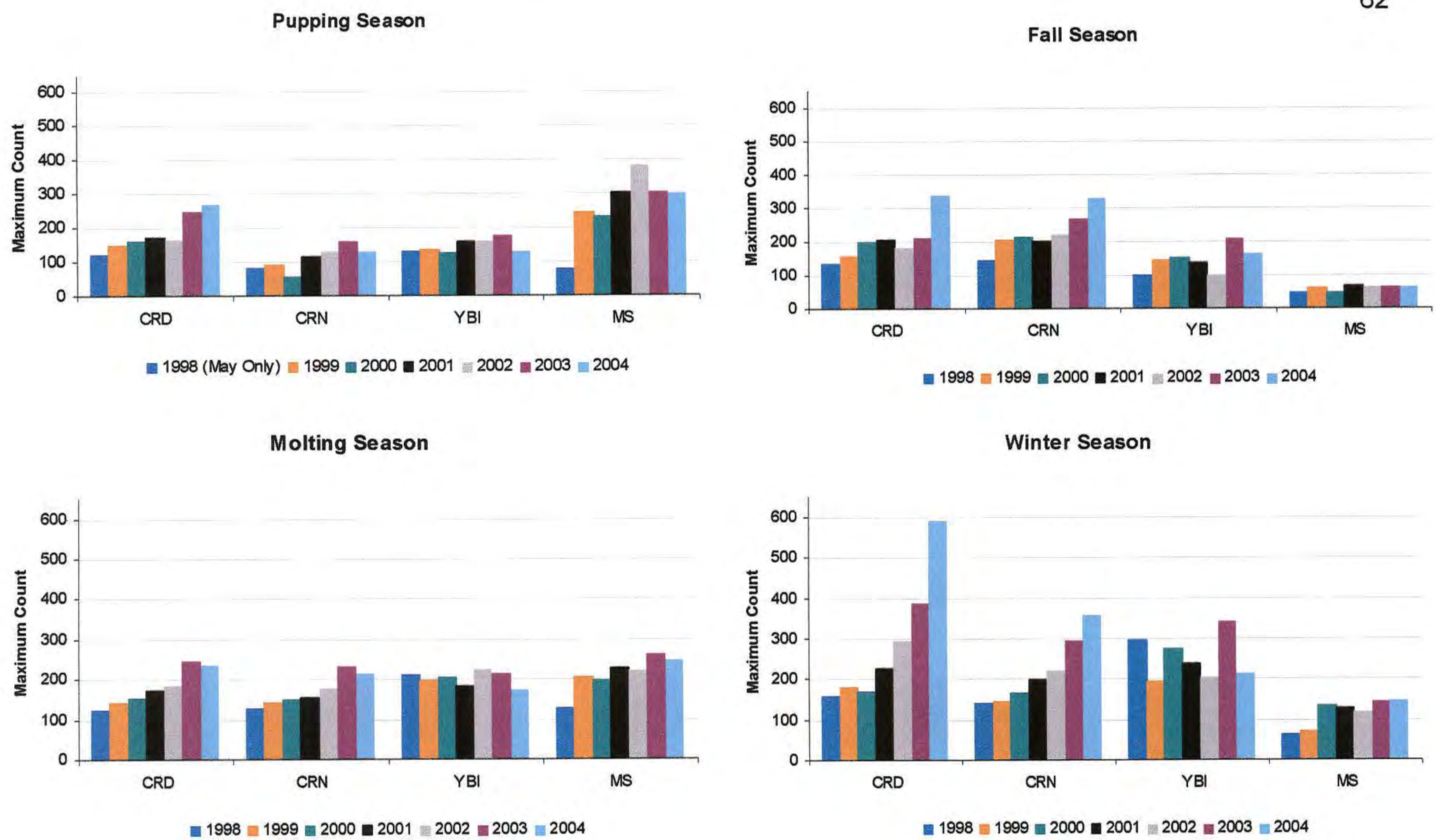


Figure 7. Maximum seasonal harbor seal counts at Castro Rocks Day (CRD), Castro Rocks Night (CRN), Yerba Buena Island (YBI), and Mowry Slough (MS): May 1998 – mid March 2005.

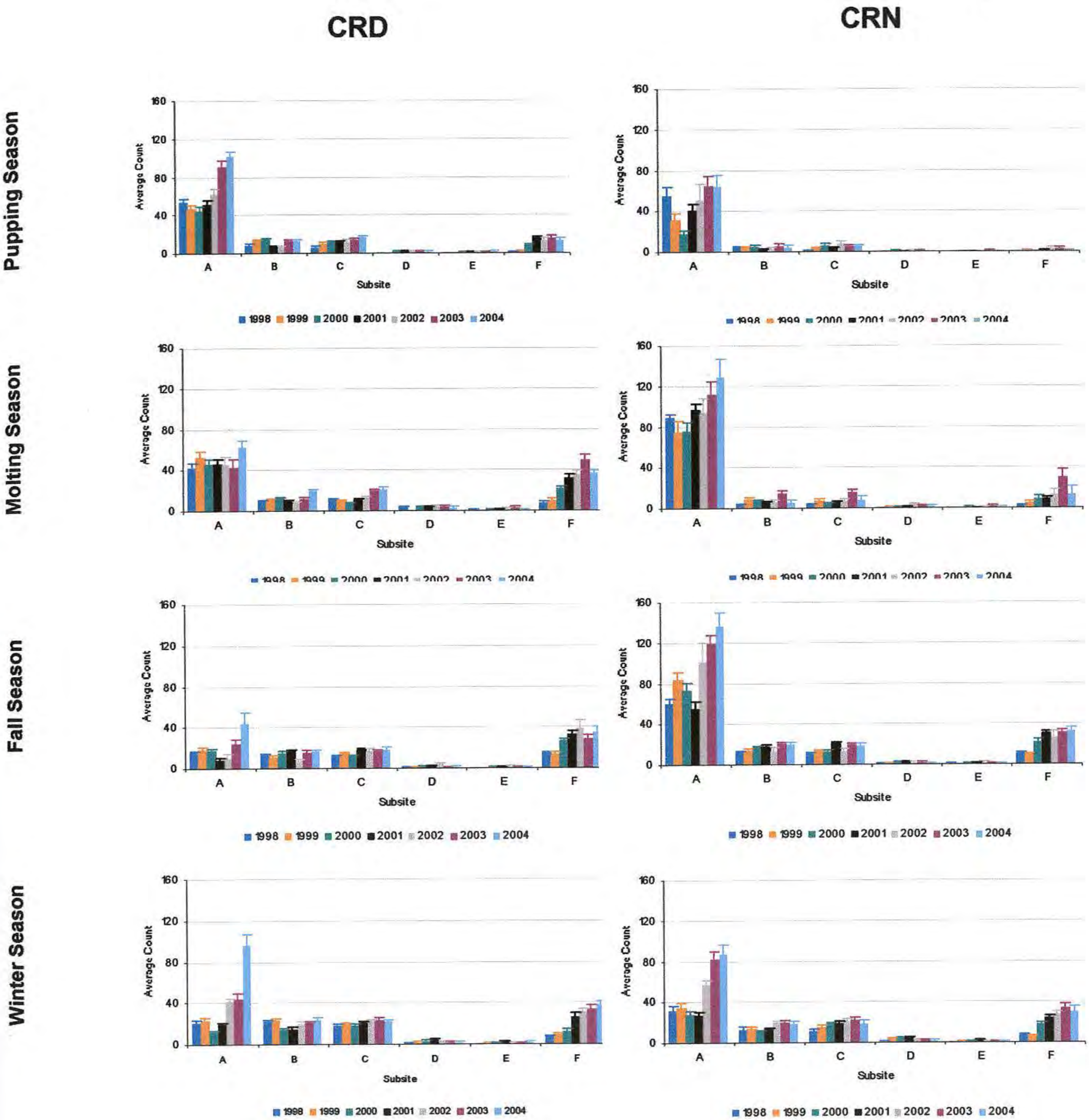


Figure 8. Average number (±SE) of seals hauled out on each subsite at Castro Rocks Day (CRD) and Night (CRN) during each season: May 1998 – mid March 2005. Only those surveys taken when the survey tide height was ≤2 ft were used.

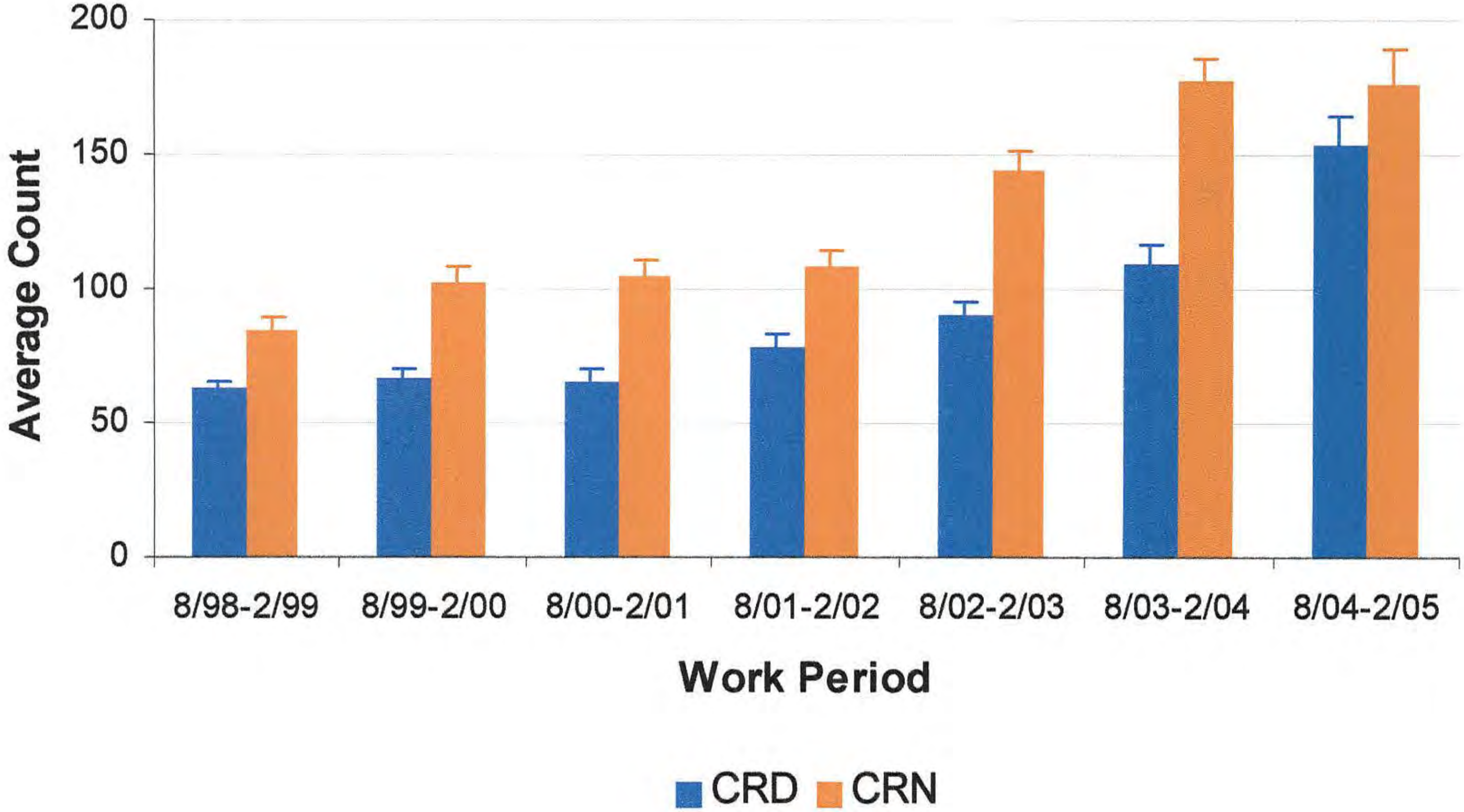


Figure 9. Average counts (±SE) at Castro Rocks Day (CRD) and Night (CRN) during construction work periods. Construction activities did not begin until the end of the 2000-2001 work period. All averages were calculated using only those surveys taken at tide heights of ≤2 ft.

