UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

March 30, 2012

In response, refer to:
2011/06233

Bijan Sartipi
District Director
California Department of Transportation, District 4
111 Grand Avenue
Oakland, California 94623

Dear Mr. Sartipi:

Thank you for your agency's letter of December 7, 2011, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Effective July 1, 2007, the Federal Highway Administration (FWHA) assigned, and the California Department of Transportation (Caltrans) has assumed all responsibilities for ESA consultation and approval on most highway projects in California. Therefore, Caltrans is now considered the federal action agency for ESA consultations with NMFS for federally funded projects. This letter transmits NMFS' biological opinion for Caltrans' proposed Bon Air Bridge Replacement Project (Project) on Corte Madera Creek in Marin County, California. The enclosed biological opinion describes NMFS' analysis of the effect of implementing the proposed Project on threatened Central California Coast (CCC) steelhead (*Oncorhynchus mykiss*) and threatened southern Distinct Population Segment (DPS) of the North American green sturgeon (*Acipenser medirostris*); and designated critical habitat for CCC steelhead, southern DPS green sturgeon, and CCC coho salmon (*Oncorhynchus kisutch*), in accordance with section 7 of the ESA. In the enclosed biological opinion, NMFS concludes that the Project is not likely to jeopardize the continued existence of CCC steelhead and southern DPS green sturgeon; and not likely to adversely modify designated critical habitat for CCC steelhead, southern DPS green sturgeon, and CCC coho salmon. However, NMFS anticipates take of green sturgeon as a result of the Project. An incidental take statement with non-discretionary terms and conditions is included with the enclosed biological opinion.

This letter also serves as consultation under the authority of, and in accordance with, the Essential Fish Habitat (EFH) provisions of the Magnuson Stevens Fishery Conservation and Management Act (MSA). The Bon Air Bridge location includes areas identified as EFH for various life stages of species managed under the Pacific Fishery Management Council. The MSA requires all Federal agencies to consult with NMFS on all actions, or proposed

actions, permitted, funded, or undertaken by the agency, that may adversely affect EFH. Only species managed under a Federal fishery management plan are covered by the Magnuson-Stevens Act. EFH for salmons, groundfish, and coastal pelagic species could be affected by the project. Because these species are managed under the Pacific Fishery Management Council, NMFS has included EFH Conservation Recommendations to avoid, minimize, or otherwise offset potential adverse effects to EFH.

Please contact Joe Heublein at (707) 575-1251 or joe.heublein@noaa.gov if you have any questions concerning this section 7 consultation, or if you require additional information.

Sincerely,

Kevin Chu

for Rodney R. McInnis
Regional Administrator

Enclosures

cc: Chris Yates, NMFS, Long Beach, California
Eric Chavez, NMFS, Long Beach, California
Boris Deunert, Caltrans District 4
Hamid Shamsapour, City of Larkspur, California
Greg Martinelli, CDFG, Yountville, California
Joseph Terry, USFWS, Sacramento, California
Copy to File Administrative File: 151422SWR2012SR00008

Enclosure 1

BIOLOGICAL OPINION

ACTION AGENCY:	California Department of Transportation
ACTION:	Bon Air Bridge Replacement Project, Marin County, California.
CONSULTATION CONDUCTED BY:	National Marine Fisheries Service, Southwest Region
FILE NUMBER:	2011/06233
DATE ISSUED:	**March 30, 2012**

I. CONSULTATION HISTORY

The California Department of Transportation (Caltrans) currently acts as the Federal action agency for Endangered species Act (ESA) consultations as per the agreement with the Federal Highways Administration (FHWA) in accordance with Section 6005 (a) of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (PL-109-59) to assume the FHWA Secretary's responsibilities under the National Environment Policy Act of 1969 (42 USC § 4351, *et seq.*) and all or part of the FHWA Secretary's responsibilities for environmental review, consultation, or other action required under any environmental law with respect to one or more Federally funded highway projects within the state.

A site visit between staff from ICF International (applicant's environmental consultant) and NOAA's National Marine Fisheries Service (NMFS) at the Bon Air Bridge was held on March 3, 2010. During this site visit, staff from ICF International and NMFS discussed the potential effects of the project on Central California Coast (CCC) steelhead, CCC coho salmon, North American green sturgeon, designated critical habitat, and potential avoidance, minimization, and compensation measures for these species.

In addition to the site visit described above, an agency coordination meeting was held on December 14, 2010, in Larkspur to discuss construction timing and noise issues relative to the clapper rail (*Rallus longirostris*) breeding season and steelhead migration season. In attendance were NMFS, US Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), Caltrans, City of Larkspur (City), and ICF International. On January 13, 2011, NMFS' staff sent an email to Caltrans requesting additional information and outlining recommended measures to avoid and minimize project impacts on listed fish species.

On December 8, 2011, NMFS received Caltrans' Biological Assessment and December 7, 2011, letter requesting initiation of formal consultation under section 7 of the ESA for the Bon Air Bridge Replacement Project (Project). Caltrans requested formal consultation because the proposed Project was likely to adversely affect CCC steelhead and green sturgeon, and designated critical habitat for CCC steelhead, green sturgeon, and CCC coho salmon. After reviewing the Biological Assessment, NMFS found the initiation package complete and initiated formal consultation on December 12, 2011.

II. PROPOSED ACTION

Caltrans proposes to use FHWA's funds to work with the City to replace the aging, structurally deficient Bon Air Bridge. The bridge is located where Bon Air Road crosses Corte Madera Creek, two kilometers west of Highway 101 and approximately three kilometers west of the confluence of Corte Madera Creek and San Pablo Bay, in Marin County, California. The Bon Air Road Bridge was constructed in 1958, was lengthened in 1965, and seismically retrofitted and widened in1994. The proposed bridge will involve less than half the spans and columns of the existing bridge, thereby improving the conveyance capacity of the creek. The Project will be implemented by the City and will involve the use of heavy equipment (excavator, pile driver, *etc.*) to construct the new bridge and temporary trestle foundations and superstructure, and demolish the old bridge. Construction of the temporary trestles and new bridge, and demolition of the old bridge and removal of temporary trestles will occur in four sequential years between mid-2013 and late-2018; during this time, all in-water work will occur during the in-water work season (September 1 to November 30) to avoid the clapper rail breeding season and impacts to federally listed fish species.

A. Description of Project Activities

The bridge currently consists of ten spans and is 128 meters long by 13.4 meters wide; it carries one lane of traffic in each direction with a 2.4-meter bicycle path on the north side of the bridge and a 1.5-meter sidewalk on the south side of the bridge. The new bridge will be five-spans founded on four column pairs (eight total columns) with two abutments, totaling 118 meters long by 19 meters wide. The proposed bridge will generally follow the alignment of the existing bridge but will lack a curve on the northeast end (allowing a shorter length) and involve widening on the north side by approximately 4 meters. The new structure will carry one 3.6-meter lane of traffic in each direction and have a 1.8-meter bicycle path and 1.5-meter sidewalk in each direction. Proposed construction activities will take place 19 meters north and 19 meters south of the existing bridge.

Replacement of Bon Air Bridge will involve the following sequential activities: 1) construction of a temporary northern trestle and demolition of the north side of the existing bridge; 2) construction of the northern half of the bridge (*i.e.* abutments, foundation [four columns], and superstructure); 3) construction of a temporary southern trestle and demolition of the south side of the existing bridge; 4) construction of the southern half of the bridge (*i.e.* abutments, foundation [four columns], and superstructure); and 5) removal of the temporary trestles.

Construction of the new five-span bridge will require two temporary trestle bridges spanning across Corte Madera Creek. First, a temporary 9- to 15-meter wide trestle will be constructed on the north side of the existing bridge with a tie-in point to Bon Air Road. From the banks of the creek, approximately 64 12- to 14-inch steel "H" piles will be placed into the creek bed approximately 9 meters apart and 21 meters deep for the northern trestle. These piles will support the timber trestle deck, and demolition of the northern half of existing bridge and construction of the northern half of the new bridge will be accomplished from this trestle. The northern half of the existing bridge will be demolished with heavy equipment and rubble and debris will be contained and disposed of off-site; existing concrete piles will be cut approximately one foot below the channel bottom. Four new columns for the northern half of the new permanent bridge will then be constructed from the trestle. To construct each of the four new bridge columns, four temporary 10-foot diameter steel casing will be driven into the creek bottom to a depth of approximately 21 meters. After the 10-foot diameter casings are in place, an 8-foot diameter hole will be drilled inside each casing. A temporary 8-foot diameter casing may be utilized to keep the holes stable. The water in the casings will be pumped to settling tanks prior to discharge and disposed of following National Pollution Discharge Elimination System (NPDES) requirements. Concrete will then be poured into the dewatered 8-foot diameter holes. The same construction method will be used for construction of the southern portion of the bridge (*i.e.* trestle construction, existing bridge demolition, new bridge construction). Both trestle bridges will be removed after the new bridge is completed.

B. Pile Driving

The City anticipates using vibratory and impact hammers to drive all piles to a depth of 21 meters. A vibratory hammer will be used to drive piles associated with the temporary trestles (128 12- to 14-inch steel H piles) and the bridge foundation (eight 10-foot diameter steel casings) to a depth of 15 meters. An impact hammer with a bubble curtain for sound attenuation is proposed to drive all piles the remaining 6 meters. Pile driving of trestle piles and steel casings will occur on separate days in four in-water work seasons (September 1 to November 30) 2013-2018.

1. <u>Temporary Trestle Piles</u>

Vibratory hammer driving of individual 12- to 14-inch steel H piles (128 H-piles in total) to a depth of 15 meters will take approximately eight minutes. Approximately 550 impact hammer strikes will be required to drive each of these trestle piles an additional 6 meters. Six trestle piles will be installed per day (3,300 strikes per day), and trestle pile installation will occur over 10-12 days between September 1 and November 1 in the first and second years of construction (2013 and 2014). Extraction of trestle piles will be accomplished with a vibratory hammer, and may take between 40 minutes and several hours per pile. Approximately ten piles will be extracted per day. Caltrans expects that trestle pile extraction will occur over approximately 12 days between September 1 and October 31 of 2016.

2. Temporary Steel Casings

Vibratory hammer driving of individual 10-foot diameter steel casings (eight casings in total) to a depth of 15 meters will take approximately 16 minutes. Approximately 700 impact hammer strikes will be required to drive each of these piles an additional 6 meters. A maximum of one steel casing will be installed per day (700 strikes per day). Caltrans expects casing installation will occur over 4-8 days between September 1 and November 15 in year one (2013) and September 1 and October 15 in year three (2015). Extraction of steel casings will be accomplished with a vibratory hammer, and may take between one hour and several days per pile; this will occur subsequent to casing installation and prior to November 15.

C. Description of the Action Area

Bon Air Bridge is located on Corte Madera Creek in southeastern Marin County, California, approximately three kilometers east of the confluence of Corte Madera Creek and San Pablo Bay. San Pablo Bay is positioned between the Golden Gate and Sacramento-San Joaquin Delta ("Delta") in the San Francisco Bay region ("Bay"). Corte Madera Creek is approximately 100 meters wide at mean higher high water and flows roughly north to south at the existing bridge. Waters in this area are brackish and, due to close proximity to San Pablo Bay, subject to tidal influence and associated changes in surface elevation. During low tides, the wetted channel beneath the bridge can be narrow (less than 2 meters wide) with wide mud flat margins. Riverine and saline emergent wetlands are located along the adjacent shorelines, and mixed ruderal/landscaped vegetation occupies a small upland portion between wetland habitat and residential and commercial properties.

For the purposes of this consultation, the action area consists of the estuarine water column, substrate, and shoreline areas around the Bon Air Bridge. Until new information indicates otherwise, NMFS believes a 150 decibel (dB) root-mean-square pressure (RMS) threshold for behavioral responses for salmonids and green sturgeon is appropriate. As described below in the Effects of the Action section, the action area extends the entire width of Corte Madera Creek from approximately 500 meters upstream to approximately 500 meters downstream of the Bon Air Bridge. This area encompasses the area NMFS anticipates will experience elevated sound pressure levels greater than 150 dB RMS referenced to one micropascal (re: 1 μPa) during pile driving, and encompasses all other effects of the action.

III. ANALYTICAL FRAMEWORK

A. Jeopardy Analysis

In accordance with policy and regulation, the jeopardy analysis in this biological opinion relies on four components: (1) the Status of the Species, which evaluates each species' range-wide conditions, the factors responsible for that condition, and the species' likelihood of both survival and recovery; (2) the Environmental Baseline, which evaluates the condition of the listed species in the action area, the factors responsible for that condition, and the relationship of the action area to the likelihood of both survival and recovery of the listed species; (3) the Effects of the Action, which determines the direct and indirect effects of the proposed Federal action and the

effects of any interrelated or interdependent activities on the species in the action area; and (4) Cumulative Effects, which evaluates the effects of future, non-Federal activities in the action area on the species.