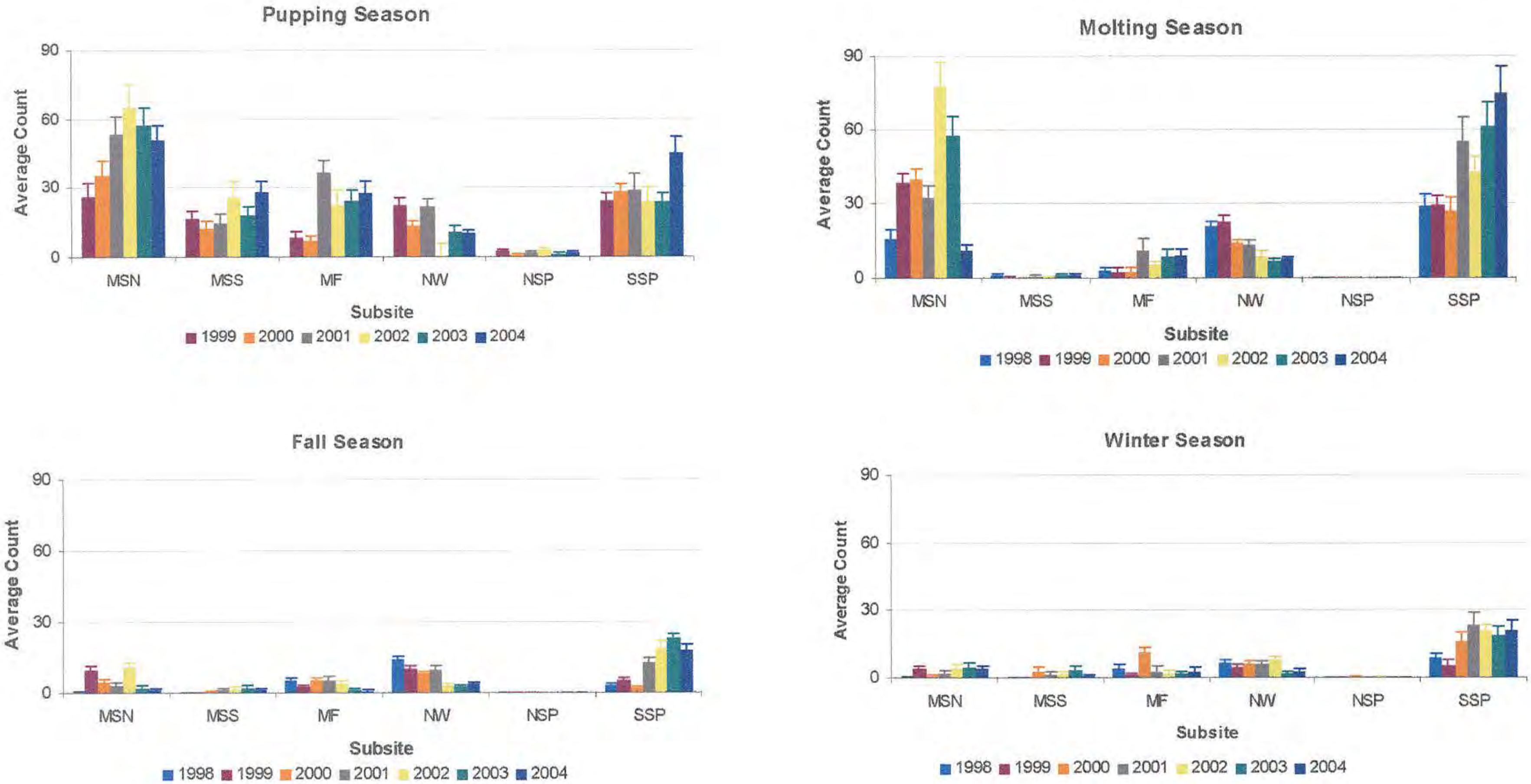


Figure 10. Average Counts (±SEM) at Mowry Slough during each season. Average counts were calculated regardless of tide height. Molting 1998 – Winter 2004. MSN – Mowry Slough North, MSS – Mowry Slough South, MF – Mud Flats, NW – Newark Slough, NSP – North Salt Pile, SSP – South Salt Pile

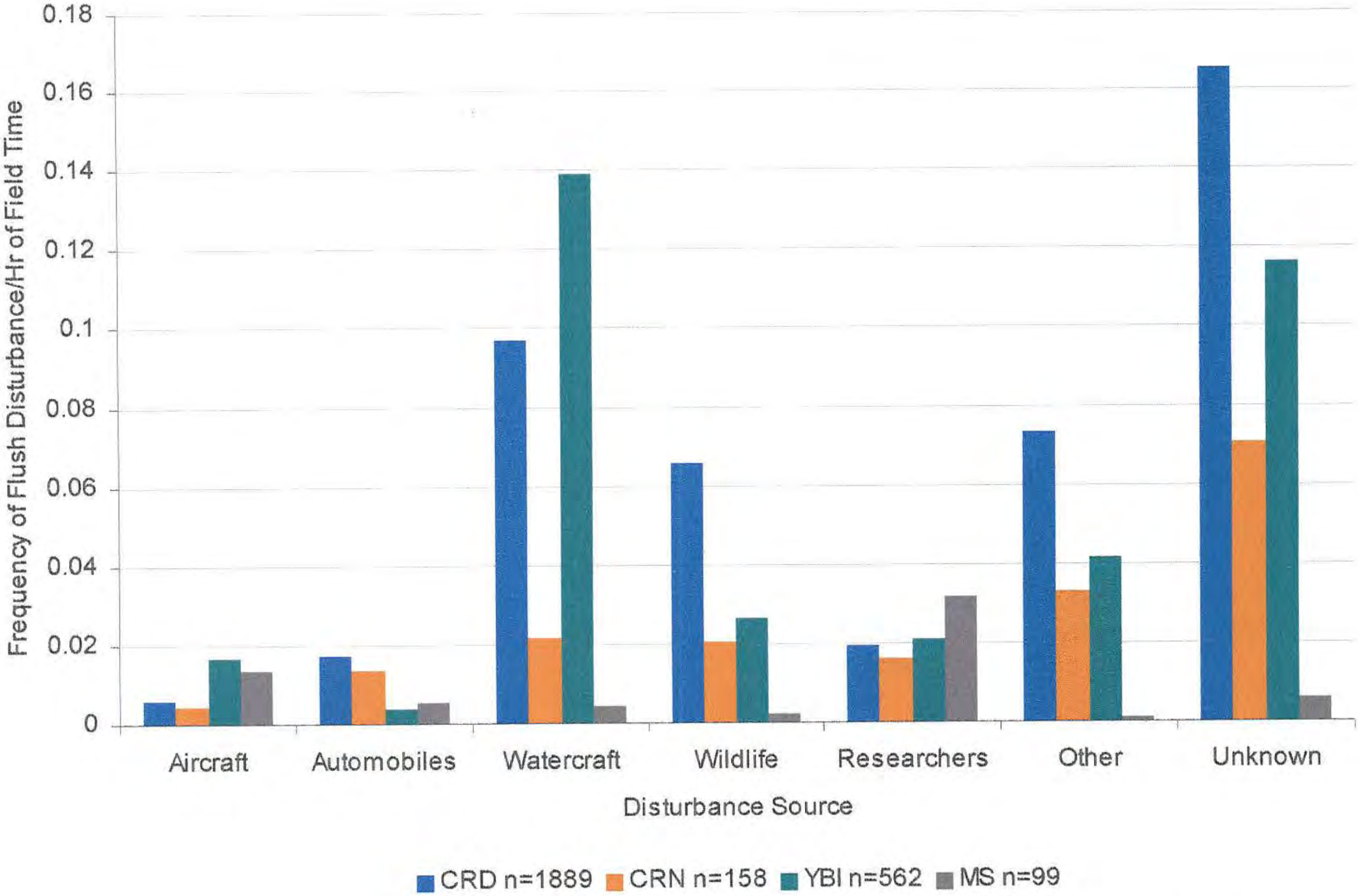


Figure 11. Frequency per hour of field time for disturbance sources at Castro Rocks Day (CRD), Night (CRN), Yerba Buena Island (YBI) and Mowry Slough (MS). Only those disturbances which caused a flush are included.: May 1998 – mid March 2005, includes data collected at tide heights of ≤ 2 ft. NOTE: Disturbances due to watercraft include watercraft associated with construction activities.

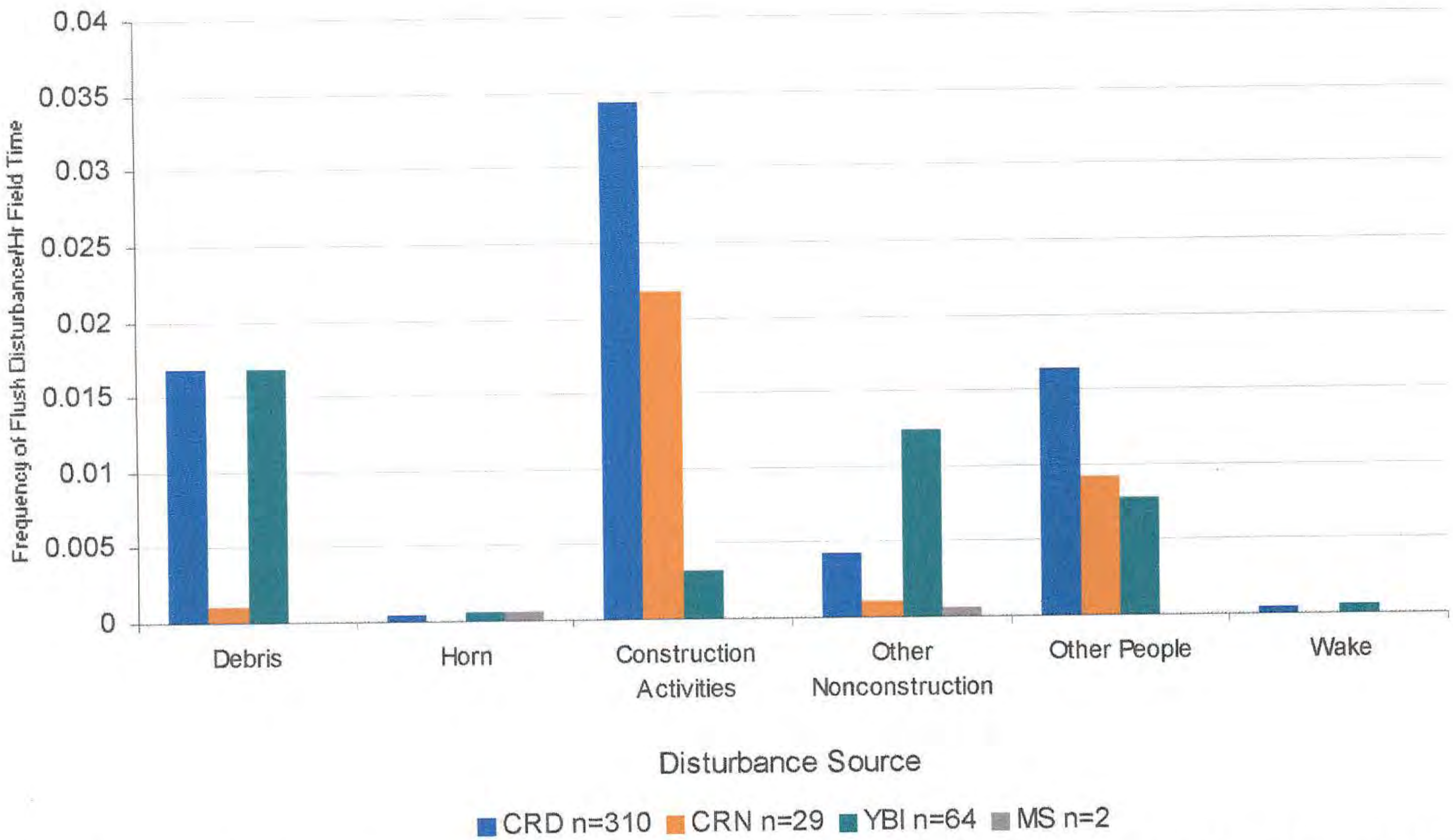


Figure 12. Frequency per hour of field time for disturbance sources included in the "other" category at Castro Rocks Day (CRD), Night (CRN), Yerba Buena Island (YBI) and Mowry Slough (MS). Only those disturbances which caused a flush at tide heights of ≤ 2 ft are included, May 1998 – mid March 2005. NOTE: Disturbances related to construction work are included in the categories "debris" and "other people".

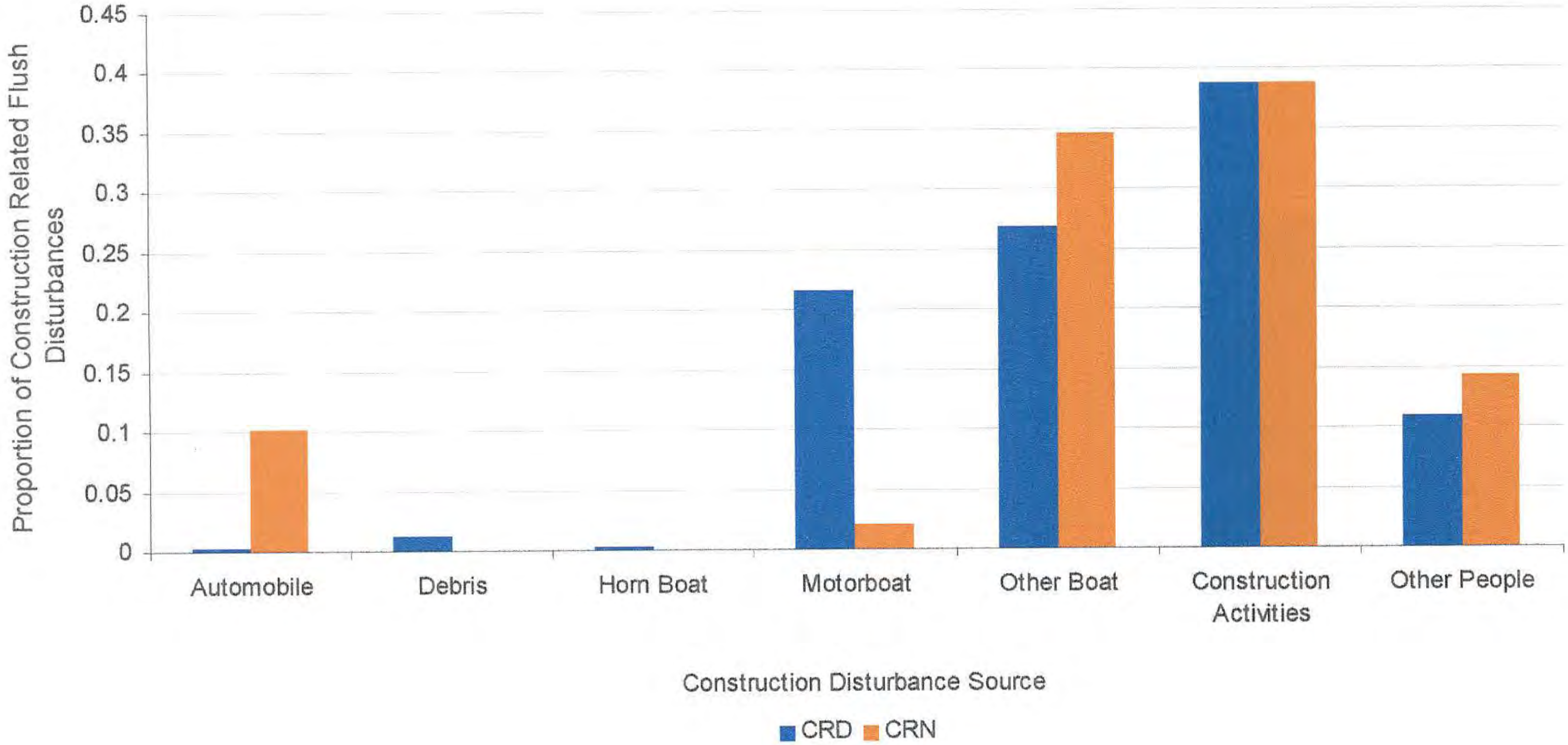


Figure 13. Proportion each construction source contributed to the overall construction-related flush disturbances at Castro Rocks during the daytime (CRD) and night (CRN). Only those disturbances recorded at tide heights of ≤2 ft were included in the analyses. Includes all construction-related flush disturbances recorded since the commencement of construction activities (January 2001).

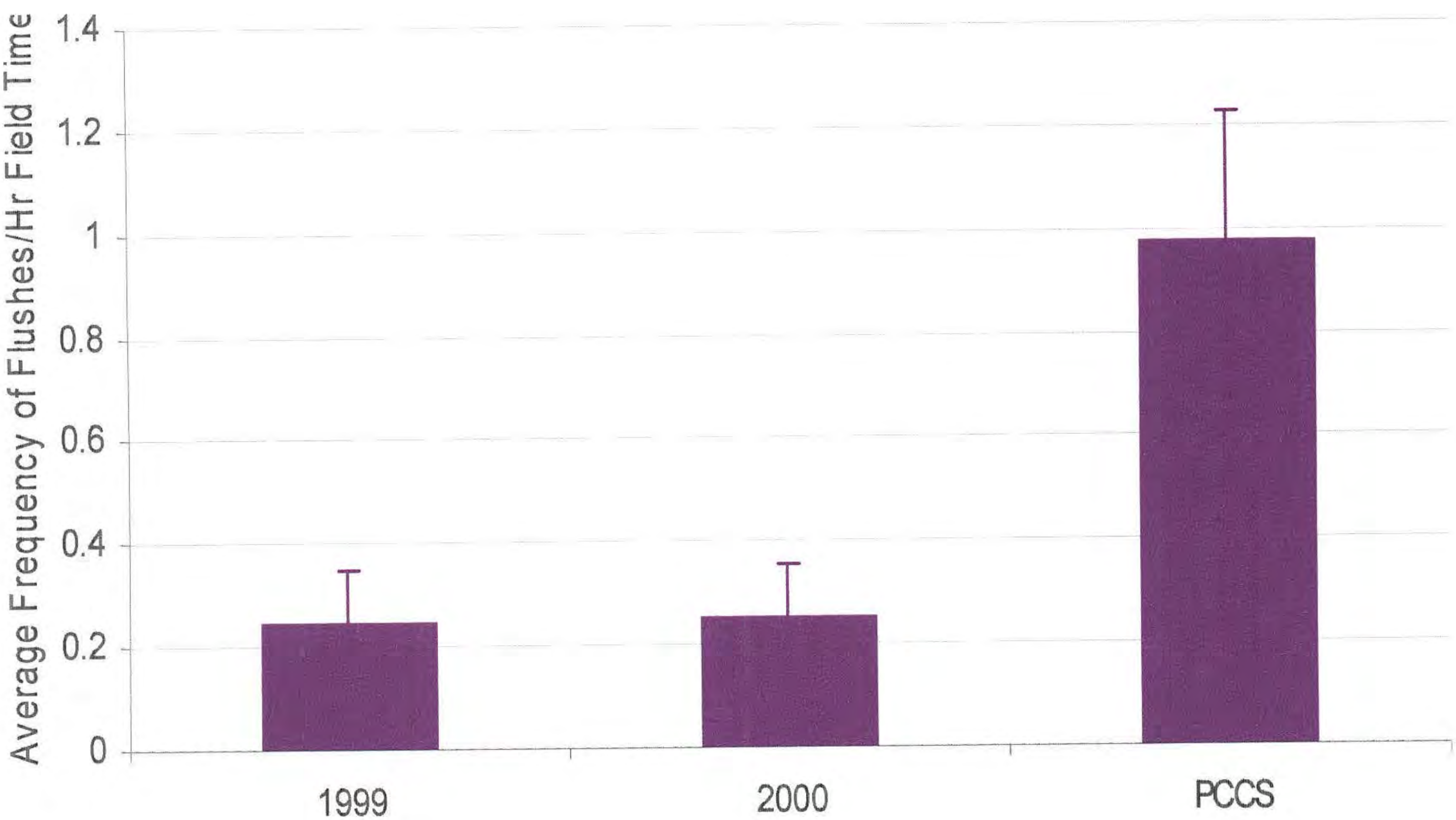
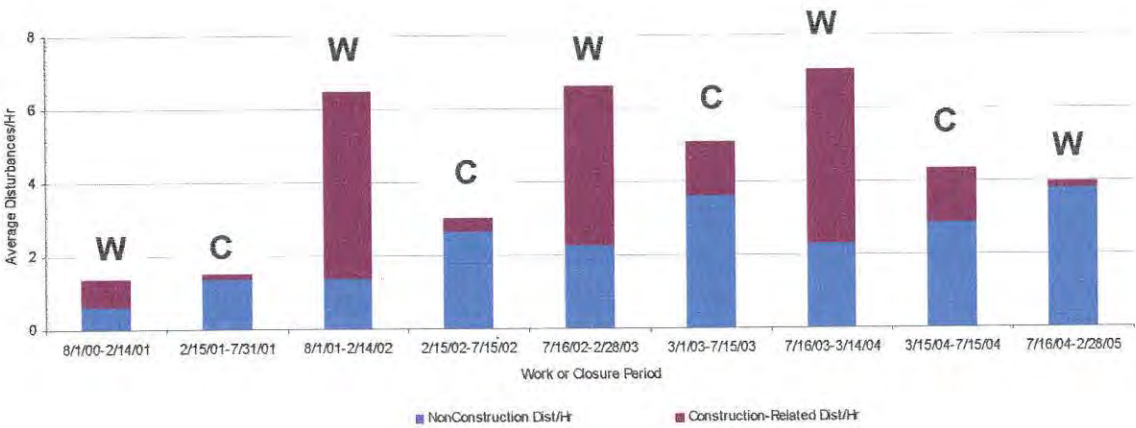


Figure 14. Average frequency of disturbances/hr of field time to cause a flush during Preconstruction core sampling (PCCS) in January/February 2001 compared to the same time period in 1999 and 2000; includes both construction-related and non construction-related disturbances sources.

A



B

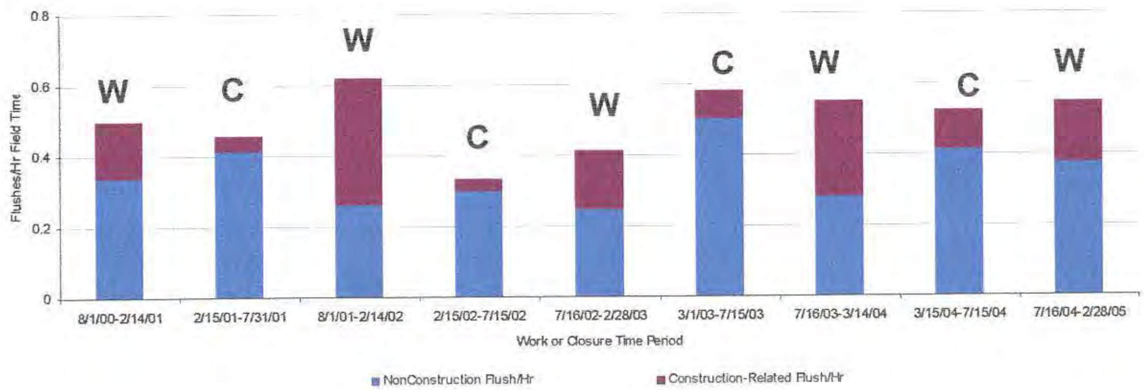
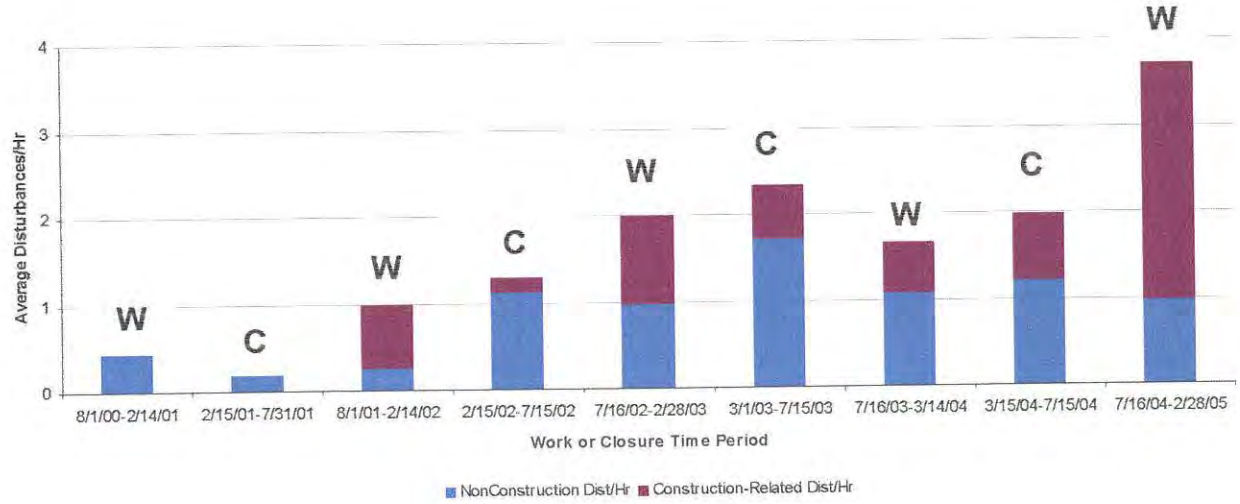


Figure 15. Disturbances (A) and flushes (B) per hour of field time at Castro Rocks DAYTIME, showing the proportion of the overall disturbances or flushes due to nonconstruction, or construction related activities during each work (W) or closure (C) period. NOTES: 1. Only disturbances recorded when the tide height was ≤2ft are included. 2. The work period was longer during the 2002/2003 (7/16/02-2/28/03), 2003/2004 (7/16/03-3/14/04) and 2004/2005 (7/16/04-2/28/05) work periods compared to prior years (August 1st – February 14th). 3. The scale on figures A and B are different, with a 10-fold difference between the two.

A



B

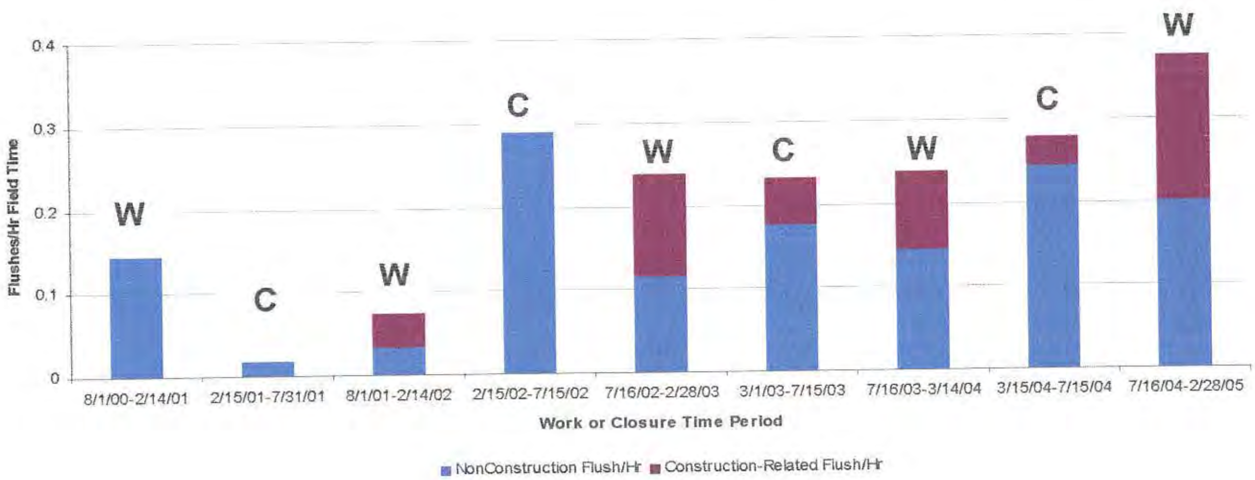


Figure 16. Disturbances (A) and flushes (B) per hour of field time at Castro Rocks NIGHTTIME exhibiting the proportion of the overall disturbances or flushes due to nonconstruction, or construction related activities during each work (W) or closure (C) period. NOTES: 1. Only disturbances recorded when the tide height was ≤2ft are included. 2. The work period was longer during the 2002/2003 (7/16/02-2/28/03) and 2003/2004 (7/16/03-3/14/04) work periods compared to prior years (August 1st – February 14th). 3. The scale on figures A and B are different, with a 10-fold difference between the two.