The jeopardy determination is made by adding the effects of the proposed Federal action and any Cumulative Effects to the Environmental Baseline and then determining if the resulting changes in species status in the action area are likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the listed species in the wild.

The jeopardy analysis in this biological opinion places an emphasis on the range-wide likelihood of both survival and recovery of the listed species and the role of the action area in the survival and recovery of the listed species. The significance of the effects of the proposed Federal action is considered in this context, taken together with cumulative effects, for purposes of making the jeopardy determination. We use a hierarchical approach that focuses first on whether or not the effects on salmonids in the action area will impact their respective populations. If the populations will be impacted, we assess whether this impact is likely to affect the ability of the populations to support the survival and recovery of the Distinct Population Segment (DPS) or Evolutionary Significant Unit (ESU).

B. Adverse Modification Determination

This biological opinion does not rely on the regulatory definition of destruction or adverse modification of critical habitat at 50 CFR §402.02.[1] Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

The adverse modification analysis in this biological opinion relies on four components: (1) the Status of Critical Habitat, which evaluates the range-wide and watershed-wide condition of critical habitat in terms of primary constituent elements (PCEs – sites for spawning, rearing, and migration), the factors responsible for that condition, and the resulting conservation value of the critical habitat overall; (2) the Environmental Baseline, which evaluates the condition of critical habitat in the action area, and the factors responsible for that condition; (3) the Effects of the Action, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the PCEs in the action area and how that will influence the conservation value of affected critical habitat units; and (4) Cumulative Effects, which evaluates the effects of future, non-Federal activities in the action area on the PCEs and how that will influence the conservation value of affected critical habitat units.

For purposes of the adverse modification determination, we add the effects of the proposed Federal action on critical habitat in the action area, and any Cumulative Effects, to the Environmental Baseline and then determine if the resulting changes to the conservation value of critical habitat in the action area are likely to cause an appreciable reduction in the conservation value of critical habitat range-wide. If the proposed action will negatively affect PCEs of critical habitat in the action area we then assess whether or not this reduction will impact the value of the DPS or ESU critical habitat designation as a whole.

[1] This regulatory definition has been invalidated by Federal Courts.

C. Use of Best Available Scientific and Commercial Information

To conduct the assessment, NMFS examined an extensive amount of information from a variety of sources. Detailed background information on the biology and status of the listed species and critical habitat has been published in a number of documents including peer-reviewed scientific journals, primary reference materials, and governmental and non-governmental reports. Additional information regarding the effects of the Project's actions on the listed species in question, their anticipated response to these actions, and the environmental consequences of the actions as a whole was formulated from the aforementioned resources, the biological assessment for this Project, and Project meeting notes if applicable. For information that has been taken directly from published, citable documents, those citations have been referenced in the text and listed at the end of this document. A complete administrative record of this consultation is on file at the NMFS North Central Coast Office (NCCO) (Administrative Record Number 151422SWR2012SR00008).

IV. STATUS OF THE SPECIES AND CRITICAL HABITAT

This biological opinion analyzes the effects of the Project on the following Federally-listed species and designated critical habitat:

Central California Coast steelhead (*Oncorhynchus mykiss*) DPS
Threatened (71 FR834; January 5, 2006)
Critical habitat (70 FR 52488; September 2, 2005)
North American green sturgeon (*Acipenser medirostris*) southern DPS
Threatened (April 7, 2006; 71 FR 17757)
Critical habitat (September 8, 2008; 74 FR 52300)
California Central Coast coho salmon (*Oncorhynchus kisutch*) ESU
Critical habitat (64 FR 24049; May 5, 1999)

CCC coho salmon have been extirpated from the Corte Madera Creek watershed, but CCC coho salmon critical habitat is still present in the watershed. Thus, CCC coho salmon will not be affected by the proposed project and are omitted from the discussion below. However, since designated critical habitat for CCC coho salmon occurs within the action area, effects to this critical habitat are discussed where appropriate.

A. Species Description and Life History

1. Steelhead

Steelhead are anadromous forms of *O. mykiss*, spending some time in both freshwater and saltwater. Steelhead young usually rear in freshwater for one to three years before migrating to the ocean as smolts, but rearing periods of up to seven years have been reported. Migration to the ocean usually occurs in the spring. Steelhead may remain in the ocean for one to five years (one to three years is most common) before returning to their natal streams to spawn (Busby *et*

al. 1996). The distribution of steelhead in the ocean is not well known. Coded wire tag recoveries indicate that most steelhead tend to migrate north and south along the continental shelf (Barnhart 1986).

Steelhead can be divided into two reproductive ecotypes, based upon their state of sexual maturity at the time of river entry and the duration of their spawning migration: stream maturing and ocean maturing. Stream maturing steelhead enter fresh water in a sexually immature condition and require several months to mature and spawn, whereas ocean maturing steelhead enter fresh water with well-developed gonads and spawn shortly after river entry. These two reproductive ecotypes are more commonly referred to by their season of freshwater entry (*i.e.*, summer [stream maturing] and winter [ocean maturing] steelhead). The timing of upstream migration of winter steelhead is correlated with higher flow events, such as freshets or sandbar breaches. Adult summer steelhead migrate upstream from March through September. In contrast to other species of *Oncorhynchus*, steelhead may spawn more than one season before dying (iteroparity); although one-time spawners represent the majority.

Survival to emergence of steelhead embryos is inversely related to the proportion of fine sediment in the spawning gravels. However, steelhead are slightly more tolerant than other salmonids, with significant reductions in survival when fine materials of less than 0.25 inches in diameter comprise 20 to 25 percent of the substrate. Fry typically emerge from the gravel two to three weeks after hatching (Barnhart 1986).

Upon emerging from the gravel, fry rear in edgewater habitats and move gradually into pools and riffles as they grow larger. Older fry establish territories which they defend. Cover is an important habitat component for juvenile steelhead, both as a velocity refuge and as a means of avoiding predation (Meehan and Bjornn 1991). Steelhead, however, tend to use riffles and other habitats not strongly associated with cover during summer rearing more than other salmonids. Young steelhead feed on a wide variety of aquatic and terrestrial insects, and emerging fry are sometimes preyed upon by older juveniles. In winter, juvenile steelhead become less active and hide in available cover, including gravel or woody debris. Suspended sediment concentrations, or turbidity, can influence the distribution and growth of steelhead (Bell 1973, Sigler *et al*. 1984, Newcombe and Jensen 1996). Bell (1973) found suspended sediment loads of less than 25 milligrams per liter (mg/L) were typically suitable for rearing juvenile steelhead

Water temperature can influence the metabolic rate, distribution, abundance, and swimming ability of rearing juvenile steelhead (Barnhart 1986, Bjornn and Reiser 1991, Myrick and Cech 2005). Optimal temperatures for steelhead growth range between 10 and 20 degrees (°) Celsius (C) (Hokanson *et al.* 1977, Wurtsbaugh and Davis 1977, Myrick and Cech 2005). Fluctuating diurnal water temperatures are also important for the survival and growth of salmonids (Busby *et al.* 1996). Because rearing juvenile steelhead can reside in freshwater all year, adequate flow and temperature are important to the population at all times.

Outmigration of steelhead appears to be more closely associated with size than age. In Waddell Creek, Shapovalov and Taft (1954) found steelhead juveniles migrating downstream at all times of the year, with the largest numbers of young-of-year (YOY) and age 1+ steelhead moving downstream during spring and summer.

2. Green Sturgeon

The North American green sturgeon ranges from the Bering Sea, Alaska, to Ensenada, Mexico. Presently, spawning has been confirmed to occur in the Klamath and Rogue Rivers (Northern DPS) and the Sacramento and Feather Rivers[2] (Southern DPS). Adults spawn in large rivers during the spring and early summer and eggs are laid in turbulent areas on the river bottom and settle into the interstitial spaces between cobble and gravel (Adams *et al*. 2007). Like salmonids, green sturgeon require cool water temperatures for egg and larval development, with optimal temperatures ranging from 11 to 17˚C (Van Eenennaam *et al*. 2005). Eggs hatch after 6–8 days, and larval feeding begins 10–15 days post-hatch; metamorphosis of larvae into juveniles typically occurs after a minimum of 45 days (post-hatch) when fish have reached 60–80 mm total length (TL) (Beamesderfer *et al*. 2007). After rearing in freshwater or the estuary of their natal river for one to four years, young green sturgeon move into coastal waters (Nakamoto *et al*. 1995, Adams *et al*. 2002). Juvenile green sturgeon captured in the Klamath River estuary ranged from 320 to 660 mm TL (Nakamoto *et al.* 1995). Records of juvenile green sturgeon in San Francisco estuary are limited, but juveniles captured in the Delta are typically greater than 200 mm TL, suggesting Southern DPS green sturgeon also spend several months rearing in freshwater before entering the estuary. Laboratory studies, conducted by Allen and Cech, Jr. (2007), indicated juveniles approximately 6 months old (approximately 34 cm TL) were tolerant of saltwater, but approximately 1.5 year old (approximately 75 cm TL) green sturgeon appeared more capable of successful osmoregulation in salt water. Furthermore, green sturgeon observed from coastal marine waters in limited entry groundfish bottom trawl and California halibut commercial fisheries between 2007 and December 2010 (n=88) were greater than 60 cm fork length (or greater than approximately 65 cm TL) (WCGOP 2011, unpublished data). Green sturgeon are one of the most marine-oriented and widely distributed of the sturgeons; sexually immature fish that have entered coastal marine waters ("subadults ") spend several years at sea before reaching reproductive maturity and returning to freshwater to spawn for the first time (Nakamoto *et al*. 1995).

Green sturgeon do not mature until they are at least 15–17 years of age at a size of 1.4–2.2 m in length (Beamesderfer *et al*. 2007). The length at first maturity is estimated to be 152 cm TL (14-16 years) for males and 162 cm TL (16-20 years) for females in the Klamath River (Van Eenennaam *et al*. 2006), and 145 cm TL for males and 166 cm TL for females in the Rogue River (Erickson and Webb 2007). Adult green sturgeon are iteroparous and believed to spawn every 2-4 years (Moyle 2002, Erickson and Webb 2007). Although males are capable of spawning annually, female sturgeon typically require two years to complete vitellogenesis. Green sturgeon fecundity (50,000–115,000 eggs; Van Eenennaam *et al*. 2008) is reportedly lower than other sturgeons, but the egg size is larger.

Mature green sturgeon enter their natal river in the spring and, in the Northern DPS, typically leave the river during the subsequent autumn when water temperatures drop below 10°C and flows increase (Erickson and Webb 2007). Recent telemetry studies by Heublein *et al.* (2009)

[2] Spawning was recently confirmed in the Feather River downstream of Oroville Dam (Seesholtz 2011)

revealed adults typically enter the Bay and begin their upstream spawning migrations between late February and early May. Based on egg capture and upstream migration of tagged fish, peak spawning is estimated to occur in deep turbulent sections of the Sacramento River between April and mid-June (Poytress *et al*. 2011, Heublein *et al.* 2009). CDFG (2002) report Southern DPS green sturgeon spawning occurs above Hamilton City and possibly as far upstream as Keswick Dam on the Sacramento River. Incidental capture of green sturgeon post-larvae in salmon out-migrant traps indicates successful spawning can occur in the Sacramento River both upstream and downstream of Red Bluff Diversion Dam (Rkm 391) (Israel and Klimley 2008). More specifically, green sturgeon eggs have been captured in egg mats in the Sacramento River from below the confluence of Antelope Creek (Rkm 377) up to the confluence of Ink's Creek (Rkm 426) (Poytress *et al*. 2011). In the Southern DPS, tagged adult green sturgeon displayed two outmigration strategies; presumably after spawning, green sturgeon emigrated from Sacramento River during summer months, or remained in the river until the onset of winter flows (Heublein *et al.* 2009).