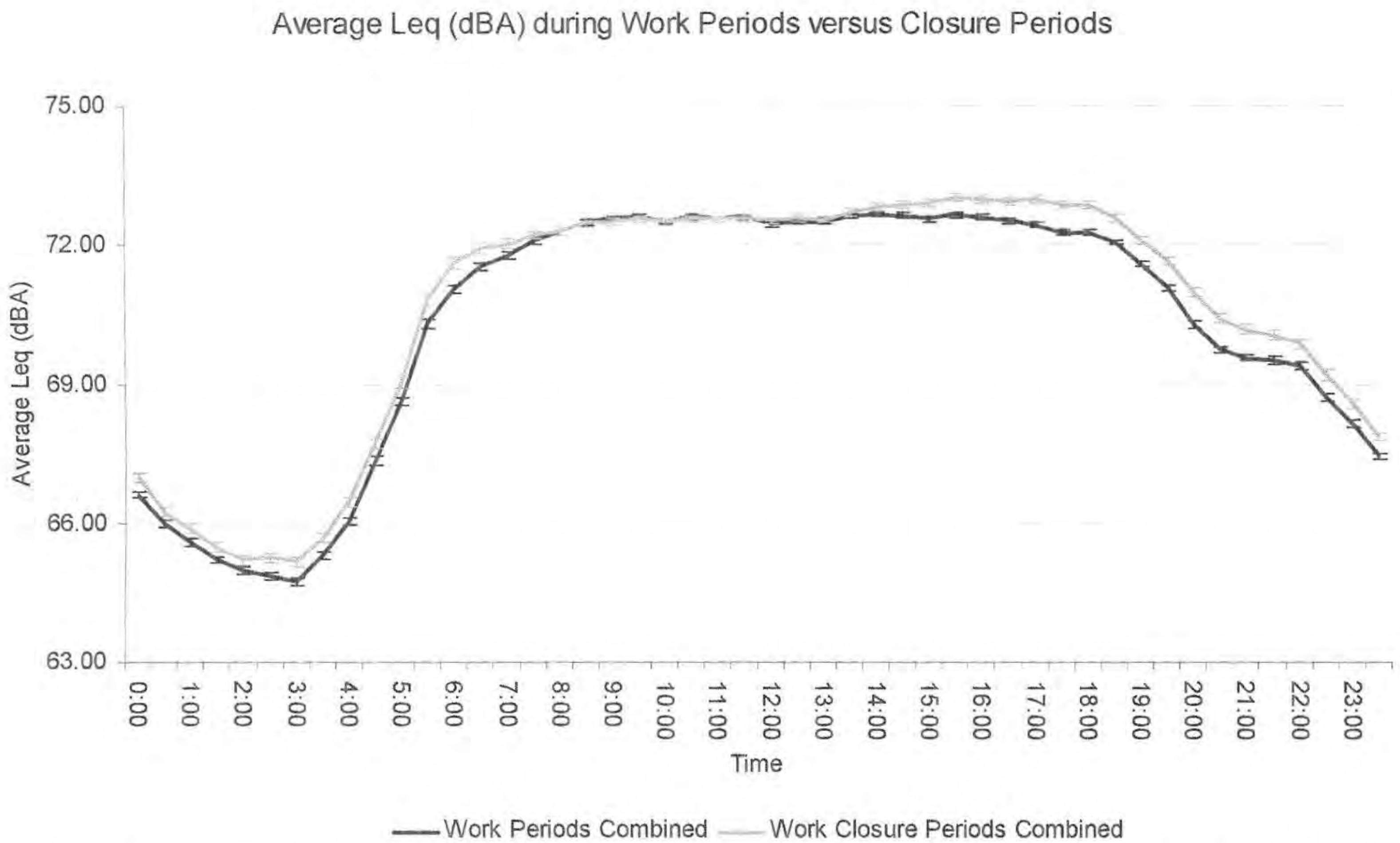
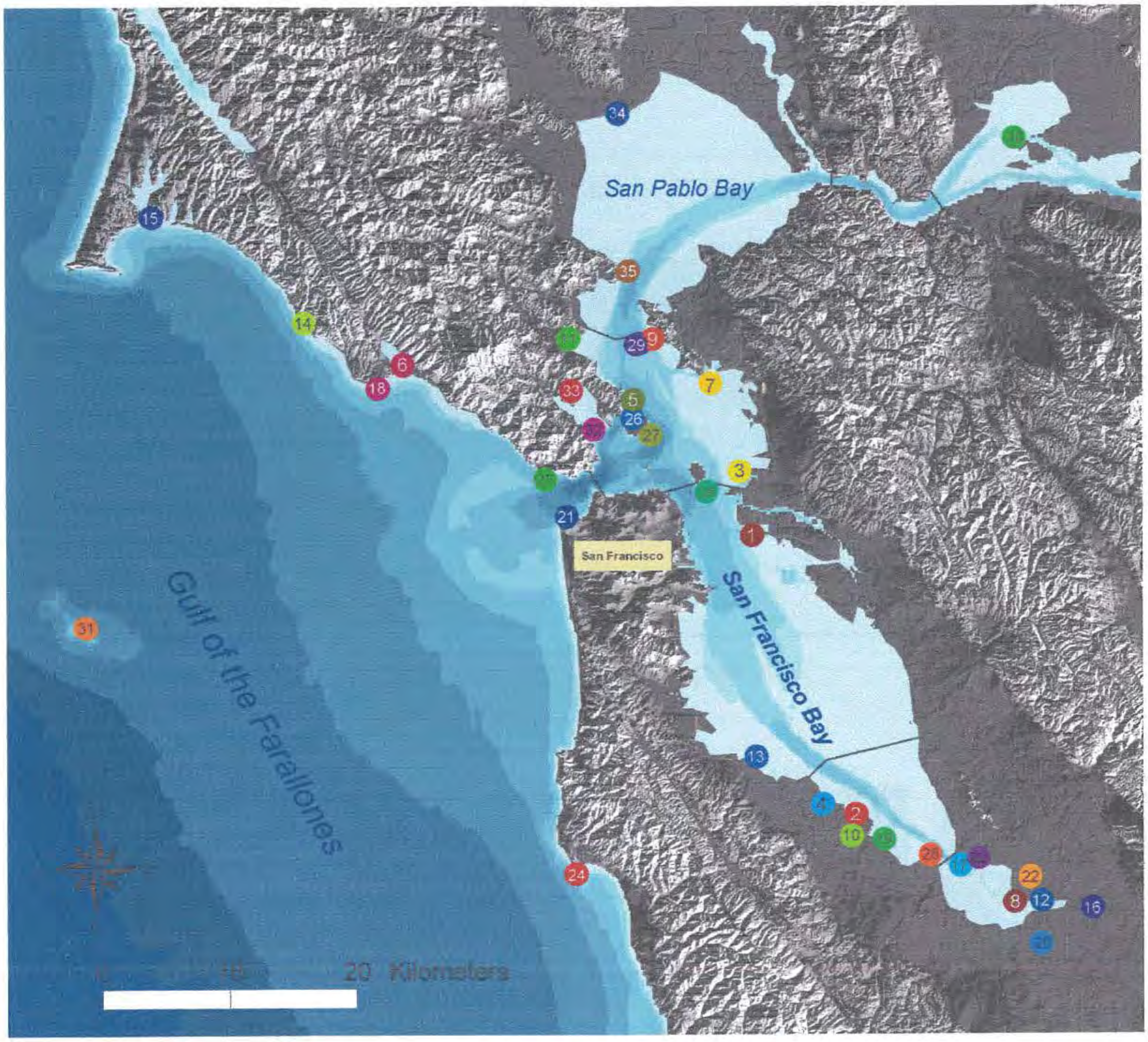


Figure 17. Average Leq (± SE) levels at Castro Rocks throughout the day comparing all air acoustic data during work periods (1/1/01-2/14/01, 8/1/01-2/14/02, 7/16/02-2/28/03, 7/16/03-3/14/04, 7/16/04-2/28/05) versus work closure periods (2/15/01-7/31/01, 2/15/02-7/15/02, 3/1/03-7/15/03, 3/15/04-7/15/04). Leq represents the level of a constant sound over a period of time that has the same sound energy as the actual (unsteady) sound over the same time period. NOTE: Due to equipment difficulties, very limited data is available December 2002-March 2003 and October 2004-February 2005.



Harbor Seal Haul Out Sites

- 1 Alameda Breakwater
- 2 Bair Island
- 3 Bay Bridge Sandspit
- 4 Belmont Slough
- 5 Bluff Point, Tiburon
- 6 Bolinas Lagoon
- 7 Brook's Island
- 8 Calaveras Point
- 9 Castro Rocks
- 10 Corkscrew Slough
- 11 Corte Madera
- 12 Coyote Creek
- 13 Coyote Point
- 14 Double Point (PRNS)
- 15 Drakes Estero (PRNS)
- 16 Drawbridge
- 17 Dumbarton Point
- 18 Duxbury Reef
- 19 Greco Island
- 20 Guadalupe Slough
- 21 Land's End
- 22 Mowry Slough
- 23 Newark Slough
- 24 Pillar Point
- 25 Pt. Bonita
- 26 Pt. Ione, Angel Island
- 27 Pt.Blunt, Angel Island
- 28 Ravenswood Point
- 29 Red Rock
- 30 Ryer Island (Suisun Bay)
- 31 SE Farallon Island
- 32 Sausalito Boatworks
- 33 Strawberry Spit
- 34 Tubb's Island
- 35 Two Sisters
- 36 Yerba Buena Island
- Bridge

Figure 18: Map of active and historical harbor seal haul-out sites in San Francisco Bay, California, and along the adjacent central California coastline.
Bathymetry data: California Dept. of Fish and Game, Teale Data Center, California digital elevation model. Land relief data: USGS, SF Bay Region shaded relief map.

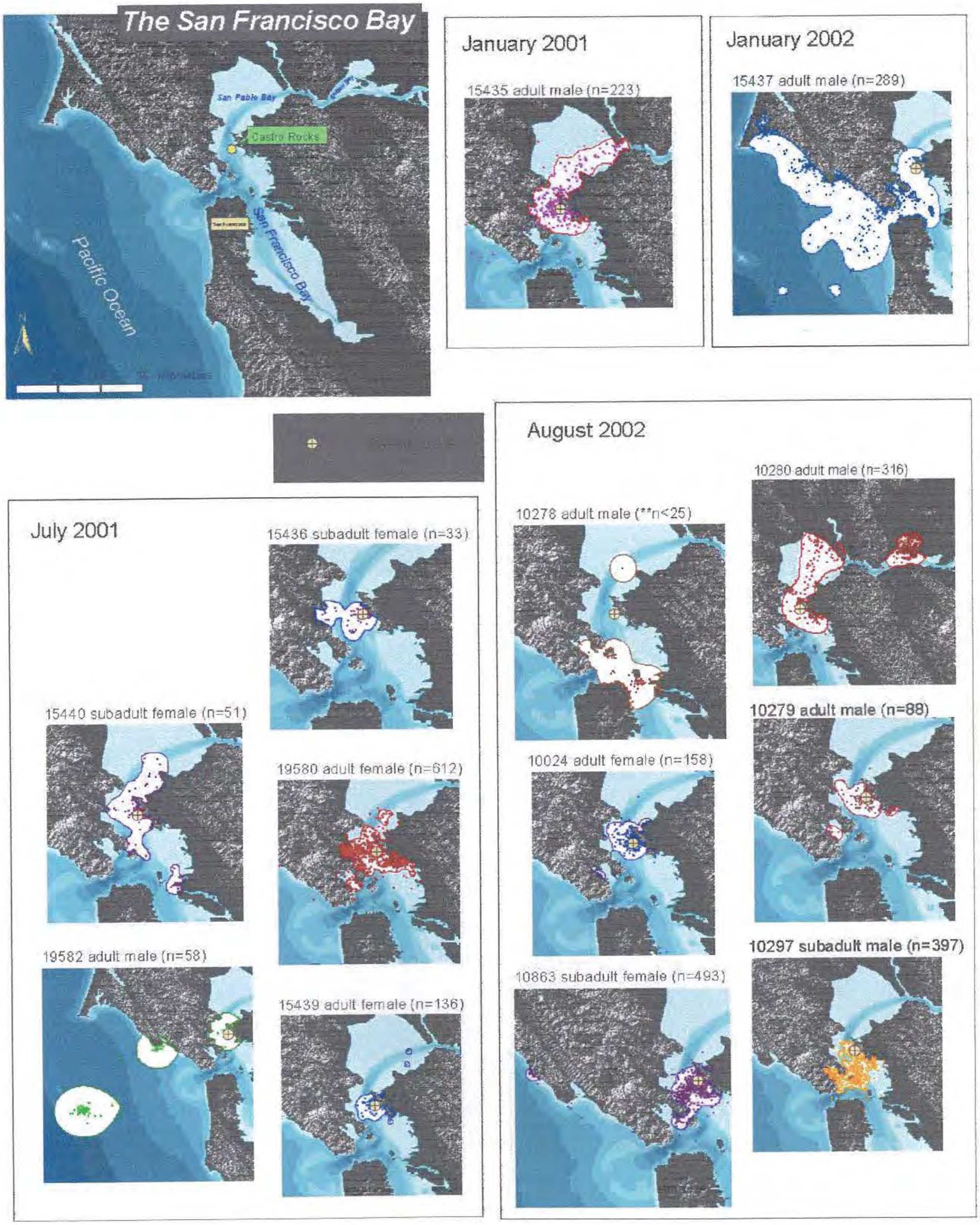


Figure 19(A): Use areas and point location sample sizes for harbor seals tagged at Castro Rocks with satellite-linked telemetry tags, by tagging date, 1/01 – 8/02.