Subadult and adult green sturgeon move between coastal waters and various estuaries along the U.S. West Coast between San Francisco Bay, CA, and Grays Harbor, WA (Lindley *et al*. 2008, Lindley *et al*. 2011). Multiple rivers and estuaries are visited by dense aggregations of green sturgeon in summer months (Moser and Lindley 2007, Lindley *et al*. 2011). Notably, capture of green sturgeon in San Pablo Bay and detections of tagged green sturgeon indicated adult and subadult green sturgeon can be present in the Bay during all months of the year (Kelly *et al*. 2007; Heublein *et al.* 2009; Lindley *et al*. 2011). Relatively little is known about how green sturgeon use habitats in the coastal ocean and in estuaries, or the purpose of their episodic aggregations there at certain times (Lindley *et al*. 2008; Lindley *et al*. 2011). Genetic studies examining the stock composition of estuarine aggregations (Israel *et al*. 2009) indicate that almost all green sturgeon in the San Francisco Bay system belong to the Southern DPS. This is corroborated by tagging and tracking studies which found that no green sturgeon tagged in the Klamath or Rogue rivers (*i.e.*, Northern DPS spawning rivers) were detected in San Francisco Bay (Lindley *et al*. 2011). However, green sturgeon in coastal waters adjacent to San Francisco Bay may include Northern DPS green sturgeon. Genetic analysis of tissue samples collected from observed green sturgeon bycatch in coastal waters adjacent to San Francisco Bay indicated that approximately 17% (*i.e.*, 3 out of 18) of the green sturgeon encountered and sampled belonged to the Northern DPS and approximately 83% (*i.e.*, 15 out of 18) belonged to the Southern DPS (Israel 2010).

Green sturgeon feed on benthic invertebrates and fish (Adams *et al.* 2002). Radtke (1966) analysed stomach contents of juvenile green sturgeon captured in the Delta and found the majority of their diet was benthic invertebrates such as mysid shrimp and amphipods (*Corophium spp*). Manual tracking of acoustically-tagged green sturgeon in the San Francisco Bay estuary indicates they are generally demersal but make occasional forays to surface waters, perhaps to assist their migration (Kelly *et al*. 2007). Recent telemetry data in coastal ocean habitats suggest that green sturgeon spent a longer duration in areas with high seafloor complexity, especially where a greater proportion of the substrate consists of boulders (Huff *et al*. 2011). However, while presumably feeding on benthic invertebrates in estuaries green sturgeon do not appear to utilize hard substrates (Dumbauld *et al*. 2008). Preliminary data from mapping surveys conducted in Willapa Bay, WA, showed densities of "feeding pits"

(depressions in the substrate believed to be formed when green sturgeon feed) were highest over shallow intertidal mud flats, while harder substrates (*e.g.*, gravel) had no pits (M. Moser, unpublished data). In their natal rivers, telemetry data indicates mature green sturgeon prefer deep pools, presumably for the purposes of spawning and conserving/restoring energy (Erickson and Webb 2007; Heublein *et al*. 2009). Similar tracking studies involving juvenile green sturgeon have not been conducted, and their behavior and habitat preferences in rivers and estuaries are largely unknown.

B. Status of Species and Critical Habitat

In this opinion, NMFS assesses four population viability parameters to help us understand the status of CCC steelhead and southern DPS green sturgeon and their populations' ability to survive and recover. These population viability parameters are: abundance, population growth rate, spatial structure, and diversity (McElhany *et al.* 2000). NMFS has used existing information to determine the general condition of each population and factors responsible for the current status of each DPS or ESU.

We use these population viability parameters as surrogates for numbers, reproduction, and distribution, the criteria found within the regulatory definition of jeopardy (50 CFR 402.20). For example, the first three parameters are used as surrogates for numbers, reproduction, and distribution. We relate the fourth parameter, diversity, to all three regulatory criteria. Numbers, reproduction, and distribution are all affected when genetic or life history variability is lost or constrained resulting in reduced population resilience to environmental variation at local or landscape-level scales.

1. <u>CCC Steelhead</u>

Historically, approximately 70 populations[3] of steelhead existed in the CCC steelhead DPS (Spence *et al.* 2008). Many of these populations (about 37) were independent, or potentially independent, meaning they had a high likelihood of surviving for 100 years absent anthropogenic impacts (Bjorkstedt *et al*. 2005). The remaining populations were dependent upon immigration from nearby CCC steelhead DPS populations to ensure their viability (McElhaney *et al*. 2000; Bjorkstedt *et al*. 2005).

While historical and present data on abundance are limited, CCC steelhead numbers are substantially reduced from historical levels. A total of 94,000 adult steelhead were estimated to spawn in the rivers of this DPS in the mid-1960s, including 50,000 fish in the Russian River – the largest population within the DPS (Busby *et al.* 1996). Near the end of the 20th Century, McEwan (2001) estimated the wild run population in the Russian River Watershed was between 1,700-7,000 fish. Abundance estimates for smaller coastal streams in the DPS indicate low but stable levels with recent estimates for several streams (Lagunitas, Waddell, Scott, San Vicente, Soquel, and Aptos creeks) of individual run sizes of 500 fish or less (62 FR 43937). For more

[3] Population as defined by Bjorkstedt *et al*. 2005 and McElhaney *et al*. 2000 as, in brief summary, a group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group. Such fish groups may include more than one stream. These authors use this definition as a starting point from which they define four types of populations (not all of which are mentioned here).

detailed information on trends in CCC steelhead abundance, see: Busby *et al*. 1996, NMFS 1997, and NMFS 2005.

Some loss of genetic diversity has been documented and attributed to previous among-basin transfers of stock and local hatchery production in interior populations in the Russian River (Bjorkstedt *et al.* 2005). Reduced population sizes and fragmentation of habitat in San Francisco streams has likely also led to loss of genetic diversity in these populations.

CCC steelhead have experienced a serious decline in abundance and long-term population trends suggest a negative growth rate. This indicates the DPS may not be viable in the long term. DPS populations that historically provided enough steelhead immigrants to support dependent populations may no longer be able to do so, placing dependent populations at increased risk of extirpation. However, because CCC steelhead have maintained a wide distribution throughout the DPS, roughly approximating the known historical distribution, CCC steelhead likely possess a resilience that is likely to slow their decline relative to other salmonid DPSs or ESUs in worse condition. Data from the 2008/09 and 2009/2010 adult CCC steelhead returns indicate a decline in returning adults across their range compared to other recent returns (*e.g.*, 2006/2007, 2007/2008) (Jeffrey Jahn, NMFS, personal communication, August 2011). The most recent status update concludes that steelhead in the CCC steelhead DPS remain "likely to become endangered in the foreseeable future" (Williams *et al.* 2011), as new and additional information available since the previous status review (Good *et al.* 2005) does not appear to suggest a change in extinction risk. On August 15, 2011, NMFS chose to maintain the threatened status of the CCC steelhead DPS (76 FR 50447).

2. <u>Southern DPS Green Sturgeon</u>

To date, little population-level data have been collected for green sturgeon. In particular, there are no published abundance estimates for either Northern DPS or Southern DPS green sturgeon in any of the natal rivers based on survey data (Israel *et al*. in prep). As a result, efforts to estimate green sturgeon population size have had to rely on sub-optimal data with known potential biases, including monitoring designed for white sturgeon (*Acipenser transmontanus*) populations, harvest time series, or entrainment from water diversion and export facilities (Adams *et al*. 2007). Of these sources, only the water diversion data indicate a possible trend, suggesting Southern DPS green sturgeon abundance or recruitment has declined since 1986 in the Sacramento River (Adams *et al*. 2007).

More recent genetic techniques and monitoring surveys are beginning to clarify questions about green sturgeon population size. Genetic data collected from incidental captured larval green sturgeon in salmon out-migrant traps suggest that the number of adult green sturgeon in the upper Sacramento River (Southern DPS green sturgeon) remained roughly constant between 2002 and 2006 in river reaches above Red Bluff (Israel and May 2010). Recently developed surveys using dual frequency identification sonar have estimated 175 to 250 sturgeon (±50) in the mainstem Sacramento River during the spawning season in 2010 and 2011 (pers. comm. with Ethan Mora, UC Davis, on January 10, 2012). However, this estimate includes considerable uncertainty; all sturgeon detections were assumed to be green sturgeon and a small number of white sturgeon were potentially misidentified as green sturgeon. Furthermore, spawning

population estimates assumed individual fish did not move in and out of survey areas throughout the season (*i.e.* observations of multiple individuals moving in and out of an area could be recorded as one individual). Given these uncertainties, caution must be taken in using these estimates to infer the spawning run size for the Sacramento River, until further analyses are completed.

Recruitment data for Southern DPS green sturgeon are essentially nonexistent. Incidental catches of larval green sturgeon in the mainstem Sacramento River and of juvenile green sturgeon at the state and Federal pumping facilities in the South Delta suggest that green sturgeon are successful at spawning, but that annual year class strength may be highly variable (Beamesderfer *et al*. 2007; Adams *et al*. 2007). Successful recruitment into the population is unclear. Because green sturgeon are long-lived and spawn multiple times throughout their lifetime, spawning failure in one year can be made up for in another spawning year. In general, sturgeon year class strength appears to be episodic with overall abundance dependent on a few successful spawning events (NMFS 2010b).

Recently, Erickson *et al*. (unpublished) estimated spawning run sizes for Northern DPS rivers ranging from 426 to 734 adult green sturgeon using mark-recapture methods (Israel *et al*. in prep). These estimates appear to be inconsistent with harvest data indicating that 200 to 450 Northern DPS green sturgeon were harvested each year in the Klamath River tribal fishery from 1985 to 2003, with no evidence of declining catches (Adams *et al*. 2007). The inconsistencies may be due to error in the population estimates and/or because the recent population estimates were based on data collected from a different time period compared to the tribal harvest data. Adams *et al*. (2007) concluded that the abundance of mature green sturgeon in the Southern DPS is much smaller than in the Northern DPS (Adams *et al*. 2007), but the absolute and relative abundance of the two DPS remain highly uncertain. Carefully designed studies remain needed to provide absolute estimates of abundance for the species.

Recently enacted fishing regulations and conservation measures have reduced current fishery impacts to green sturgeon throughout its range (http://www.nmfs.noaa.gov/pr/species/fish/greensturgeon.htm). For example, commercial and sport fisheries in California, Oregon, Washington (United States), and British Columbia (Canada) now ban retention of green sturgeon.

Green sturgeon face a variety of threats in the freshwater, estuarine, and marine environments within which they move throughout their life history. Threats to this species include: reduction/loss of spawning areas, insufficient freshwater flow rates in spawning areas, contaminants (*e.g.*, pesticides), harvest bycatch, poaching, entrainment by water projects, influence of exotic species, small population size, impassable barriers, and elevated water temperatures (Adams *et al*. 2007). The most recent status review update concluded the southern DPS green sturgeon is likely to become endangered in the foreseeable (NMFS 2005); a principal factor in NMFS' conclusion was the reduction of potential spawning habitat to a single area in the Sacramento River due to migration barriers (*e.g.*, dams). Historical spawning habitat may have extended up into the three major branches of the upper Sacramento River above the current location of Shasta Dam; however, those habitats have been made inaccessible or altered by dams (Mora *et al*. 2009; Adams *et al*. 2007). The reduction of spawning habitat to a single system

increases the vulnerability of the spawning population to catastrophic events and of early life stages to variable environmental conditions within the system. Severe threats to the single remaining spawning population, coupled with the inability to alleviate those threats using current conservation measures, led to the decision to list the species as threatened on April 7, 2006 (71 FR 17757).

3. Status of Critical Habitat

The condition of CCC steelhead and CCC coho salmon critical habitat, specifically its ability to provide for their conservation, has been degraded from conditions known to support viable populations. NMFS has determined that currently depressed population conditions are, in part, the result of the following human-induced factors affecting critical habitat: logging, agriculture, mining, urbanization, stream channelization, dams, wetland loss, and water withdrawals (including unscreened diversions for irrigation). Impacts of concern include impairment or loss of PCEs and essential features such as altered stream bank and channel morphology, elevated water temperature, lost spawning and rearing habitat, habitat fragmentation (lost migration PCEs), impaired gravel and wood recruitment from upstream sources, degraded water quality, lost riparian vegetation, and increased erosion into streams from upland areas (Weitkamp *et al*. 1995; Busby *et al*. 1996; 64 FR 24049; 70 FR 37160; 70 FR 52488). Furthermore, diversion and storage of river and stream flow has dramatically altered the natural hydrologic cycle degrading migration and rearing PCEs in many of the streams within the DPS and ESU. Altered flow regimes can delay or preclude migration, dewater aquatic habitat, and strand fish in disconnected pools, while unscreened diversions can entrain juvenile fish.