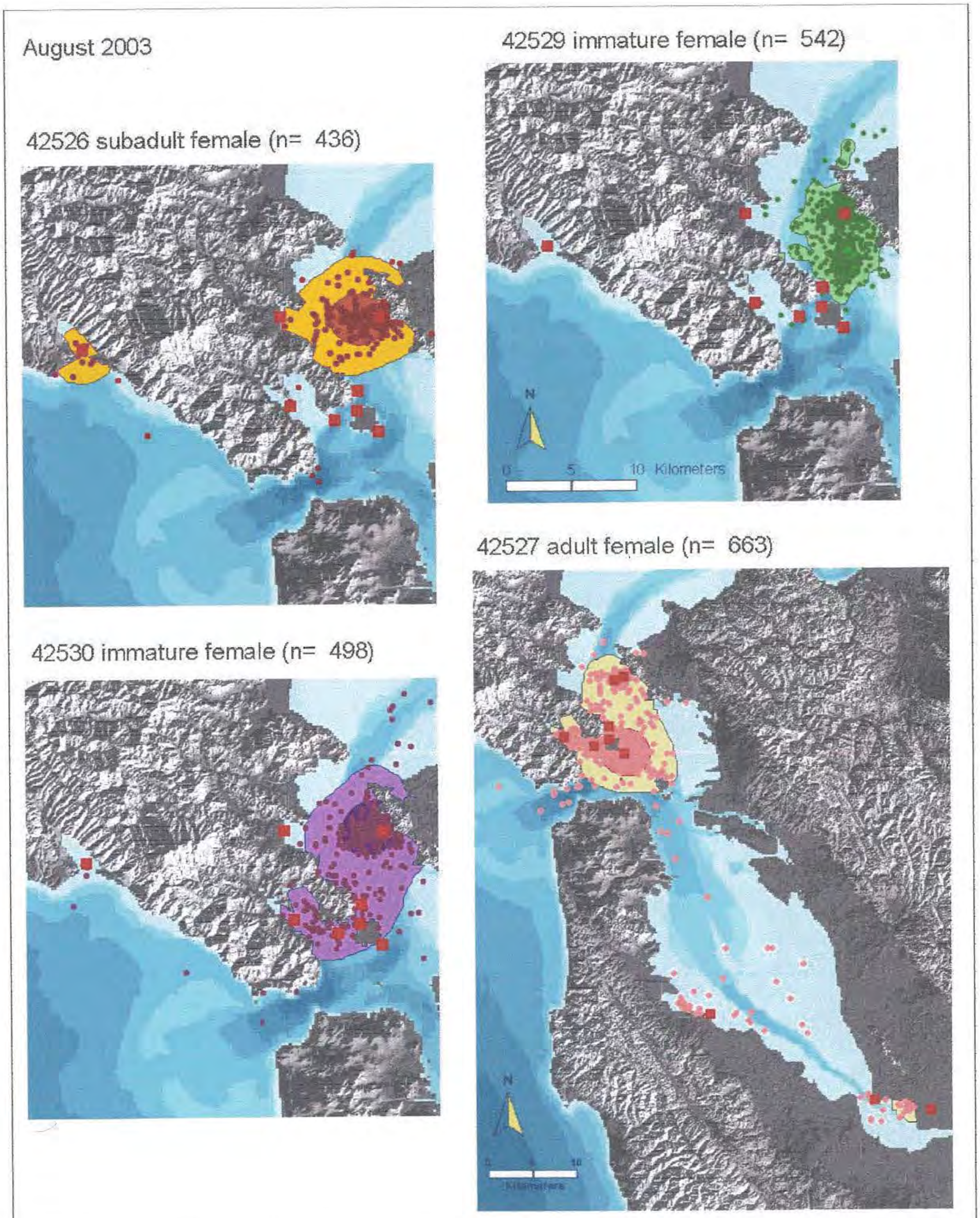


Figure 19(B): Use areas and point location sample sizes for harbor seals tagged at Castro Rocks with satellite-linked telemetry tags, by tagging date (8/03). Harbor seal haul-out sites are shown as red squares.

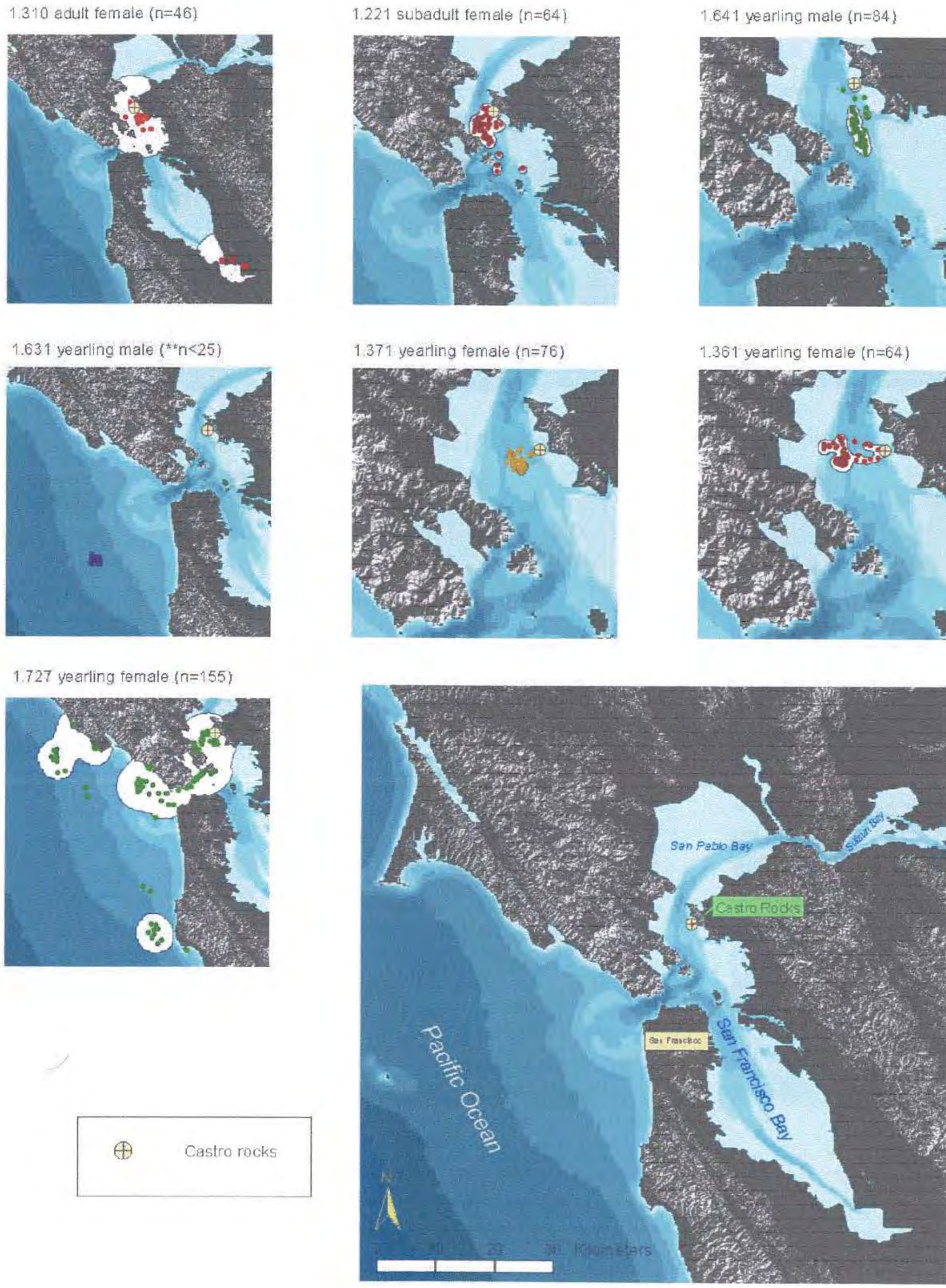


Figure 20(A): Use areas and sample sizes for VHF telemetered harbor seals tagged in the winter (Jan 2001 and Jan 2002), prior to pupping season (March-May). **Use areas based on small point location sample size (n<25) are noted.

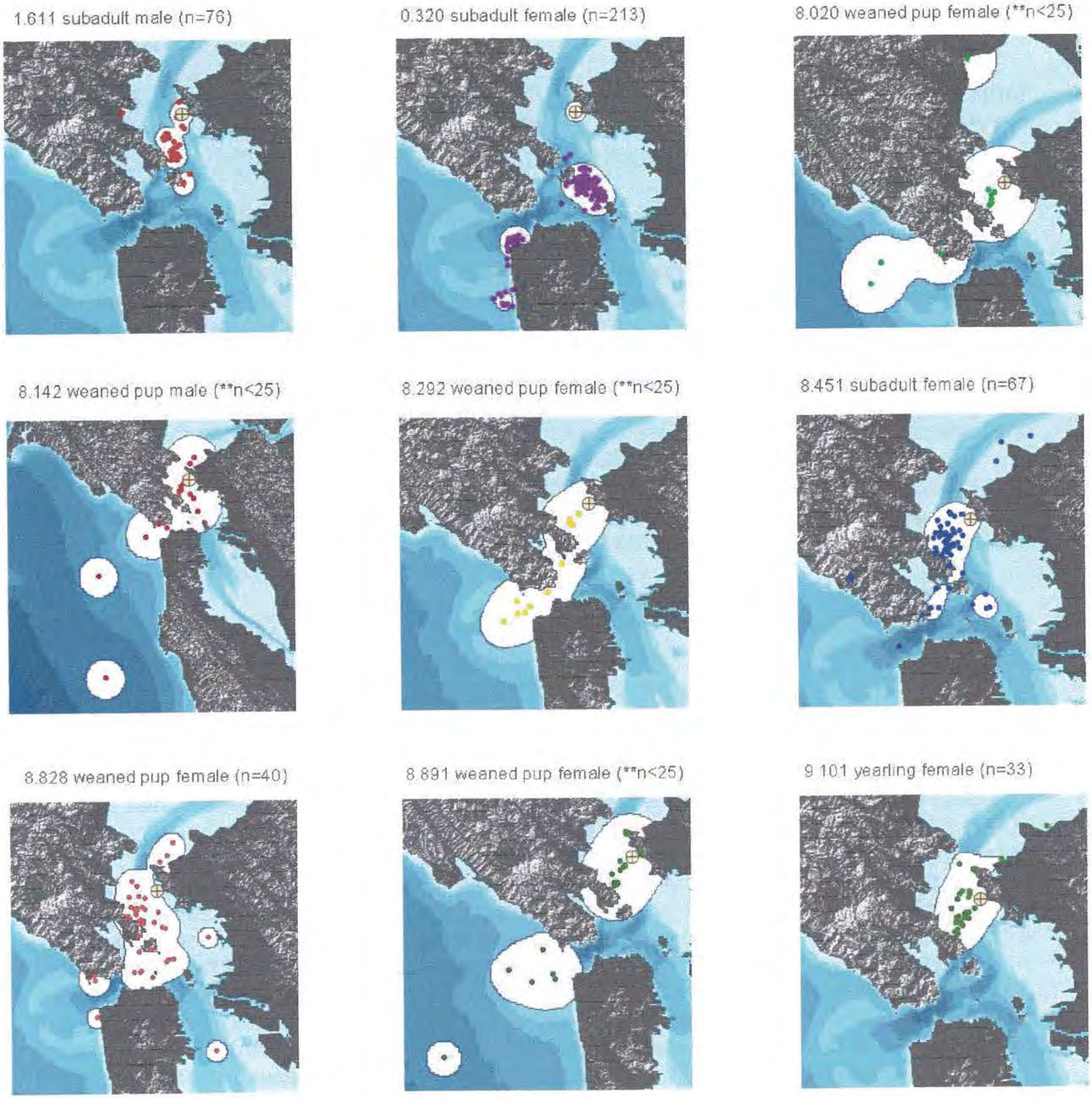


Figure 20(B): Use areas and sample sizes for VHF telemetered harbor seals tagged in the molting season (July 2001 and Aug 2002), prior to fall/winter seasons (August – February). **Use areas based on small point location sample size (n<25) are noted.