The current condition of critical habitat for the southern DPS of green sturgeon is degraded over its historical conditions. It does not provide the full extent of conservation values necessary for the recovery of the species, particularly in the upstream riverine habitat of the Sacramento River. In particular, passage and water flow PCEs have been impacted by human actions, substantially altering the historical river characteristics in which the southern DPS of green sturgeon evolved. In addition, the alterations to the Delta may have a particularly strong impact on the survival and recruitment of juvenile green sturgeon due to their protracted rearing time in the Delta and estuary.

C. Factors Responsible for Steelhead and Green Sturgeon Stock Declines

NMFS cites many reasons (primarily anthropogenic) for the decline of steelhead (Busby *et al*. 1996; Good *et al.* 2005) and southern DPS of green sturgeon (Adams *et al.* 2002; NMFS 2005). The foremost reason for the decline in these anadromous populations is the degradation and/or destruction of freshwater and estuarine habitat, including critical habitat, caused by (as described briefly above) anthropogenic disturbances such as urban development, agriculture, logging, water resource development, and dams. Additional factors contributing to the decline of salmonid populations (and, where applicable, green sturgeon populations) include: poor estuary/lagoon management (Smith 1990, Bond 2006; Hayes *et al.* 2008; Hayes *et al.* 2011), commercial and recreational bycatch and harvest, artificial propagation (Waples 1991), natural stochastic events , marine mammal predation (Hanson 1993, NMFS 1999), reduced marine-derived nutrient transport (Bilby *et al.* 1996; Bilby *et al.* 1998; Gresh *et al.* 2000), and most recently poor ocean conditions (Lindley *et al.* 2009).

D. Global Climate Change

Our changing climate is likely to affect listed species in the future. Modeling of climate change impacts in California suggests average summer air temperatures are expected to increase (Lindley *et al*. 2007). Heat waves are expected to occur more often, and heat wave temperatures are likely to be higher (Hayhoe *et al*. 2004). Total precipitation in California may decline; critically dry years may increase (Lindley *et al*. 2007; Schneider 2007). The Sierra Nevada snow pack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled (Luers *et al*. 2006). Wildfires are expected to increase in frequency and magnitude, by as much as 55 percent under the medium emissions scenarios modeled (Luers *et al*. 2006). Vegetative cover may also change, with decreases in evergreen conifer forest and increases in grasslands and mixed evergreen forests. The likely change in amount of rainfall in Northern and Central Coastal streams under various warming scenarios is less certain, although as noted above, total rainfall across the state is expected to decline. For the California North Coast, some models show large increases (75 to 200 percent) while other models show decreases of 15 to 30 percent (Hayhoe *et al*. 2004). Many of these changes are likely to further degrade salmonid habitat by, for example, reducing stream flows during the summer and raising summer water temperatures. Estuaries may also experience changes detrimental to green sturgeon. Estuarine productivity is likely to change based on changes in freshwater flows, nutrient cycling, and sediment amounts (Scavia *et al.* 2002). In marine environments, ecosystems and habitats important to sub adult and adult salmonids are likely to experience changes in temperatures, circulation and chemistry, and food supplies (Feely *et al.* 2004; Brewer 2008; Osgood 2008; Turley 2008). The projections described above are for the mid to late 21st Century. In shorter time frames natural climate conditions are more likely to predominate (Cox and Stephenson 2007; Smith *et al.* 2007).

V. ENVIRONMENTAL BASELINE

The environmental baseline is the current status of species and critical habitat in the action area based on analysis of the effects of past and ongoing human and natural factors. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impacts of State or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

Corte Madera Creek originates in the foot hills of Mount Tamalpais and flows east to meet San Pablo Bay. Bon Air Bridge is located approximately three kilometers west of the confluence of Corte Madera Creek and San Pablo Bay, in Marin County, California. A small run of CCC steelhead persist in the Corte Madera Creek watershed (Leidy *et al.* 2005). Juvenile (pre-smolt) steelhead are not physiologically capable of rearing in lower Corte Madera Creek; saltwater tolerant steelhead smolts are believed to rapidly emigrate from Corte Madera Creek to more productive ocean waters. Therefore, the lower tidal portion of Corte Madera Creek functions primarily as a migratory corridor for steelhead. With regard to the larger steelhead DPS, the

habitat within the action area represents a very small portion of the available migratory habitat. However, without this migratory habitat steelhead would not be able to access spawning habitat, and higher quality rearing habitat upstream and within tributaries such as San Anselmo Creek.

There are no known records of green sturgeon in Corte Madera Creek and the creek is too small to support spawning of green sturgeon. The tidal portions of Corte Madera Creek, however, provide accessible rearing and foraging habitat for juvenile, subadult, and adult green sturgeon, which may be present in the Bay and tidal creeks and sloughs draining to the Bay year-round. Available fisheries data from tidal creeks and sloughs draining into the Bay (ongoing monitoring studies, fish relocation reports, *etc.*) shows very few green sturgeon have been found in sampling efforts. Based on this, NMFS concludes small tidal creeks or sloughs (like lower Corte Madera Creek) are unlikely to contain an abundance of green sturgeon. Within the Bay, concentrations of subadult and adult green sturgeon are only known to exist in open water. Juvenile green sturgeon are occasionally caught as bycatch in the commercial herring fishery near Paradise Cove in San Pablo Bay, approximately 6 kilometers south of the mouth of Corte Madera Creek (pers. Comm. Mike Holm).

A. Status of Listed Species and Habitat in the Action Area

The tidal waters of Corte Madera Creek include designated critical habitat for CCC steelhead, southern DPS green sturgeon, and CCC coho salmon, and contains rearing and migration habitat PCE's. Salmonid rearing habitat, however, is likely to be limited to areas upstream of the tidal portion of Corte Madera Creek. At Bon Air Bridge, Corte Madera Creek is approximately 100 meters wide and flows roughly north to south with perennial brackish water, receiving freshwater runoff from upstream and tidal influences from San Pablo Bay. Open water, shallow mudflats, and marsh habitats exist within the action area. Lower Corte Madera Creek is relatively sinuous within the action area and flows in an open "z" path; 300 meters upstream of Bon Air Bridge, the creek curves approximately 70 degrees (from east to south), and then curves approximately 70 degrees (from south to east) 200 meters downstream of the bridge. During low tides, the wetted channel beneath the bridge can be narrow (less than 2 meters wide) with wide mud flat margins. The bed is composed mostly of clay with an occasional layer of silty sand. Within the action area, a raised pedestrian pathway (levee) and shoreline development separate all but a narrow fringe of wetland habitat from Corte Madera Creek, with some tidally influenced saline emergent wetland located northeast of the bridge adjacent to Corte Madera Creek. Approximately one kilometer upstream of the bridge Corte Madera Creek exists in a narrow, trapezoidal, and concrete-lined flood control channel for approximately 1.5 kilometers before returning to more natural stream bed and bank conditions

Very little fisheries data is available for lower Corte Madera Creek or the action area. Records of juvenile *O. mykiss* presence in August and September of 2005, approximately 2.5 kilometers upstream of the action area, indicate available salmonid rearing habitat exists upstream of the tidal portion of Corte Madera Creek (Rich and Assoc. 2006). In fall 2011, no salmonids or sturgeon were collected during dewatering and fish relocation activities conducted approximately 500 meters upstream of Bon Air Bridge (Martin 2011). Steelhead smolts, however, were not

likely to be migrating through the action area when relocation activities took place (October). As described previously, there are no known records of green sturgeon in Corte Madera Creek.

B. Factors Affecting Species Environment within the Action Area

The dominant factors affecting habitat within the action area are shoreline development, fill of wetlands, and reduction or modification of freshwater inflow, which have resulted in loss of estuarine and wetland habitat ..

C. Previous Section 7 Consultations and Section 10 Permits in the Action Area

Pursuant to section 7 of the ESA, NMFS has conducted one interagency consultation that affected the action area of this project. In June 2011, the Corps completed consultation with NMFS on the Kentfield Sewage Force Main Replacement and Berens/McAllister Sloughs Culverts Replacement Project. The project included the construction of three 36-inch diameter culverts to replace the existing single 36-inch diameter culvert connecting McAllister Slough to Corte Madera Creek approximately 500 meters upstream of Bon Air Bridge (NMFS administrative record #151422SWR2011SR00275). This consultation concluded that the project was not likely to adversely affect CCC steelhead, CCC coho salmon, or southern DPS green sturgeon. These improvements to the connection between Berens/McAllister Sloughs and Corte Madera Creek could provide habitat benefit at the northern edge of the Action Area by potentially increasing tidal action and fish accessibility to off-channel wetland and shallow water habitats.

Activities related to NMFS' Section 10(a)(1)(A) research and enhancement permits and section 4(d) limits or exceptions could potentially occur in the Corte Madera Creek watershed. Salmonid monitoring approved under these programs includes carcass surveys, smolt outmigration trapping, and juvenile density surveys. In general, these activities are closely monitored and require measures to minimize take during the research activities. NMFS has analyzed the effects of these activities and determined that they are unlikely to jeopardize listed salmonids or green sturgeon, or adversely modify the critical habitats of these species.

VI. EFFECTS OF THE PROPOSED ACTION

The purpose of this section is to identify the direct and indirect effects of the proposed action, and any interrelated or interdependent activities, on threatened CCC steelhead and green sturgeon. Our approach was based on knowledge and review of the ecological literature and other relevant materials. We used this information to gauge the likely effects of the proposed Project via an exposure and response framework that focuses on what stressors (physical, chemical, or biotic), directly or indirectly caused by the proposed action, that steelhead and green sturgeon are likely to be exposed to. Next, we evaluate the likely response of steelhead and green sturgeon to these stressors in terms of changes to survival, growth, and reproduction, and changes to the ability of PCEs to support the value of critical habitat in the action area. PCEs include sites essential to support one or more life stages of the species. These sites for migration, spawning, and rearing in turn contain physical and biological features that are essential to the

conservation of the species. Where data to quantitatively determine the effects of the proposed action on CCC steelhead and their critical habitat were limited or not available our assessment of effects focused mostly on qualitative identification of likely stressors and responses.

Construction activities associated with the Bon Air Bridge Replacement are expected to affect green sturgeon and steelhead and their critical habitats primarily through underwater noise during pile driving and, to a lesser extent, temporary degradation of water quality. Pile driving activities associated with the replacement of Bon Air Bridge are expected to take place over four in-water work seasons (September 1 to November 30). Steelhead are not likely to be present in the action area during the project's in-water activities. Green sturgeon can be present in the Bay year-round, and a small number of green sturgeon may intermittently utilize waters of the action area to forage or rear; therefore, a small number of green sturgeon could be exposed to the project's in-water activities in fall. The potential effects of these activities are presented in detail below.

A. Species Effects

1. Sound Pressure Impacts on Fish from Pile Driving

a. Overview of Pile Driving Impacts

Pile driving activities may affect listed salmonids and green sturgeon through exposure to high underwater sound levels produced during pile driving and degradation of water quality during pile driving activities. The underwater sound pressure waves that have the potential to adversely affect listed salmonids and green sturgeon originate with the contact of the hammer with the top of the pile. The impact of the hammer on the top of the pile causes a wave to travel down the pile and the pile to resonate radially and longitudinally like a gigantic bell. Most of the acoustic energy is a result of the outward expansion and inward contraction of the walls of the pile as the compression wave moves down the pile from the hammer to the end of the pile buried in the waterway's bottom materials. Water is virtually incompressible and the outward movement of the pile (by a fraction of an inch) followed by the pile walls pulling back inward to their original shape, sends an underwater pressure wave propagating outward from the pile in all directions. The pile resonates, sending out a succession of waves even as it is pushed several inches deeper into the bottom. Piles can be composed of wood, steel, or concrete. Different types of piles result in different levels of underwater noise. For the proposed project, steel piles will be used for construction.

Available information indicates that fish may be injured or killed when exposed to elevated underwater sound pressure waves generated by steel piles installed with impact hammers. Pathologies associated with very high sound levels are collectively known as *barotraumas*. Barotraumas are pathologies associated with exposure to drastic changes in pressure. These include hemorrhage and rupture of internal organs, including the swim bladder and kidneys in fish. Death can be instantaneous, occur within minutes after exposure, or occur several days later. An important characteristic of the underwater sound that causes injury is the frequency. During pile installation, most energy is contained within the frequency range (100-1,000 Hertz) which results in reverberation of the swim bladder.