Appendix A – Publications, Posters and Presentations

Publications:

Grigg EK, Green DE, Allen SG, Markowitz H, (2002) Diurnal and Nocturnal Haul Out Patterns of Harbor Seals (*Phoca vitulina richardsi*) at Castro Rocks, San Francisco Bay, California, California Fish and Game Journal 2002 88(1): 15-27.

Surveys of harbor seals, *Phoca vitulina richardsi*, at Castro Rocks, San Francisco Bay (SFB), California, were conducted from May 1998 through April 2001. Surveys were conducted at all hours of the day, and disturbance data and seal responses were recorded continuously during these surveys. Harbor seals hauled out at Castro Rocks during the daytime and nighttime throughout the year. Over the course of the study period, mean nighttime counts were significantly higher than mean daytime counts. Maximum daytime and nighttime seal counts were recorded during the fall season. Tidal dependence alone was not a clear predictor of fluctuations in seal numbers hauling out during the daytime compared to the nighttime. Seals at this site experienced high levels of disturbance from a variety of sources during the daytime, and significantly lower levels of disturbance at night. We believe that, in this highly urbanized environment, high levels of daytime disturbance contribute to the higher use of this haul-out site at nighttime, versus daytime. Given projected increases in the number of people living and working around SFB, protecting the integrity of haul-out sites in SFB is an important facet of protecting the harbor seal population.

Grigg EK, Allen SG, Green DE, Markowitz H, (2003) Harbor Seal (*Phoca vitulina richardii*) population trends in the San Francisco Bay Estuary, 1970-2002. California Fish and Game Journal, 90(2): 51-70, Spring 2004.

Pacific harbor seals, *Phoca vitulina richardii*, have used the San Francisco Bay estuary in California as a nursery area and foraging site for thousands of years. Like other pinniped species, harbor seals in California were intensively hunted in the late 1800's and early 1900's, resulting in population declines obvious in the San Francisco Bay (SFB) by the 1920's. In 1972, the Marine Mammal Protection Act was passed, providing protection and management of harbor seal populations. We examined historical data (1970-1997) and our own ground counts at three primary SFB haulout sites (1998-2002) in order to understand the degree of recovery of the SFB harbor seal population. One of the largest estuaries on the west coast of the United States, SFB today is highly urbanized and heavily impacted by human activity. We documented a mixed response and recovery of harbor seals in SFB, likely due to a combination of factors, including habitat alteration, disturbance, pollution, and survey techniques. From 1970-2002, seal numbers at all three sites increased slightly during the fall/winter season, and increased at two sites during the pupping/molting season. At the largest SFB rookery site, however, no change was seen in seal numbers during the pupping/molting season.

Students Working With This Project (Includes Completed and Active Work):

Galloway, M. (2000) Factors influencing scanning rates of harbor seals at Yerba Buena Island, California. Master's Thesis, San Francisco State University, Department of Biology, San Francisco, CA, 90 pages.

Bohorquez, A. (2002) Pupping phenology and haul out patterns of harbor seals in San Francisco, California. Master's Thesis, San Francisco State University, Department of Biology, San Francisco, CA.

Nickel, B. (2003) Pacific harbor seal (*Phoca vitulina richardii*) distribution, movement and foraging activities in the San Francisco Estuary, California. M. A. candidate, San Francisco, California, San Francisco State University.

Grigg, E.K. (In Progress) Habitat suitability models, habitat use patterns, and haul-out site selection factors of Pacific harbor seals (*Phoca vitulina richardii*) in the San Francisco Bay estuary. PhD candidate, Davis, California, University of California, Davis, Graduate Group in Ecology.

Additional Data Contributions:
In order to assist in region-wide surveys and ongoing monitoring, the RBHSS contributes data on harbor seal numbers and distribution in SFB to:

- the National Park Service
- the Gulf of the Farallones National Marine Sanctuary
- the Don Edwards San Francisco Bay National Wildlife Refuge (U.S. Fish and Wildlife Service)
- Angel Island State Park

Posters:
Grigg EK, Green DE, Allen SG, Markowitz H, Disturbances to Harbor Seals (*Phoca vitulina richardsi*) in San Francisco Bay, California, an Urbanized Estuary. Society for Marine Mammalogy Biennial Conference, Maui HI, November 26 – December 3, 1999

We monitored disturbances to two primary harbor seal haul-out sites within San Francisco Bay, from May 1998 through April 1999: Castro Rocks (CR), and Yerba Buena Island (YBI). The major causes of disturbance were human-related: watercraft, aircraft and automobiles. We examined watercraft disturbances in order to evaluate the effects of distance on seal reactions. Watercraft within 200 m of the CR and YBI haul-out sites elicited a response from seals 73.1% and 74.4% of the time, respectively, and flushed seals off the haul-out sites 29.0% and 10.8% of the time, respectively. Despite the significantly higher occurrence of watercraft near the haul out site at YBI than at CR ($p<0.0001$), animals at YBI were less prone to flush off the haul out site ($p<0.006$). Watercraft close to the haul out site were more likely to flush seals during the pupping season at CR, and during the fall season at YBI. At both sites, watercraft disturbed seals more frequently on weekends than on weekdays (CR: $p<0.05$; YBI: $p<0.006$).

We suggest that the differences in seal reactions at these two locations are due to 1) reproductive status, 2) varying disturbance levels, and 3) habituation. CR is a major pupping site in San Francisco Bay and females with pups may have an increased tendency to flush during the pupping season. Only a few pups occur at YBI and seals were more prone to flush during the fall at YBI, when counts were low and transient animals may be present. Habituation to disturbance by YBI seals may account for the significantly reduced tendency to flush (compared to CR, $p<0.005$). Furthermore, habituation may explain why weekend and weekday seal numbers at YBI were not significantly different, but were significantly different at CR ($p<0.01$).

Green DE, Grigg EK, Petersen HM, Galloway M, Bohorquez AS, Sanders AM, Allen SG, Markowitz H, Trends in harbor seal (*Phoca vitulina richardsi*) haul out patterns at Castro Rocks and Yerba Buena Island in San Francisco Bay, California. Society for Marine Mammalogy Biennial Conference, Maui HI, November 26 – December 3, 1999

We examined two primary harbor seal haul out sites within San Francisco Bay, California, from May 1998 through April 1999, in order to determine the effects of tide height and time of day on the haul out patterns of the seals. The mean number of seals present at Castro Rocks (CR) and Yerba Buena Island (YBI) varied with tide height. Mean number of seals on the haul out declined as tide height rose at both sites, with the greatest number of seals present when the tide height was ≤ 2 ft. CR is a mid- to low-tide haul out site, and space on the haul out site is unavailable at high tides. However, haul out space is available at YBI at much higher tides, and we recorded seals at this site up to a 6.5 ft tide height.

Time of day also influenced the number of seals seen on both haul out sites. At CR, there was a slight drop in mean number of seals using the site from approximately 0500 until 1200, with high mean numbers of seals present on the haul out during the night (2100-0300). At YBI, there appears to be a stronger relationship between time of day and haul out site use, with a sharp drop in the numbers from 1000-1200. Based on surveys taken between 0600-2000, we suggest that there is a bimodal haul out pattern at this site, with high numbers present in the early morning hours (prior to 0800) and in the mid-afternoon (1300-1700).

Tide height appears to be a stronger factor in haul out patterns at CR, due to the geography of that site. The relationship between time of day and haul out numbers may be due to the role of human-related disturbance to seals at both sites.

Bohorquez A, Grigg EK, Green DE, Markowitz H, Allen S, Red Pelaged Harbor Seals in the San Francisco Bay. Society for Marine Mammalogy Biennial Conference, Maui HI, November 26 – December 3, 1999

Red pelage in the northern pacific harbor seal (*Phoca vitulina richardsi*) in San Francisco Bay has been recorded in the bay since 1969. There have also been sightings in Oregon and Washington, Japan, Ireland and Maine, but not in the numbers seen within the San Francisco Bay. Allen et al. (1993) reported that red-pelage resulted from iron oxide adherence to the keratin surface on the shaft of the hairs, possibly related to flocculation of ferrous iron in the water column. Red-pelage occurs in all sex and age classes, except for pups. In May of 1999, a higher proportion of red pelaged harbor seals were recorded in the San Francisco Bay seal population (42.9% at Castro Rocks, 49.3 at Yerba Buena Island) using the highest proportion of red pelaged animals in the maximum total count. Using the average proportion of red pelaged animals over the month of May, however, we see similar proportion to those previously recorded (28% in 1999, 27% in the 1980s; Allen et al. 1993). At Yerba Buena Island, we also see a drop in the proportion of red pelaged animals in the winter months (6.4% in December), this may correspond to the Herring migration through the area surrounding the island, which may attract more seals from the coastal colonies. In spring 1999, at Castro Rocks, a higher daily proportion of red pelaged mothers were seen in April (67%). The daily proportion of red pelaged mothers dropped significantly in the month of May (18%). Comparison of daily proportions for the two months showed a significant difference ($p<0.02$) for the two months. Individual mothers were identified and followed throughout the breeding season. Many red pelaged mothers were seen with late stage pups, suggesting successful pupping.

Galloway MJ, Grigg EK, Green DE, Markowitz H, Allen, SG, Differential Scanning between Male and Female *Phoca vitulina richardsi* Hauled-Out at Yerba Buena Island, California. Animal Behaviour Society Conference, Georgia, August 5-10, 2000.

Previous studies have shown conflicting results in scanning behavior between adult male and female harbor seals. Scanning refers to movements that increase the seals visual field. This study compares differences in scanning bouts by hauled-out seals at Yerba Buena Island, CA (YBI) between October 1998 and September 1999. YBI is primarily utilized by males at all times of the year. Up to three seals at different locations of the site were selected. Seal behavior was recorded for 15 seconds per minute for up to 8 10-minute observations during the 45 4-hour surveys. The number of scanning bouts from focal male and female seals was analyzed. Overall results suggest that females scan more frequently. The differences between scanning bouts were significant when comparing seals near the water. Females near the water scanned significantly more than males on surveys with below average disturbance levels and above average seal counts indicating that several factors may have an influence on female scanning behavior.

Green DE, Grigg EK, Markowitz H, Allen SG, Update on the population status of harbor seals (*Phoca vitulina richardsi*) in San Francisco Bay, California. Marine Conservation Biology Institute 2nd Symposium, San Francisco, CA, June 2001.

Since May 1998, we have been surveying the San Francisco Bay harbor seal population. We evaluated population numbers and percent pups at three major Bay haul out sites (Castro Rocks, Mowry/Newark Slough and Yerba Buena Island) and compared our current data to historical harbor seal counts for the Bay. Our data support the theory of a stable Bay population, in contrast to the dramatic rise in harbor seal numbers along the coast of California. Although our maximum harbor seal counts at Castro Rocks are significantly higher than seal counts at that site in the 1980's, a nearby haul out site (Strawberry Spit) was abandoned by harbor seals in the early 1980's. Consequently, some seals may have shifted from the Strawberry Spit site to Castro Rocks. Seal numbers have remained stable at Mowry Slough, the Bay's largest harbor seal rookery, since the 1970's. Yerba Buena Island is not generally recognized as a harbor seal rookery, and data at that site is limited prior to 1995. However, we have noted stable seal numbers, with a slight increase in pup numbers, at Yerba Buena Island. The lack of growth in the Bay seal population may be due to one or more of the following: limited food availability, pollutants in the Bay waters affecting female reproductive success, limited suitable haul out space in the face of increased shoreline development, and increases in human disturbance around haul out areas.

Bohorquez, AS, Nickel BA, Grigg EK, Green DE, Bouse RM, Jaffe BE, Allen SG, Markowitz H. The high price of gold: possible effects of hydraulic mining on harbor seals in San Francisco. Conservation Biology Conference, Hilo, HI, July 2001.

The Gold Rush of the 1853 brought prosperity to California; however, the costs of the methods used to extract that gold are still being assessed today. The use of highly pressurized water washed over one billion tons of sediment from the Sierra Nevada foothills, a portion of which remains in the San Francisco Bay (SFB). The SFB also has the highest proportion of harbor seals with a red discoloration of their pelage. The red color results from iron oxide adherence to the keratin surface on the shaft of the coat hairs. This iron may adhere while seals are foraging in sediment contaminated by re-exposed hydraulic mining debris. In order to test this hypothesis, a model will be developed from a collaborative approach integrating behavioral, geological and chemical methods by, (1) synthesizing behavioral information obtained from VHF radio and satellite tagged harbor seals into a Geographic Information System (GIS); (2) classifying habitat from a digital terrain model based on bathymetric and hydraulic mining sediment data; and (3) chemically analyzing the red pelage for the hydraulic mining signature and other metals that may be linked to the debris. We present this plan to demonstrate the benefits of collaborative analysis for conservation issues.