Exposure to sound for longer periods of time can also injure and kill fish (Hastings 1995). Hastings (1995) found death rates of 50 percent and 56 percent for gouramis (*Trichogaster sp*.) when exposed to continuous sounds at 192 dB referenced to one micropascal squared second (re: $1\mu Pa^2$-s) at 400 Hz and 198 dB re: $1\mu Pa^2$-s at 150 Hz, respectively, and 25 percent for goldfish (*Carassius auratus*) when exposed to sounds of 204 dB re: $1\mu Pa^2$-s at 250 Hz for two hours or less. Hastings (1995) also reported that acoustic "stunning," a potentially lethal effect resulting in a physiological shutdown of body functions, immobilized gourami within eight to thirty minutes of exposure to the aforementioned sounds. These sound pressure levels can also result in hearing damage to fish (Enger 1981; Hastings *et al.* 1995, 1996). Additional detrimental effects on fish from sound levels such as those noted above include stress, increasing risk of mortality by reducing predator avoidance capability, and interfering with communication necessary for navigation and reproduction (Scholik and Yan 2001; Shin 1995; and Popper 1997).

In the *Compendium of Pile Driving Sound Data* (Illingworth & Rodkin 2007) the most recent pile driving case studies are compiled in order to provide information regarding the underwater sound pressure levels generated with the installation of steel and concrete piles by different hammer types. Several pile driving case studies conducted within the San Francisco Bay region are included in the compendium. A dual metric criteria of 206 dB re: 1μPa peak (sound pressure level) SPL for any single strike and an accumulated sound exposure level (SEL) of 187 dB re: $1\mu Pa^2$-s are currently used by the Fisheries Hydroacoustic Working Group (FHWG[4]) to correlate physical injury to fish greater than 2 grams in size from underwater sound pressure produced during the installation of piles with impact hammers. As distance from the pile increases, sound attenuation reduces sound pressure levels and the potential harmful effects to fish also decrease. Disturbance and noise associated with construction at the pile driving site may also startle fish and result in dispersion from the action area.

A study in Puget Sound, Washington suggests that pile driving operations disrupt juvenile pink and chum salmon (*Oncorhynchus spp.*) behavior (Feist *et al*. 1992). Though no underwater sound measurements are available from that study, comparisons between juvenile salmon schooling behavior in areas subjected to pile driving/construction and other areas where there was no pile driving/construction indicate that there were fewer schools of fish in the pile-driving areas than in the non-pile driving areas. The results are not conclusive but may indicate that pile-driving operations affect the distribution and behavior of juvenile anadromous salmonids.

Currently, there is very little data available regarding effects of pile driving directly focused on green sturgeon. Like the juvenile salmonids described in the above study, juvenile green sturgeon utilize estuarine environments as foraging habitat and migration routes to the ocean; therefore, it is reasonable to assume pile driving operations may affect the estuarine distribution and behavior of juvenile green sturgeon as well. There is uncertainty as to the behavioral response of fish to underwater sound produced when driving piles in or near water. Until new information indicates otherwise, NMFS believes a 150 dB RMS re: 1μPa[5] pressure threshold for behavioral responses for salmonids and green sturgeon is appropriate.

---

[4] Member agencies of the FHWG include Caltrans, FHWA, NMFS (Northwest and Southwest Regions), USFWS, CDFG, and Oregon and Washington Departments of Transportation.

[5] Throughout the remainder of this document, sound pressure metrics are referenced to the following pressures: peak

b. Project Specific Considerations

The results of the above pile driving projects and information available in the literature are helpful in assessment of the potential effects of pile driving associated with the proposed project, but considerable uncertainty remains. Effects on an individual fish during pile driving at the Bon Air Bridge will be dependent on a number of variables associated with environmental conditions at the project site and variables associated with the specific construction schedule.

As stated above, a dual metric criteria of 206 dB peak SPL for any single strike and an accumulated SEL of 187 dB are currently used by NMFS and the FHWG as thresholds to correlate physical injury to fish greater than 2 grams in size from underwater sound produced during the installation of piles with impact hammers. As distance from the pile increases, sound attenuation reduces sound pressure levels and the potential harmful effects to fish also decrease.

Water depth at the pile driving site will also influence the rate of sound attenuation. In deep water areas high sound pressure waves are likely to travel farther than in shallow waters. Within shallow water, much of the acoustic energy is expected to be absorbed by the bottom and reflected off the surface back down to the bottom and even backwards towards the pile. The rate of attenuation is much higher in shallower water; reducing the expected area of adverse effects as compared to deeper water. Water depths during pile driving for the proposed project will vary with tide and pile location, and range from 0 to approximately 3 meters. The relatively narrow and curved creek channel bordered by shallow mudflat and marsh within the action area should provide some sound transmission loss as sound travels outward from the piles.

Methods may be used during construction to aide sound attenuation. Encapsulating the piles within an air bubble curtain attenuates the sound, thereby decreasing the area in which the adverse sound-related impacts occur. Bubble curtains reduce the area of sound impedance from the pile and, therefore, reduce the area of potential noise impacts on fish. The City proposes to use a bubble curtain to attenuate under water sound levels and minimize potential impacts during all impact hammer pile driving. Previous Caltrans projects in the Bay involving pile driving indicate the use of a bubble curtain is capable of providing 10 dB of attenuation during impact hammer pile driving of 12-inch steel H-pile and 126-inch steel pipe piles (Illingworth and Rodkin, Inc. 2007). For the impact hammer pile driving of the proposed 14-inch H and 10-foot steel pipe pilings the bubble curtain is anticipated to reduce sound pressure levels by approximately 10 dB for (Illingworth and Rodkin, Inc. 2007). The assessment of acoustic impacts associated with this project will be based on an estimated minimum reduction in sound pressure that these measures provide.

The timing and duration in which pile driving will occur will influence the level of potential impact on steelhead and green sturgeon. In-water construction activities for the proposed project are expected to occur between September 1 and November 30 over four years; impact hammer pile driving will be completed by November 15, November 1, and October 15 in years one through three, respectively. Steelhead spawning and rearing is not believed to occur in the action area. Adult CCC steelhead migration and juvenile steelhead smoltification/emigration in lower

---

dB SPL and RMS are both referenced to1μPa, accumulated or single strike SELs are referenced to 1μPa^2-s.

Corte Madera Creek and neighboring watersheds is likely to occur between December and April and January and July, respectively (Fukushima and Lesh 1998; Rich 2000). Therefore, CCC steelhead are not likely to be migrating through lower Corte Madera Creek during pile driving activities. Juvenile, sub-adult, and adult green sturgeon may be present in the Bay and tidal creeks and sloughs draining to the Bay year-round. Therefore, green sturgeon could be present in the tidal portion of Corte Madera Creek during fall. It is unclear, however, if these fish will be present during pile driving (which is unlikely to occur during the entire work window –see below) and exposed to the elevated sound pressure levels in the action area. Until more specific information on green sturgeon distribution is available, NMFS expects a small number of green sturgeon (juvenile, sub-adult, and adult) will be present in lower Corte Madera Creek during the fall and may be subjected to harmful sound levels during pile driving.

c. Assessment of Pile Driving Effects

Vibratory hammer pile driving and pile extraction is not anticipated to generate sound levels necessary to adversely affect fish. Sound monitoring data collected from pile driving projects throughout the Bay indicate that sound pressure levels resulting from the proposed project's impact hammer pile driving activities will, in some instances, exceed the dual metric criteria and therefore likely result in injury to green sturgeon (Illingworth & Rodkin 2007). With the use of a bubble curtain, exceedance of the 206 dB peak threshold is only anticipated adjacent to the H-piles and steel casings (<10 meters and 14 meters, respectively). Additionally, the proposed pile driving is anticipated to exceed the 187 dB SEL threshold for physical injury within 35 meters of pile driving of H-piles, and 430 meters of steel casings. If an unimpeded open water sound propagation path was possible during impact hammer pile driving, the 150 dB RMS threshold for behavioral responses could extend into open waters, substrate, and shoreline of Corte Madera Creek that fall within a several kilometer radius of the Bon Air Bridge. This area, however, includes major bends and shallow water mud flats both upstream and downstream of the bridge (described in greater detail in the section "V. ENVIRONMENTAL BASELINE" above). These features will diffract and attenuate sound waves and sound levels above 150 dB RMS are not likely to extend significant distances beyond these major bends. Therefore, the proposed pile driving is anticipated to exceed the 150 dB RMS threshold for behavioral responses within approximately 500 meters of piles and casings.

Table 1: Summary of attenuated impact hammer pile driving impacts

Temporary Structure	Pile Sizes and Type	Maximum Number of Piles	Piles installed per day/strikes per day	Distances to Reach Sound Pressure Thresholds		
				206 dB Peak SPL	187 dB SEL cumulative	150 dB RMS
Temporary Trestle	12-to 14-inch steel H-piles	128	6/3,300	<10 meters	35 meters	~500 meters
Bridge Foundation Piles	10-foot diameter steel pipe casing	8	1/700	14 meters	430 meters	~500 meters
Total Piles For Project		**136**				

Impact Hammer Pile Driving: 14-inch-diameter H piles and 10-foot-diameter steel piles. As described above, piles driven with an impact hammer will produce the highest sound levels and have the largest area of impact, but will only persist for a short period of time over three fall work seasons (28-40 total days). A total of 3,300 strikes per day will be required to install up to six 14-inch H-piles per day for 20-24 days (128 H-piles over two fall work seasons). This will result in an accumulated SEL of greater than187 dB within 35 meters of the pile. Based upon this data, fish within a radial distance of 35 meters of pile driving could be subject to physical injury, and behavioral effects within a radial distance of 500 meters. A total of 700 strikes will be required to install up to one 10-foot diameter steel casings per day for 8-16 days (eight steel casings over two fall work seasons). This will result in an accumulated SEL of greater than187 dB within 430 meters of the pile. Based upon this data, fish within a radial distance of 430 meters of pile driving could be subject to physical injury, and behavioral effects within a radial distance of 500 meters. The sound pressure impacts associated with driving up to six H-piles or one steel casing per day would not occur continuously throughout a given day, as the majority of the piles will be installed with a vibratory hammer. These exposure estimates are based on maximum potential sound levels associated with the project including incorporation of sound attenuation measures. NMFS expects bubble curtains and the shallow sinuous creek channel could attenuate sound levels to a greater extent than those analyzed, and impact hammer pile driving could involve fewer strikes per day than the numbers described (thus reducing the distance to reach the onset of physical injury thresholds).

For the purposes of this analysis, the zone within the action area where there may be injury or mortality to green sturgeon extends the entire width of Corte Madera Creek upstream and downstream of Bon Air Bridge approximately 35 meters when H piles are being driven and 430

meters when steel casings are being driven. Green sturgeon could experience a range of barotraumas, including the damage to the inner ear, eyes, blood, nervous system, kidney, and liver. These injuries are expected to result in the delayed mortality of many of these fish. Beyond this range, NMFS estimates fish will generally survive during pile driving and not sustain permanent harm or injury. Fish within the range of 150 dB RMS (the entire width of Corte Madera Creek approximately 500 meters upstream and downstream of Bon Air Bridge) may demonstrate temporary abnormal behavior indicative of stress or exhibit a startle response. As described previously, a fish that exhibits a startle response may not be injured, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment, and startle responses are likely to diminish as fish leave the area.

Therefore, NMFS expects barotraumas resulting in injury or death to fish that persist in this zone that extends approximately the entire width of Corte Madera Creek upstream and downstream of Bon Air Bridge approximately 35 meters when H piles are being driven and 430 meters when steel casings are being driven. Smaller fish could be more vulnerable in this area as they are more likely to be entrained in tidal currents and unable to actively swim out of or away from this zone. Pile driving activities will be limited to a short time period (28-40 days) between September 1 and November 15 over three fall seasons; this time period precedes juvenile steelhead emigration and adult steelhead migration and, as explained above, NMFS does not expect juveniles will attempt to rear in the action area. Therefore, steelhead are not likely to be injured or killed by the proposed pile driving. Juvenile southern DPS green sturgeon present in Corte Madera Creek must initially emigrate from the Sacramento River watershed and pass through San Pablo Bay; these juveniles are likely to be growing on the way and relatively large (>300 millimeters)Upon reaching Corte Madera Creek. Therefore, juvenile green sturgeon present in Corte Madera Creek during pile driving are not likely to be passively entrained in tidal currents or unable to swim out of or away from this zone. In addition to a typical improvement in swimming performance with an increase in size, larger adult fish can usually tolerate higher sound pressure levels and experience lower mortality rates than juvenile fish (Yelverton *et al*. 1975; Popper and Hastings 2009). Subadult and adult sturgeon are relatively large fish and could, presumably, tolerate higher levels of sound pressure and be less affected by pile driving activities than smaller fish. However, they are vulnerable to injury or death from pile driving (especially if within close proximity), as demonstrated by SPLs generated from driving large piles (approximately 8 feet in diameter) during the construction of the Benicia-Martinez Bridge that resulted in the death of a 24-inch white sturgeon (Caltrans unpublished data, 2002).

Steel casings associated with this project are similar in size to those used in the Benicia-Martinez Bridge, and peak SPL greater than 206 dB could exist within 14 meters of steel casings during 4-8 days of pile driving in two seasons (total 8-16 days). The likelihood of green sturgeon exposure to this area of peak SPL is low due to the low density of green sturgeon in the entire action area and short duration of this impact hammer pile driving. The SEL "zone" described above is much larger and extends the entire width of Corte Madera Creek upstream and downstream of Bon Air Bridge approximately 35 meters when H piles are being driven and 430 meters when steel casings are being driven. Green sturgeon could be present in this zone at some point during impact hammer pile driving (three seasons, 28-40 total days). The action area, however, is not a known aggregation or foraging site for green sturgeon. The few green sturgeon exposed to this zone are likely to be actively moving and not exposed to impact hammer pile

driving for extended periods of time. Based on this information, NMFS believes few southern DPS green sturgeon will be injured by proposed pile driving and it is unlikely that any will be killed.

2. Construction Impacts on Fish

For the Bon Air Bridge Replacement Project, in-water construction activities consist of primarily installing new piles and removal of the existing bridge foundation. The potential impacts of construction activities include sub-lethal impacts from exposure to increased turbidity (Sigler 1988; Sigler *et al.* 1984; Kirn *et al.* 1986; Emmett *et al.* 1988; Servizi 1988); redistribution and/or release of contaminants, with increased potential for chronic or acute toxicity; introduction of toxic chemicals from construction equipment; and noise impacts from pile driving (discussed above).

a. Turbidity.

To minimize turbidity associated with project activities, the contractor will adhere to a maximum threshold for turbidity established by the Regional Water Quality Control Board. In addition, the contractor will be required to avoid in-water work at extreme high tides. Construction activities, however, are still expected to create temporary increases in turbidity in the adjacent water column. There is little direct information available to assess the effects of turbidity in San Francisco Bay estuary on juvenile or adult green sturgeon. NMFS assumes that green sturgeon will be affected by turbidity through interference with foraging and migratory behavior. Because they forage in bottom sediments, green sturgeon may be less affected by turbidity than non-demersal fish. The extent of turbidity plumes resulting from the proposed project will depend on the tide, creek flow, and wind conditions during these activities. Because fish tend to avoid areas of high turbidity and return when concentrations of suspended solids are lower, impacts to sturgeon are expected to be temporary. These localized elevated levels of turbidity will disperse from the project area with tidal circulation. Southern DPS green sturgeon in the San Francisco Bay estuary commonly encounter areas of minor increases in turbidity due to wind and wave action and benthic foraging activities of other aquatic organisms. NMFS expects green sturgeon that encounter relatively minor turbidity from this project may move to clearer waters nearby. The localized areas of turbidity associated with this project's in-water construction is not expected to result in harm or injury, or behavioral responses that impair migration or make green sturgeon more susceptible to predation.

b. Contaminants.

In the aquatic environment, most anthropogenic chemicals and waste materials, including toxic organic and inorganic chemicals, eventually accumulate in the sediment. Contaminated sediments may be directly toxic to aquatic life or can be a source of contaminants for bioaccumulation in the food chain (Ingersoll 1995). Fine sediments in the project areas increase the likelihood of a problem with contaminants, because this fraction consists of particles with relatively large ratios of surface area to volume, which increase the sorptive capacity (the likelihood of taking up) of sediments for contaminants.

Dillon and Moore (1990) reported that major pollutant sources for San Francisco Bay include the freshwater flow from the Sacramento-San Joaquin River systems, over 50 waste treatment plants, and about 200 industries which are permitted to discharge directly into the Bay (citing Luoma and Phillips 1988). Contaminants from these sources may have entered lower Corte Madera Creek due to tidal action. Environmental contaminants discharged into aqueous systems tend to associate with particulate material in the water column and with consolidated bedded sediments. The level of contaminants in the project site is unknown, but suspension of sediments associated with construction activities could increase contaminant levels in the water column. These potentially minor and localized elevations in contaminants should be quickly diluted to levels that are unlikely to adversely affect listed salmonids or green sturgeon by tidal circulation.

c. Toxic Chemicals.

Equipment refueling, fluid leakage, equipment maintenance, and construction activities near streams and tidally influenced areas pose some risk of contamination of aquatic habitat and subsequent injury or death to listed salmonids and green sturgeon. Oils and similar substances from construction equipment can contain a wide variety of polynuclear aromatic hydrocarbons (PAHs), and metals. Both can result in adverse impacts to salmonids. PAHs can harm the benthic prey items (Eisler 2000). Some of the effects that metals can have on fish are: immobilization and impaired locomotion, reduced growth, reduced reproduction, genetic damage, tumors and lesions, developmental abnormalities, behavior changes (avoidance), and impairment of olfactory and brain functions (Eisler 2000).

Fueling of equipment on or around the Bon Air Bridge will occur at designated staging areas. Spill containment and remediation material will be nearby, and spills will be cleaned up immediately. Fresh cement or concrete will be contained within temporary steel casings or otherwise isolated from waters of Corte Madera Creek. Due to these measures, NMFS expects that accidents will be minimized and toxic chemical contamination of the action area will be minimized to levels which are unlikely to adversely affect fish.

B. Impacts to Critical Habitat

The action area is located within the tidal waters of Corte Madera Creek, and is designated critical habitat for CCC steelhead, CCC coho salmon, and the southern DPS of green sturgeon. Upon completion of construction, NMFS anticipates the proposed project will result in impacts to salmonids and green sturgeon critical habitat in the action area. The potential effects of this project to designated critical habitat associated with construction activities include temporary impacts on water quality and a temporary reduction in migration and foraging areas from noise and turbidity during construction, including pile driving and removal of the current bridge. Benthic foraging areas occupied by the temporary trestle piles will be also be unavailable to fish for at least the 3-4 year construction period. Temporary impacts on water quality, migration space, and forage is not expected to permanently reduce the value of PCEs of salmonids and green sturgeon critical habitat, because water quality, migration space, and forage in the action area is expected to return to current conditions once the project is completed. In addition, forage resources are available nearby elsewhere in the Bay (Baxter *et al.* 1999) should green sturgeon seek food in the action area and be deterred during construction activities.

The proposed Bon Air Bridge will have less than half the spans and piers of the existing bridge; existing bridge piers will be removed to approximately one foot below the mud-line to avoid future exposure from scour. Even with a reduction in the number of spans and in-water structures, the new bridge is likely to occupy a larger in-water and overwater area due to the wider bridge deck and relatively large pier size. Thus, bridge construction is likely to result in a small net loss in benthic foraging habitat adjacent to the bridge. Following bridge construction, conveyance of flow and debris in Corte Madera Creek is anticipated to improve, and there will be an overall reduction in the number of in-water structures associated with the bridge. NMFS expects that these changes are unlikely to have a more than a minimal negative or positive effect on existing designated critical habitat in the action area due to their small size.

VII. CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR § 402.02 as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation". Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

NMFS does not anticipate any cumulative effects in the action area other than those ongoing actions already described in the Environmental Baseline above and climate change. Given current baseline conditions and trends, NMFS does not expect to see significant improvement in habitat conditions in the near future due to existing land and water development affecting the Bay. In the long term, climate change may produce temperature and precipitation changes that may adversely affect listed salmonids and green sturgeon habitat in the action area. Flow in Corte Madera Creek may be affected by precipitation changes, for example.

VIII. INTEGRATION AND SYNTHESIS OF EFFECTS

CCC steelhead and southern DPS green sturgeon have experienced serious declines in abundance and long-term population trends suggest a negative growth rate. Human-induced factors have reduced populations and degraded habitat, which in turn has reduced the population's resilience to natural events, such as droughts, floods, and variable ocean conditions. Global climate change presents another real threat to the long-term persistence of the population, especially when combined with the current depressed population status and human caused impacts. Within the action area, the effects of shoreline development and urbanization are evident. These activities have eliminated tidal marsh habitats, degraded water quality, and altered the hydrology and fish habitat of the action area. As a result, forage species that listed salmonids and green sturgeon depend on have been reduced, periodic sources of contaminants are introduced from stormwater runoff, and natural shoreline habitat areas have been eliminated.

Based on project timing and location as described above in the Effects of the Action section, CCC steelhead are unlikely to be adversely affected by the proposed project. Due in part to the

limited number of green sturgeon records in tidal creeks and sloughs of the Bay, NMFS assumes few green sturgeon will be present in the action area during in-water construction. NMFS is not aware of any records of green sturgeon in Corte Madera Creek, and general migration patterns of adult and subadult green sturgeon do not indicate the action area is a migration corridor or aggregation area for green sturgeon. However, a small number of green sturgeon may intermittently utilize waters of the action area to forage or rear. These green sturgeon are likely to be impacted by construction activities. Turbidity, sediment, and contaminant effects will likely result in minor and temporary changes to fish behavior, and are not expected to injure or kill southern DPS green sturgeon.

Pile driving activities are expected to occur in four in-water construction seasons (September 1 to November 30) and adverse effects from high underwater sound pressure levels are anticipated during the impact hammer pile driving days as described above in the Effects section. Because steelhead are unlikely to be adversely affected, NMFS does not believe the project will appreciably diminish the numbers, reproduction, or distribution of CCC steelhead.

NMFS does not believe the project will appreciably diminish the numbers, reproduction, or distribution of the North American southern DPS green sturgeon. Any green sturgeon present in the action area during the construction window likely make up a small proportion of the southern DPS of green sturgeon; the small number of green sturgeon injured as a result of the project will not impact future adult returns, due to the large number of individual green sturgeon unaffected by the project compared to the small number of green sturgeon likely affected by the project.

The project will impact CCC steelhead, CCC coho salmon, and southern DPS green sturgeon critical habitat at the project site during the approximate three month in-water work window over four seasons. However, this area represents a small portion of Corte Madera Creek, and will become available to steelhead and green sturgeon again once the project is complete. NMFS expects that the minor or temporary impacts on estuarine habitat in the action area will have insignificant impacts on the value of migration and rearing PCEs in the action area. These impacts are unlikely to appreciably diminish the value of designated CCC steelhead, CCC coho salmon, and southern DPS green sturgeon critical habitat.

IX. CONCLUSION

After reviewing the best available scientific and commercial data, the current status of steelhead and green sturgeon (CCC steelhead and southern DPS green sturgeon), the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the Bon Air Bridge Replacement Project in Larkspur, California is not likely to jeopardize the continued existence of threatened CCC steelhead or threatened southern DPS green sturgeon.

After reviewing the best available scientific and commercial data, the current status of critical habitat, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed Bon Air Bridge Replacement Project in Larkspur, California is not likely to adversely modify or destroy

designated critical habitat for CCC steelhead, CCC coho salmon, or southern DPS green sturgeon.

X. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are nondiscretionary, and must be undertaken by Caltrans for the exemption in section 7(o)(2) to apply. Caltrans has continuing duty to regulate the activity covered by this incidental take statement. If Caltrans: (1) fails to assume and implement the terms and conditions, or (2) fails to require its designees to adhere to the terms and conditions of the incidental take statement, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Caltrans or the City must report the progress of the actions and its impact on the species to NMFS as specified in the incidental take statement (50 CFR §402.14(I)(3)).

A. Amount or Extent of Take

NMFS anticipates that take of green sturgeon associated with the Bon Air Bridge Replacement Project will be in the form of injury through temporary impacts from construction activities associated with pile driving. The number of green sturgeon that may be incidentally taken during activities at the Bon Air Bridge Replacement Project is expected to be small. Because finding dead or injured fish will be difficult due to their size in relation to the size of the action area, the difficulty in observing dead or injured fish in the waters of the Corte Madera Creek due to depth and the presence of predators and scavengers such as birds, NMFS will use the area of sound pressure wave impact that extends into the water column from each pile, and the time period for pile driving, as surrogates for numbers of fish. For southern DPS green sturgeon, over three seasons between September 1 and November 15, those fish located within the following radial distances of impact hammer pile driving of 12- to14-inch H piles and 10-foot diameter steel casings may be injured:

- Attenuated H-piles - 206 dB peak SPL at <10 m, 187 dB accumulated SEL at 35 m, and 150 dB RMS at approximately 500 m;

- Attenuated steel casings - 206 dB peak SPL at 14 m, 187 dB accumulated SEL at 430 m, and 150 dB RMS at approximately 500 m.