Grigg EK, Green DE, Allen SG, and Markowitz H Population Status and Trends of Harbor Seals (*Phoca vitulina richardsi*) in San Francisco Bay, CA, 1970-2000, State of the Estuary Biennial Conference, San Francisco, CA , October 2001.

Numerous large-scale construction activities are scheduled for San Francisco Bay (SFB) over the next decade, including two bridge retrofit projects and the San Francisco Airport runway expansion. These projects have the potential to affect the population of harbor seals, the only resident marine mammals in SFB. Ground-based counts were used to evaluate population numbers and population changes between 1970 and 2000. Since May 1998, we have been surveying three major harbor seal haul out sites in San Francisco Bay (SFB), California: Mowry Slough (MS), Castro Rocks (CR) and Yerba Buena Island (YBI). We evaluated current data against historical harbor seal counts for the Bay, including an additional SFB haul out site (Strawberry Spit, SS) that was abandoned in the early 1980's due to development and a shift in food resources. In addition, we developed a model of population trends of seals in SFB using stepwise polynomial regressions on the natural logarithm of maximum yearly seal counts. Although the SFB population has remained stable over the past 30 years, there have been shifts in the number of seals using each site during both the pupping and non-pupping seasons. During the pupping season, maximum counts increased at both CR and YBI, while counts at MS decreased. During the non-pupping season, maximum counts increased at all sites. We believe that increases at these sites were influenced by the abandonment of the SS haul out site and by increases at nearby coastal sites. A cubic regression provided the best fit for data during both the pupping and non-pupping seasons. We plan to use this model to compare predicted and actual seal counts in SFB during future large-scale construction activities over the next decade. Harbor seals are a top predator species in SFB, and are faced with high levels of anthropogenic stress. Evaluating long-term population trends is an essential component in understanding and protecting this resident species.

Nickel B, Grigg KE, Green DE, Allen SG, Markowitz H, Pacific harbor seal (*Phoca vitulina richardsi*) distribution, movement, and foraging activities within an urban estuary: implications for the effects of seismic retrofitting in San Francisco Bay, California. Society for Marine Mammalogy Biennial Conference, Vancouver, CA, November 2001.

Continual urban development and human population growth in San Francisco Bay (SFB), California, increases the possibility that harbor seals will abandon preferred breeding habitat due to anthropogenic disturbance and habitat degradation. A primary harbor seal haul-out site and rookery, Castro Rocks (CR), is adjacent to the Richmond-San Rafael Bridge (RSRB) in northern SFB. From January to May, 2001, we conducted a pilot study on harbor seal movements and foraging activities using a combination of VHF and satellite-linked telemetry. This study complements an ongoing monitoring program investigating the effects of a large-scale seismic retrofit of the RSRB on the SFB harbor seal population.

Four harbor seals were captured and tagged (VHF: 1 adult female, 2 subadult females; PTT: adult male) at CR in January 2001. Three of four tagged harbor seals showed high site fidelity to CR and used consistent foraging areas within the study area. An adult female and one sub-adult female were recorded at CR 60% and 90% of study days, respectively; an adult male hauled out at CR during 81% of haul-out site surveys. Harbor seals consistently foraged in areas within a mean distance of 6 km from the primary haul out site. Home range estimates varied widely from 50 km2 (sub-adult female) to 638 km2 (adult female). These results support previous studies indicating harbor seals exhibit high haul-out site fidelity in and around the pupping season, and illustrates the importance of CR as a significant site for resident seals of SFB. With preferred habitat shrinking at an accelerated rate, the potential loss of important SFB sites poses a threat to the sustainability of the resident harbor seal population. Further research on the movements and foraging activities of harbor seals in relation to the seismic retrofit is required to accurately assess potential effects to the resident population.

Austin K, Bohorquez A, Green D, Grigg E, Markowitz H, and Allen S. Observations of epimeletic behavior in Northern Pacific harbor seal mothers toward their dead pups at Castro Rocks, San Francisco Bay, California. Society for Marine Mammalogy Biennial Conference, Vancouver, CA, November 2001.

Occurrences of epimeletic behavior of mothers toward their dead offspring have been frequently documented in cetaceans, especially prominent in bottlenose dolphins, yet this phenomenon has rarely been observed in pinnipeds. Further, the few existing records of this care-giving behavior in pinniped mothers directed to their dead pups only lasted for short durations. While unavoidable factors may cause the death of the offspring, the response of the mother may be to continue nurturance regardless of the cost. Data concerning mother-pup interactions of Northern Pacific harbor seals were gathered at Castro Rocks, San Francisco Bay, California throughout the 2001 pupping season. During this time period, two adult females were observed carrying their dead pups in the water surrounding the site, placing the dead pups onto the site and following the dead pups back into the water after they had been washed away with the rising tides. Unlike previous observations, in both of our cases the mother-pup pairs were seen for extremely prolonged periods of time. In the first instance, the pup survived for 3 days although it was born with a partial lanugo coat. The mother exhibited the aforementioned behaviors toward the pup for at least 4 weeks after it had died. In the second case, the pup was not observed while alive but the pair was seen together for at least 3 weeks. Photographic records established the identity of the mother and pup and confirmed that these were two distinct instances. We believe that this is the longest recorded observation of epimeletic behavior of mothers toward their offspring in pinnipeds.

Green DE, Grigg EK, Markowitz H, Allen SG, The Impacts of Preconstruction Core Sampling at the Richmond-San Rafael Bridge, CA on Harbor Seal (*Phoca vitulina*) Haul Out Patterns. Society for Marine Mammalogy Biennial Conference, Vancouver, CA, November 2001.

Castro Rocks (CR), the second largest rookery in San Francisco Bay, is located next to the Richmond-San Rafael Bridge. Prior to a large-scale seismic retrofit of the bridge, preconstruction core sampling (PCCS) was conducted from January 24 through February 14, 2001 near CR. We examined changes in harbor seal site use during PCCS and summarized PCCS-related disturbances. We have been monitoring harbor seals at CR since May 1998. During surveys, biologists recorded 1) total count of seals present on CR and 2) behavioral data pertaining to disturbances to seals. Mean number of seals on CR during PCCS was significantly less than during the same time period in 1999 and 2000 ($F=4.29$, $p<0.05$, $df=46$), as well as during the 3 weeks following PCCS work ($t=2.75$, $p<0.05$, $df=15$). The frequency of disturbances/hr of field time was significantly higher during the PCCS compared to the same time period in 1999 and 2000 ($F=6.43$, $p<0.005$, $df=46$). In addition, the number of disturbances to cause a flush/hr was significantly higher during the PCCS than during the same time period in 1999 and 2000 ($F=5.73$, $p<0.01$, $df=46$). Mean number of disturbances/hr and mean number of flushes/hr were greater during PCCS compared to the 3 weeks prior to and following PCCS, although not statistically significant. Taken collectively, these data suggest that seal haul out patterns at CR will be impacted when the seismic retrofit construction is conducted near the haul out site. What, if any, long term effects construction activities will have on harbor seal haul out patterns at CR remains unclear at this time.

Grigg EK, Nickel B, Green DE, Allen S, Markowitz H. Spatial Analysis of Habitat Use Patterns of Harbor Seals (*Phoca vitulina richardsi*) in San Francisco Bay, California. Society for Marine Mammalogy Biennial Conference, Vancouver, CA, November 2001, GIS Remote Sensing Workshop.

A Geographic Information System (GIS) was used to investigate relationships between harbor seals and hydrographic features in San Francisco Bay (SFB), California. From January to May 2001, we conducted a pilot study on harbor seal habitat use in SFB, using VHF and satellite-linked telemetry. Analysis was done on an integrated database of behavioral and environmental data. Four harbor seals were captured and tagged (1 adult female, 2 subadult females; PTT: 1 adult male) at a major SFB haul-out site in January 2001. Using ArcView GIS, we overlaid harbor seal locations onto a digital elevation model (USGS DEM) of bathymetric features. We calculated distances traveled from primary harbor seal haul-out sites to foraging areas, as well as the farthest distance traveled by each seal from its primary haul-out site. Fixed kernel utilization distributions were estimated in order to define individual home ranges and foraging areas. Additionally, a spatial dive model (interpolated from point locations of mean dive length) was created to investigate dive patterns within individual home ranges. Three of four seals tagged in the pilot study used consistent foraging areas, within a mean distance of 6 km from each individual's primary haul-out site. Maximum distance traveled by any seal tracked was 59.58 km, representing a shift by the adult female to an alternate rookery. Home range estimates varied widely from 50 km2 (subadult female) to 638 km2 (adult female). There was some overlap of harbor seal foraging areas with prominent SFB bathymetric features, such as major shipping channels. Mean water depths in which seals were located ranged from 6-11 m. This study complements an ongoing monitoring program investigating the effects of a large-scale seismic retrofit of the Richmond-San Rafael Bridge on the SFB harbor seal population. The use of GIS to analyze spatial patterns of habitat use within SFB greatly enhances the ability to assess effects on the resident population. Research continues on harbor seal movements and foraging activities using VHF and satellite-linked telemetry. Future analysis will incorporate vegetation and prey distribution, sediment type, and primary productivity in order to accurately model environmental features encountered by the SFB harbor seal population.

Bohorquez A., Markowitz, H., Allen, S. Factors Influencing harbor Seal Pupping Behaviors at Castro Rocks, San Francisco Bay, California. Society for Marine Mammalogy Biennial Conference, Vancouver, CA, November 2001.

The seismic retrofit of the Richmond-San Rafael Bridge (RSRB) in the San Francisco Bay, poses many threats to the local colony of Pacific harbor seals (Phoca vitulina richardsi) in San Francisco Bay (SFB). Effects may be as obvious as site abandonment, or as subtle as slight changes in haul out pattern. For mother-pup pairs, availability of optimal haul out space is important for pup growth and survival. In this study, haul out patterns of mother-pup pairs were monitored at Castro Rocks, a haul out site adjacent to the RSRB. We sectioned Castro Rocks into different quadrants to determine if there was a correlation between environmental variables and use of each quadrant by the mother-pup pairs. Over three years, we found a significant difference in quadrant usage by mother-pup pairs ($F=15.6$, $p<0.02$, $df=16$). The reasons for these differences may have multiple causes including weather, topography, depth, or proximity to human activities. We considered the effects of environmental factors (temperature, rain, cloud coverage, wind speed and direction) each day on the number of pups in each quadrant, to determine if there was a significant relationship. From this, we designed a model for the number of pups that we predict to be in each quadrant, given existing environmental and anthropogenic factors. In the upcoming years, if we see a change in quadrant use by mother-pup pairs after the seismic-retrofitting of the RSRB begins, we can eliminate environmental factors as a cause by using this model.

Nickel, B., Grigg, E., Green, D., Markowitz, H., Allen, S., Should I stay or should I go?: Monitoring Pacific harbor seal (*Phoca vitulina richardsi*) movement and site use in and around the San Francisco Estuary. California and World Oceans Conference, October 2002, Santa Barbara, CA.

A large-scale bridge seismic retrofit project near a primary San Francisco Estuary (SFB) Pacific harbor seal (*Phoca vitulina richardsi*) rookery and year-round haul-out site, Castro Rocks (CR), has the potential to affect activity and residence patterns of local harbor seals. The harbor seal continues to be protected in California under the Marine Mammal Protection Act of 1972 and monitoring in relation to the seismic retrofit is required. To this end, the California Department of Transportation has funded a monitoring project to evaluate the effects of seismic construction activities on the local harbor seal population.

In this study, seals were fitted with VHF-radio and satellite-linked transmitters to collect detailed information on their spatial distribution and movement within the region. Tagged seals exhibited strong fidelity to haul-out areas and discrete foraging ranges (<50 km from the primary haul-out site) within SFB and the adjacent coast. Individual home range estimates varied widely in size from 11 km^2 to 808 km^2. Most seal locations were in or near SFB; however, five individuals moved out of the estuary to offshore foraging grounds and coastal haul-out sites. Four of these five seals returned at least once to SFB during the study period. Six seals were recorded using CR as their only haul-out site. Eleven individuals used multiple haul-out sites in and around SFB, four of which frequented coastal or offshore haul-out sites, as far away as the Farallon Islands (~65 km from CR). The need to develop adequate management techniques for seals continues as pressure from urban development persists in SFB. Information on harbor seal space use and movement from this study has important implications for the measures adopted for the effective management of harbor seals in the San Francisco Estuary.

Galloway, M, Scianamblo, L, Grigg, E, Nickel, B, Green, DE, Markowitz, H., Greig, D, Morton, C Movement and Dive Patterns of Two Rehabilitated Harbor Seal Pups (*Phoca vitulina richardii*) Released Back Into An Urbanized Estuary. Society for Marine Mammalogy Biennial Conference, North Carolina, November 2003.