If the City's monitoring indicates that sound pressure levels greater than 206 dB peak SPL or 187 dB SEL extend beyond these distances the amount of incidental take may be exceeded.

B. Effect of the Take

In the accompanying biological opinion, NMFS has determined that the anticipated take is not likely to jeopardize the continued existence of southern DPS green sturgeon.

C. Reasonable and Prudent Measures

NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of green sturgeon:

1. Undertake measures to minimize harm to green sturgeon from construction and degradation of aquatic habitat.

2. Ensure the fisheries and hydroacoustic monitoring plan minimizes harm and mortality of green sturgeon, and assists in the evaluation of project effects on green sturgeon.

3. Prepare and submit reports regarding the construction of the proposed project and the results of the fisheries and hydroacoustic monitoring program.

D. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, Caltrans and the City must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are nondiscretionary.

1. The following terms and conditions implement reasonable and prudent measure 1:

    a. The permittees must allow any NMFS employee(s) or any other person(s) designated by NMFS, to accompany field personnel to visit the project sites during construction activities described in this opinion.

    b. Once construction is completed, all construction related material must be removed, leaving the area as it was before construction. Excess materials will be disposed of at an appropriate disposal site.

2. The following terms and conditions implement reasonable and prudent measure 2:

a. A fisheries and hydroacoustic monitoring plan must be implemented that includes the following:

   i. Underwater sound measurements at various distances and depths from pile driving operations;

   ii. Evaluation of fish mortality and injury rates through the use of visual observations and collections during pile driving events.

b. The permittees must prepare and submit to NMFS for review and approval the hydroacoustic monitoring plans for pile driving at least 60 days prior to construction. Monitoring must be designed to determine if underwater sound pressure levels exceed what has been analyzed in this biological opinion.

c. Preliminary daily biological and hydroacoustic monitoring reports are to be submitted by close-of-business (COB) the day following pile driving that provides real-time data regarding the distance (actual or estimated using propagation models) to the thresholds (206 dB Peak, 187 dB accumulated SEL, and 150 dB RMS) used in this biological opinion to determine adverse effects to listed species. If underwater sound exceeds these thresholds at the distances provided above from the piles being driven, then NMFS must be contacted within 24 hours before continuing to drive additional piles.

d. A final hydroacoustic monitoring summary must be submitted to NMFS, due 30 days following pile driving events for each season The reports must provide a review of the daily monitoring data and construction process, as well as any problems that were encountered. The report must be submitted to NMFS North Central Coast Office, Attention: Supervisor of Protected Resources Division, 777 Sonoma Avenue, Room 325, Santa Rosa, California, 95404-6528.

   i. Construction related activities -- The report must include the dates construction began and was completed; a discussion of any unanticipated effects or unanticipated levels of effects on steelhead and green sturgeon, a description of any and all measures taken to minimize those unanticipated effects and a statement as to whether or not the unanticipated effects had any effect on ESA-listed fish; and the number of fish killed or injured during the project action.

   ii. Hydroacoustic and fisheries monitoring -- The report must include the a description of the methods used to monitor sound, the dates that hydroacoustic monitoring was conducted; the locations (depths and distance from point of impact) where monitoring was conducted; the total number of pile strikes per pile, the interval between strikes, the peak/SPL, RMS and SEL per strike, and accumulated SEL per day for each hydroacoustic monitor deployed; a discussion of any unanticipated effects or unanticipated levels of effects on salmonids and green sturgeon.

e. If any salmonids or sturgeon are found dead or injured during visual observations, the biologist must contact NMFS biologist Joe Heublein by phone immediately at (707) 575-1251 or the NMFS North Central Coast Office at (707) 575-6050. All salmonid and sturgeon mortalities must be retained, placed in an appropriately-sized sealable plastic bag, labeled with the date and location of collection, fork length, and be frozen as soon as possible. Frozen samples must be retained by the biologist until specific instructions are provided by NMFS. The biologist may not transfer biological samples to anyone other than the NMFS Santa North Central Coast Office without obtaining prior written approval from the NMFS North Central Coast Office, Supervisor of the Protected Resources Division. Any such transfer will be subject to such conditions as NMFS deems appropriate.

XI. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, or to develop information. NMFS has the following conservation recommendation:

1. Caltrans or the City should improve or provide funding for the improvement of listed salmonid passage barriers located within or associated with Caltrans or City maintained facilities.

XII. REINITIATION NOTICE

This concludes formal consultation on the proposed Bon Air Bridge Replacement Project. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in the biological opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, formal consultation must be reinitiated immediately.

XIII. REFERENCES CITED

A. Literature Cited

Adams, P. B., C. B. Grimes, J. E. Hightower, S. T. Lindley, M. L. Moser, and M. J. Parsley. 2007. Population status of North American green sturgeon, *Acipenser medirostris*.

Environmental Biology of Fishes 79:339-356.

Adams, P.B., C.B. Grimes, S.T. Lindley, and M.L. Moser. 2002. Status review for North American green sturgeon, *Acipenser medirostris*. NOAA, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA. 50 pp.

Allen, P.J. and J.J. Cech Jr. 2007. Age/size effects on juvenile green sturgeon, *Acipenser medirostris*, oxygen consumption, growth, and osmoregulation in saline environments. Environmental Biology of Fishes 79:211-229.

Barnhart, R.A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) - Steelhead. U.S. Fish and Wildlife Service Biological Report 82(11.60):1-21.

Baxter, R., K. Hieb, S. DeLeon, K. Flemming, and J. Orsi. 1999. Report on the 1980-1995 fish, shrimp, and crab sampling in the San Francisco Estuary, California. Edited by J. Orsi. California Department of Fish and Game, Technical Report 63, November, 1999. 503 pp.

Beamesderfer, R. C. P., M. L. Simpson, and G. J. Kopp. 2007. Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes 79:315-337.

Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. State Water Resources Control Board, Fisheries Engineering Research Program, Portland, Oregon. Contract No. DACW57-68-C-006.

Berg, L., and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42:1410-1417.

Bilby, R.E., B.R. Fransen, and P.A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164-173.

Bilby, R.E., B.R. Fransen, P.A. Bisson, and J.K. Walter. 1998. Response of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*) to the addition of salmon carcasses to two streams in southwestern Washington, United States. Canadian Journal of Fisheries and Aquatic Sciences 55:1909-1918.

Bjorkstedt, E.P., B.C. Spence, J.C. Garza, D.G. Hankin, D. Fuller, W.E. Jones, J.J. Smith, and R. Macedo. 2005. An analysis of historical population structure for evolutionarily significant units of Chinook salmon, coho salmon, and steelhead in the north-central California coast recovery domain. NOAA, National Marine Fisheries Service, Southwest Fisheries Science Center. 210 pp.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-

138 in W.R. Meehan, editor. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19. American Fisheries Society. Bethesda, MD. 751 pp.

Bond, M.H. 2006. The importance of estuary rearing to Central California steelhead (*Oncorhynchus mykiss*) growth and marine survival. Master's thesis. University of California, Santa Cruz.

Brewer, P.G. and J. Barry. 2008. Rising Acidity in the Ocean: The Other CO2 Problem. Scientific American. October 7, 2008.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27. NOAA, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. August, 1996.

Caltrans unpublished data. 2002. Fish necropsy notes, included in the Benicia Martinez Bridge Replacement Consultation File. NMFS North Central Coast Office, Santa Rosa, California. NMFS administrative record #151422-SWR02SR6292.

CDFG (California Department of Fish and Game). 2002. California Department of Fish and Game comments to NMFS regarding green sturgeon listing. California Department of Fish and Game, Inland Fisheries Division, Sacramento, California. 79 pp. (plus appendices)

Cox, P., and D. Stephenson. 2007. A changing climate for prediction. Science 113:207-208.

Dillon, T.M., and D.W. Moore. 1990. Assessment of dredged material toxicity in San Francisco Bay. Miscellaneous Paper EL-90-20, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Dumbauld, B. R., D. L. Holden, and O. P. Langness. 2008. Do sturgeon limit burrowing shrimp populations in Pacific Northwest estuaries? Environmental Biology of Fishes 83:283-296.

Emmett, R.L., G.T. McCabe, Jr. and W.D. Muir. 1988. Effects of the 1980 Mount St. Helens eruption on Columbia River estuarine fishes: implications for dredging on Northwest estuaries. Pages 74-91 In: C. A. Simenstad (ed.) Effects of dredging on anadromous Pacific coast fishes. Washington Sea Grant Program. Washington State University. Seattle, Washington.

Enger, P.S. 1981. Frequency Discrimination in Teleosts . Central Peripheral Institute of Zoophysiology, University of Oslo, Norway. Chapter 12.

Erickson, D. L. and M. A. H. Webb. 2007. Spawning periodicity, spawning migration, and size at maturity of green sturgeon, *Acipenser medirostris,* in the Rogue River, Oregon.

Environmental Biology of Fishes 79:255-268.

Feely, R.A., C.L. Sabine, K. Lee, W. Berelson, J. Kleypas, V.J. Fabry, and F.J. Millero. 2004. Impact of anthropogenic CO2 on the CaCO3 system in the oceans. Science 305, 362-366.

Feist, M.L. Blake E., James J. Anderson and Robert Miyamoto. 1992. Potential impacts of pile driving on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon behavior and distribution. FRI-UW-9603. Fisheries Resources Institute, University of Washington. Seattle.

Fukushima, L. and E.W. Lesh. 1998. Adult and juvenile anadromous salmonid migration timing in California streams. California Fish and Game 84: 133-145.

Good, T.P., R.S. Waples, and P. Adams, *editors*. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. NOAA Technical Memorandum NMFS-NWFSC-66. NOAA, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. June, 2005.

Gregory, R.S., and T.G. Northcote. 1993. Surface, planktonic, and benthic foraging by juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in turbid laboratory conditions. Canadian Journal of Fisheries and Aquatic Sciences 50:233-240.

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the northeast pacific ecosystem. Fisheries 15(1):15-21.

Hanson, L.C. 1993. The foraging ecology of harbor seals, *Phoca vitulina*, and California sea lions, *Zalophus californianus*, at the mouth of the Russian River, California. *Master of Arts* thesis, Sonoma State University, Rohnert Park, CA.

Hastings, M. C. 1995. Physical effects of noise on fishes. Proceedings of INTER-NOISE 95, The 1995 International Congress on Noise Control Engineering, Volume II: 979–984.

Hastings, M. C., Popper, A. N., Finneran, J. J., and Lanford, P. 1996. Effects of low frequency sound on hair cells of the inner ear and lateral line of the teleost fish *Astronotus ocellatus*. Journal of the Acoustical Society of America 99(3): 1759-1766.

Hayes, S.A., M.H. Bond, C.V. Hanson, E.V. Freund, J.J. Smith, E.C. Anderson, A.J. Ammann, and R.B. MacFarlane. 2008. Steelhead growth in a small Central California Watershed: Upstream and estuarine rearing patterns. Transactions of the American Fisheries Society, 137:114-128.

Hayes, S.A., M.H. Bond, C.V. Hanson, A.W. Jones, A.J. Ammann, J.A. Harding, A.L. Collins, J. Perez, and R.B. MacFarlane. 2011. Down, up, down and “smolting” twice? Seasonal movement patterns by juvenile steelhead (Oncorhynchus mykiss) in a coastal watershed with a bar closing estuary. Canadian Journal of Fisheries and Aquatic Sciences, 68:1341-1350.

Hayhoe, K., D. Cayan, C. B. Field, P. C. Frumhoff, E. P. Maurer, N. L. Miller, S. C. Moser, S. H. Schneider, K. N. Cahill, E. E. Cleland, L. Dale, R. Drapek, R. M. Hanemann, L. S. Kalkstein, J. Lenihan, C. K. Lunch, R. P. Neilson, S. C. Sheridan, and J. H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences of the United States of America, volume 101: 12422-12427.

Heublein, J. C., J. T. Kelly, C. E. Crocker, A. P. Klimley, and S.T. Lindley. 2009. Migration of green sturgeon, *Acipenser medirostris*, in the Sacramento River. Environmental Biology of Fishes 84:245–258.

Hokanson, K. E. F., C. F. Kleiner, and T. W. Thorslund. 1977. Effects of constant temperatures and diel temperature fluctuations on specific growth and mortality rates of juvenile rainbow trout, *Salmo gairdneri*. Journal of the Fisheries Research Board of Canada 34:639-648.

Hubbs, C.L. and A.B. Rechnitzer. 1952. Report on experiments designed to determine effects of underwater explosions on fish life. California Department of Fish and Game 38:333-366.