Post-release monitoring of rehabilitated animals is an important step in determining wildlife rehabilitation success, particularly if animals are rescued from and released back into a region characterized by high levels of urbanization. Although release of rehabilitated seals near areas where they are rescued is preferable, release near urban environments increases the potential for further human interaction. In this pilot study, two male Pacific harbor seal pups (*Phoca vitulina richardii*) were treated at The Marine Mammal Center (TMMC); a rehabilitation facility located in Sausalito, California, after being rescued from the highly urbanized San Francisco Bay (SFB), CA on 28 February (seal G8319) and 30 March (seal W9218) because of human interaction. Prior to release on 30 April (G8319) and 17 May (W9218), both seals were fitted with head-mounted VHF radiotransmitters to facilitate post-release monitoring. Typically, TMMC releases pinnipeds into more remote coastal areas; however, these seals were released close to their original stranding locations in order to monitor their movements and measure the success of an urban area release. G8319 remained near the release site, but was not found again after the first two days post-release. W9218 was found near the release site for the first few days post-release before traveling to various locations in SFB and the California coast. G8319 had a mean surface interval of 0.41 minutes (SD +/- 0.19) and a mean dive time of 2.26 minutes (SD+/- 0.90). W9218 had a mean surface interval of 0.35 minutes (SD 0.14) and a mean dive time of 1.92 minutes (SD 0.68). Our results suggest that movement patterns of these two rehabilitated seals are comparable to wild young of year harbor seals radiotagged within SFB. Further study is needed to gauge the success and survivability of rehabilitated seals released into urbanized regions.

<u>Oral Presentations</u>:

Green DE, Grigg E, Allen S, and Markowitz H, Nocturnal Haul Out Patterns of Harbor Seals (*Phoca vitulina richardsi*) at Castro Rocks, San Francisco Bay, California. The Wildlife Society Western Conference, Monterey CA, January 1999

Night counts of harbor seals hauled out at Castro Rocks, located near the eastern end of the Richmond-San Rafael Bridge, were collected from May 1998 through September 1998. This work was conducted as part of a project monitoring the effects of Caltrans' seismic retrofit of the bridge on this seal population. This information serves as baseline data against which future counts, collected during and following the bridge construction work, will be compared.

Seals were consistently present in high numbers on the haul out at night. The maximum monthly night count steadily increased over the five-month period from 81 in May to 140 in September. These numbers are comparable to maximum monthly daytime seal counts, which ranged from 114 to 134 during the study period, with no obvious trend such as is seen with the night counts.

This site is subject to higher levels of human disturbance during the day due to watercraft, and the higher volume of vehicular traffic on the bridge. The consistent nighttime use of Castro Rocks by seals may reflect a response to high daytime disturbance levels.

Bohorquez AS, Galloway MJ, Green DE, Grigg EK, and Allen SG, Markowitz H, Differential Response of Pacific Harbor Seals (*Phoca vitulina richardsi*) Towards Kayaks Compared to Other Watercraft. Animal Behaviour Society Conference, Georgia, August 5-10, 2000.

Previous studies have considered the effects of various types of watercraft disturbances on the haul-out patterns and behavioral responses of harbor seals. We considered the variation in occurrence of kayaks within 200m in comparison with other types of watercraft at two harbor seal haul-out sites within San Francisco Bay, California. Since kayaks are more maneuverable they often advance closer to the haul out site than other types of watercraft. A higher proportion of kayaks elicit a disturbance response from the seals than all other types of watercraft within 200m of the haul-out sites. Kayaks within 200m also caused a higher proportion of flushes. This differential response to the kayaks is a consequence of the proximity of the kayaks to the seals. Kayaks are more likely to elicit disturbance responses from hauled-out harbor seals because they are quiet and low to the water. These factors may not allow the seals to detect kayaks until they are much closer to the haul-out site and may lead to a higher startle response.

Grigg EK, Green DE, Allen SG, Markowitz H, An Analysis of Relationships between Environmental Variables and Harbor Seal (*Phoca vitulina richardsi*) Haul Out Patterns at Castro Rocks, San Francisco Bay, CA. The Wildlife Society Western Section Annual Meeting, Feb. 22-24, 2001. Sacramento, CA.

We surveyed a primary harbor seal haul-out site in San Francisco Bay, California, May 1999 - August 2000, in order to examine seasonal relationships between environmental variables and seal haul out patterns. Since tide height was correlated with seal counts, we used a subset of our data to control for this relationship while examining other variables. Multiple regressions were run to identify relationships between total seal number and air temperature, water temperature, solar radiation, wind speed and wind chill. In addition, a t test was used to compare seal counts on rainy days vs. nonrainy days.

As harbor seal haul out patterns vary by season, we examined data from each season (pupping, molting, fall, winter) independently. During the pupping season, all environmental variables, except for rain, influenced the number of harbor seals hauled out: the higher the air temperature, the lower the number of seals hauled out, whereas increases in water temperature, solar radiation, wind speed and wind chill were all related to increases in seal counts. During molting season, increases in both wind speed and wind chill were related with increases in seal counts.

In contrast, when each weather variable was taken independently, there were no significant relationships between weather variables and the number of harbor seals hauled out during fall and winter. Overall, rain effected the number of seals hauled out – with fewer seals present on rainy days. The influence of weather variables should not be generalized across sites or seasons since each location, season and even population has its own unique set of characteristics to be considered.

Bohorquez, AS, Green DE, Grigg EK, Markowitz H, Allen SG. Current status of red-pelaged harbor seals within the San Francisco Bay. Conservation Biology Conference, Hilo, HI, July 2001.

A previous study of the San Francisco Bay (SFB) red-pelaged harbor seals suggests a significant difference in haul out use by these seals at three sites within the bay. Allen et al. (1993) reported that red pelage resulted from iron oxide adherence to the keratin surface on the shaft of the hairs, likely related to foraging behavior. This coloration tends to make the red fur more brittle, leading to the loss vibrissae. Using several methods of comparison, a significant difference in the number of seals with red pelage was found between the central bay and the north and south bays. Continued analysis of this population from June 1999 to December 2000 showed significantly more of red-pelaged seals used the north and south bay haul out sites ($p<0.05$). We found red-pelaged mothers gave birth earlier in both pupping seasons ($p<0.05$). These results may indicate that red-pelaged mothers are older or foraging in nutrient rich areas, presenting a possible balance between foraging efficiency and the cost of the red-pelage. We recommend using this demographic data and the red-pelage as an indicator of optimal foraging areas and therefore identifying these areas from protecting.

Grigg, E.K.[1], Green, D.E.[1], Allen, S.G. [1,2], Nickel, B. [1], Markowitz, H.[1] and Gulland, F.[3] Overview of current monitoring of harbor seals (*Phoca vitulina richardsi*) in San Francisco Bay, CA, 6th Biennial Conference on Research in the Gulf of Farallones. San Francisco, CA, October 2001.

Numerous large-scale construction activities are scheduled for San Francisco Bay (SFB) over the next decade, including two bridge retrofit projects and the San Francisco Airport runway expansion. These projects have the potential to affect the population of harbor seals, the only resident marine mammals in SFB. Ground-based counts were used to evaluate population numbers and population changes between 1970 and 2000. Since May 1998, we have been surveying three major harbor seal haul out sites in San Francisco Bay (SFB), California: Mowry Slough (MS), Castro Rocks (CR) and Yerba Buena Island (YBI). We evaluated current data against historical harbor seal counts for the Bay, including an additional SFB haul out site (Strawberry Spit, SS) that was abandoned in the early 1980's due to development and a shift in food resources. In addition, we developed a model of population trends of seals in SFB using stepwise polynomial regressions on the natural logarithm of maximum yearly seal counts. Although the SFB population has remained stable over the past 30 years, there have been shifts in the number of seals using each site during both the pupping and non-pupping seasons. During the pupping season, maximum counts increased at both CR and YBI, while counts at MS decreased. During the non-pupping season, maximum counts increased at all sites. We believe that increases at these sites were influenced by the abandonment of the SS haul out site and by increases at nearby coastal sites. A cubic regression provided the best fit for data during both the pupping and non-pupping seasons. We plan to use this model to compare predicted and actual seal counts in SFB during future large-scale construction activities over the next decade. Harbor seals are a top predator species in SFB, and are faced with high levels of anthropogenic stress. Evaluating long-term population trends is an essential component in understanding and protecting this resident species.

Green, DE, Grigg, EK, Allen, SG, Markowitz, H. San Francisco Bay Harbor Seals. Monthly district-wide meeting for Caltrans, Oakland, CA, December 2001.

Presentation on the current findings of the project for the monthly district meeting. No abstract available.

Grigg, EK, Green, DE, Allen, SG, Markowitz, H. The Richmond Bridge Harbor Seal Survey. 8th Annual Wildlife and Aquatic Animal Medicine Symposium, University of California at Davis, January 2002.

One-hour presentation summarizing the work of the Richmond Bridge Harbor Seal Survey. No abstract available.

Green DE, Grigg EK, Markowitz H, Allen SG, San Francisco Bay Harbor Seals. Bishop O'Dowd High School, Oakland. Outreach Presentations. April 2002.

Four one-hour discussion groups about harbor seals in San Francisco Bay, California. No abstract available.

APPENDIX B

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Chuck:

In order to reassess the frequency of monitoring surveys necessary to detect a significant population change at the Castro Rocks haul out site, we ran a power analysis[1] on mean seal counts at Castro Rocks. Due to seasonal variations in mean seal counts and variability of counts at Castro Rocks, we evaluated the minimum number of survey days necessary on a seasonal basis. The power of the test was set to 0.80; in other words, what is the minimum number of surveys that would provide an 80% probability of detecting the percent population change of interest. Three levels of potential population change were assessed: 15%, 20% and 25% change. Mean annual growth rate for San Francisco Bay haul out sites (1970-2002) has been calculated at <10%[2], so increases or decreases of 15-25% would represent a noteworthy population change. The test was run using sample means (and variances) collected during seasons when construction was underway, 2001-2003. Tests were run on both daytime and nighttime data.

For daytime surveys, minimum number of surveys required varies, depending upon the desired level of change (15, 20, or 25%) detectable at Castro Rocks (Table 1). A conservative approach should be taken during more sensitive seasons at Castro Rocks, i.e. pupping and molting. During the pupping and molting seasons, 3 to 5 surveys per week would allow a detection of a 15-20% change. For fall and winter, a minimum of 5 surveys per week is necessary, in order to detect a 25% change.

	Survey days/wk required to detect noted percentage change in population		
Season	*15%*	*20%*	*25%*
Pupping	4	3	2
Molting	5	3	2
Fall	--	7	5
Winter	--	7	5

[1] Cohen, J. (1977) Statistical power analysis for the behavioral sciences (2[nd] ed.). New York: Academic Press, Inc. 474 p.

[2] Grigg, E.K., Allen, S.G., Green, D.E., and Markowitz, H. (in review) Harbor seal (*Phoca vitulina richardii*) population trends in the San Francisco Estuary, 1970-2002.

Castro Rocks is a mid- to low-tide haul out site, and daytime surveys could potentially be shortened from 7 to 5 hrs around the low tide. The greatest number of seals is typically present at Castro Rocks when the tide height is ≤ 2 ft[3] (Green et al. 2003).

A decrease in the frequency of nighttime surveys would negatively impact the detection of changes in nighttime haul out numbers. According to the power analysis, the current monitoring schedule of 2 days/week allows detection of a 20-25% change during molting and fall, and a 35-40% change during pupping and winter. The monitoring at Castro Rocks has indicated that seal use of the site is higher during the nighttime than during the daytime during the molting and fall seasons. This implies a sensitivity of the seals to daytime disturbances. Past studies have indicated that, at sites subject to high levels of daytime disturbance, harbor seals shift to nighttime site use prior to site abandonment[4,5]. A decrease in the frequency of nighttime surveys would reduce our ability to detect population changes at Castro Rocks.

Please feel free to contact us if there are any questions, or if there are any other survey scenarios you would like us to evaluate or discuss.

Sincerely,

Debbie Green,
Project Manager

Emma Grigg,
Field Coordinator

cc: Tina Fahy, NMFS
Hal Markowitz, RBHSS
Sarah Allen, RBHSS

[3] Green, D.E., Grigg, E.K., Allen, S.G. and Markowitz, H. (2003) Monitoring the potential impact of the seismic retrofit construction activities at the Richmond-San Rafael Bridge on harbor seals (*Phoca vitulina*): May 1998 – May 2003. Draft Interim Report, June 2003. Submitted to NMFS.
[4] Paulbitski, P. (1975) The seals of Strawberry Spit. Pacific Discovery 28: 12-15.
[5] Allen, S.G. (1991) Harbor seal habitat restoration at Strawberry Spit, San Francisco Bay. Report to the U.S. Marine Mammal Commission, 44 p.

Appendix C
List of Acronyms

Acronym	Definition
BEZ	Boat Exclusion Zone
Caltrans	California Department of Transportation
CRD	Castro Rocks Day
CRN	Castro Rocks Night
DEM	Digital Elevation Model
GIS	Geographical Information System
GPS	Global Positioning System
IHA	Incidental Harassment Authorization
MF	Mud Flats (Mowry Slough Subsite)
MSN	Mowry Slough North (Mowry Slough Subsite)
MS	Mowry Slough
MSS	Mowry Slough South (Mowry Slough Subsite)
NSP	North Salt Pile (Mowry Slough Subsite)
NW	Newark Slough (Mowry Slough Subsite)
PTT	Platform Terminal Transmitter
SFB	San Francisco Bay
SSP	South Salt Pile (Mowry Slough Subsite)
VHF	Very High Frequency
USCG	United States Coast Guard
YBI	Yerba Buena Island