Huff, D.D., S.T. Lindley, P.S. Rankin, and E.A. Mora. 2011. Green sturgeon physical habitat use in the coastal Pacific Ocean. PLoS One 6(9):e25156.

ICF Jones and Stokes and Illingworth and Rodkin Inc. 2009. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish – Final. Prepared for: California Department of Transportation: 298.

Illingworth and Rodkin, Inc. 2007. Compendium of Pile Driving Sound Data. Prepared for the California Department of Transportation, September 27, 2007.

Ingersoll,.C.G. 1995. Sediment tests. Pages 231-254. In: G. M. Rand (ed.) Fundamentals of aquatic toxicology: effects, environmental fate, and risk assessment. Taylor and Francis Publishers, Washington, D.C.

Israel, J. 2010. Memo to Melissa Neuman (NMFS) regarding unknown observer sample genotypes and assignment, dated August 11, 2010. 4 pp.

Israel, J.A., J. Bando, E.C. Anderson, and B. May. 2009. Polyploid microsatellite data reveal stock complexity among estuarine North American green sturgeon (*Acipenser medirostris*). Canadian Journal of Fisheries and Aquatic Sciences 66:1491–1504.

Israel, J.A. and A.P. Klimley. 2008. "Life history conceptual model for North American green sturgeon (*Acipenser medirostris*)" CDFG Delta Regional Ecosystem Restoration and Implementation Program. *FINAL*, 45 p.

Israel, J.A. and B. May. 2010. Indirect genetic estimates of breeding population size in the polyploidy green sturgeon (*Acipenser medirostris*). Molecular Ecology 2010:1058-1070.

Israel, J.A., M. Neuman, M.L. Moser, S.T. Lindley, B.W.McCovey Jr., D.L. Erickson, and P.

Klimley. In prep. Recent advances in understanding the life history of green sturgeon (*Acipenser medirostris*) and potential anthropogenic threats to this imperiled fish.

Kelly, J. T., A. P. Klimley, and C. E. Crocker. 2007. Movements of green sturgeon, *Acipenser medirostris*, in the San Francisco Bay estuary, California. Environmental Biology of Fishes 79:281–295.

Kirn, R.A., R.D. Ledgerwood and A.L. Jensen. 1986. Diet of subyearling Chinook salmon (*Oncorhynchus tshawytscha*) in the Columbia River estuary and changes effected by the 1980 eruption of Mount St. Helens. Northwest Science 60:191-195.

Lindley, S. T., D. L. Erickson, M. L. Moser, G. Williams, O. P. Langness, B.W. McCovey Jr., M. Belchik, D. Vogel, W. Pinnix, J. T. Kelly, J. C. Heublein, and A. P. Klimley. 2011. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. Transactions of the American Fisheries Society 140:108–122.

Lindley, S. T., C. B. Grimes, M. S. Mohr, W. Peterson, J. Stein, J. T. Anderson, L.W. Botsford, D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F. B. Schwing, J. Smith, C. Tracy, R. Webb, B. K. Wells, and T. H. Williams. 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication report to the Pacific Fishery Management Council. March 18, 2009, 57 pp.

Lindley, S.T., M.L. Moser, D.L. Erickson, M. Belchik, D.W. Welch, E. Rechisky, J.T. Kelly, J.C. Heublein, and A.P. Klimley. 2008. Marine migration of North American green sturgeon. Transactions of the American Fisheries Society 137:182–194

Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. R. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science, 5.

Luers, A.L., Cayan, D.R., and G. Franco. 2006. Our Changing Climate, Assessing the Risks to California. A summary report from the California Climate Change Center. 16 pp.

Luoma, S. N., and D. J. H. Phillips. 1988. Distribution, variability, and impacts of trace elements in San Francisco Bay. Marine Pollution Bulletin 19:413-425.

Martin, J., Environmental Collaborative. 2011. Email report to Amanda Morrison, NMFS, regarding the number and species of fish relocated during dewatering and fish relocation activities, November 2, 2011, included in the Kentfield Sewage Force Main Replacement and Berens/McAllister Sloughs Culverts Replacement Project Consultation File. NMFS North Central Coast Office, Santa Rosa, CA. NMFS administrative record 151422SWR2011SR00275.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Depart. Commer., NOAA Technical Memorandum NMFS-NWFSC-42.

McEwan, D. 2001. Central Valley steelhead. Pages 1-44 in R.L. Brown, editor. Contributions to the Biology of Central Valley Salmonids. Volume 1. California Department of Fish and Game Bulletin 179.

McEwan, D. and T.A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Dep. of Fish and Game. 234 pp.

Meehan, W.R., and T.C. Bjornn. 1991. Salmonid distributions and life histories. Pages 47-82 *in* W.R. Meehan, *editor*. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19. American Fisheries Society, Bethesda, MD.

Mora, E.A., S.T. Lindley, D.L. Erickson, and A.P. Klimley. 2009. Do impassable dams and flow regulation constrain the distribution of green sturgeon in the Sacramento River, California? Journal of Applied Ichthyology 25 (Supplement 2):39-47.

Moser, Mary. Research fishery biologist, NMFS NWFSC, Seattle, WA. Unpublished data regarding preliminary observations from feeding pit mapping surveys conducted in Willapa Bay, WA. Cited in: NMFS. 2011. Endangered Species Act Section 7 consultation - Biological Assessment for the continued operation of the Pacific Coast Groundfish Fisheries for the period of January 1 – December 31, 2012. Prepared by the NMFS Northwest Region Sustainable Fisheries Division. 162 pp.

Moser, M. and S. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79:243-253.

Moyle, P.B. 2002. Inland fishes of California, 2nd edition. University of California Press, Berkeley and Los Angeles, CA. 502 pp.

Moyle P.B., P.J. Foley, and R.M. Yoshiyama. 1992. Status of green sturgeon, *Acipenser medirostris*, in California. Final Report submitted to the National Marine Fisheries Service, University of California, Davis, 11 pp.

Myrick, C. A., and J. J. Cech. 2005. Effects of temperature on the growth, food consumption, and thermal tolerance of age-0 Nimbus-strain steelhead. North American Journal of Aquaculture 67:324–330.

Nakamoto, R.J., T.T. Kisanuki, and G. H. Goldsmith. 1995. Age growth of Klamath River green sturgeon (*Acipenser medirostris*). U.S. Fish and Wildlife Service Project 93-FP-13, Yreka, CA, 20 pp.

Newcombe, C. P., and J. O. T. Jensen. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact, North American Journal of Fisheries Management 16:693-727.

NMFS (National Marine Fisheries Service). 1997. Status review update for deferred and candidate ESUs of West Coast Steelhead (Lower Columbia River, Upper Willamette River, Oregon Coast, Klamath Mountains Province, Northern California, Central Valley, and Middle Columbia River ESUs). U.S. Department of Commerce, NOAA. 62 pp.

NMFS (National Marine Fisheries Service). 2005. Green sturgeon (*Acipenser medirostris*) status review update. U.S. Department of Commerce, NOAA, Southwest Fisheries Science Center, Long Beach, CA. 31 pp.

NMFS (National Marine Fisheries Service). 2009. Designation of critical habitat for the threatened Southern Distinct Population Segment of North American green sturgeon: Final biological report. Prepared by NMFS Southwest Region, Long Beach, CA. 144 pp. Available online at: http://swr.nmfs.noaa.gov/gs/GS_Critical_habitat_files/GSCHD_FinalBiologicalRpt.pdf.

NMFS (National Marine Fisheries Service). 2010a. Environmental assessment for the proposed application of protective regulations under Section 4(d) of the Endangered Species Act for the threatened Southern Distinct Population Segment of North American green sturgeon. Department of Commerce, NOAA, NMFS, Southwest Region, Long Beach, CA. 101 pp. Available online at: http://swr.nmfs.noaa.gov/gs/GreenSturgeon4d_Final_Environmental_Assessment.pdf.

NMFS (National Marine Fisheries Service). 2010b. Federal Recovery Outline for North American green sturgeon, Southern Distinct Population Segment. Prepared by NMFS Southwest Region, Santa Rosa, CA. 23 pp. December 2010. Available online at: http://swr.nmfs.noaa.gov/gs/jd/Green_Sturgeon_sDPS_Recovery_Outline.pdf.

Osgood, K. E. (editor). 2008. Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs. U.S. Department of Commerce, NOAA Tech. Memo. NMFSF/ SPO-89, 118 p.

Popper, A. N. 1997. Sound detection by fish: structure and function in using sound to modify fish behavior at power production and water-control facilities. A workshop December 12-13, 1995. Portland State University, Portland Oregon Phase II: Final Report ed. Thomas Carlson and Arthur Popper 1997. Bonneville Power Administration Portland, OR.

Popper, A.N. and M.C. Hastings. 2009. The effects of human-generated sound on fish. Integrative Zoology 4:43-52

Poytress, W.R., J.J. Gruber, and J.P. Van Eenennaam. 2011. 2010 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Annual Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Red Bluff, CA.

Radtke, L. D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta with observations on food of sturgeon. Pages 115-129 *in*: J. L. Turner and D. W. Kelley (editors). Ecological studies of the Sacramento-San Joaquin Delta Part II: Fishes of the Delta. California Department of Fish and Game Fish Bulletin.

Reiser, D.W., and T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. In: Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. W.R. Meehan, editor. U.S. Department of Agriculture Forest Service General Technical Report PNW-96.

Rich, A.A. 2000. Fishery resource conditions of the Corte Madera Creek watershed, Marin County, California. Prepared for Friends of Corte Madera Creek Watershed. Larkspur, CA.

Rich, A.A. and Associates. 2006. Report to Jeffrey Jahn, NMFS Biologist. 2005 Section 10 Permit of Takes of Endangered/Threatened Salmonids in Corte Madera Creek Watershed. January 17, 2006.

Scavia, D., J.C. Field, D.F. Boesch, R.W. Buddemeier, V. Burkett, D.R. Cayan, M. Fogarty, M.A. Harwell, R.W. Howarth, C. Mason, D.J. Reed, T.C. Royer, A.H. Sallenger, and J.G. Titus. 2002. Climate Change Impacts on U.S. Coastal and Marine Ecosystems. Estuaries 25(2): 149-164.

Scholik, A. R. and Yan, H. Y. 2001. Effects of underwater noise on auditory sensitivity of a cyprinid fish. Hearing Research 152:17-24.

Schneider, S. H. 2007. The unique risks to California from human-induced climate change. California State Motor Vehicle Pollution Control Standards; Request for Waiver of Federal Preemption, presentation May 22, 2007.

Servizi, J.A., and D.W. Martens. 1992. Sublethal responses of coho salmon (*Oncorhynchus kisutch*) to suspended sediments. Canadian Journal of Fisheries and Aquatic Sciences 49:1389-1395.

Seesholtz, A. 2011. Report to Jeffrey Jahn, NMFS Biologist. Annual report for 2011 4(d) project 16073: Lower Feather River Green Sturgeon Spawning Survey by California Department of Water Resources.

Shapovalov, L. and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. California Department of Fish and Game, Fisheries Bulletin 98:1-375.

Shin, H.O. 1995. Effect of the piling work noise on the behavior of snakehead (*Channa argus*) in the aquafarm. Journal of the Korean Fisheries Society 28(4) 492-502.

Sigler, J. W., T. C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113:142-150.

Sigler, J.W. 1988. Effects of chronic turbidity on anadromous salmonids: recent studies and assessment techniques perspective. Pages 26-37 In: C. A. Simenstad (ed.) Effects of dredging on anadromous Pacific coast fishes. Washington Sea Grant Program. Washington State University. Seattle, Washington. Sonalysts, Inc. Waterford, CT.

Smith, J.J. 1990. The effects of sandbar formation and inflows on aquatic habitat and fish utilization in Pescadero, San Gregorio, Waddell and Pomponio Creek estuary/lagoon systems, 1985-1989. Department of Biological Sciences, San Jose State University, San Jose, California. December 21, 1990.

Smith, D.M., Cusack, S., Colman, A.W., Folland, C.K., Harris, G.R., and Murphy, J.M. 2007. Improved surface temperature prediction for the coming decade from a global climate model. Science 317:796-799.

Spence, B., G., E. P. Bjorkstedt, J. C. Garza, J. J. Smith, D. G. Hankin, D. Fuller, W. E. Jones, R. Macedo, T. H. Williams, and E. Mora. 2008. A framework for assessing the viability of threatened and endangered salmon and steelhead in the North-Central California Coast Recovery Domain. U.S. Department of Commerce, NOAA, National Marine Fisheries Service, Southwest Fisheries Science Center. 194 pp.

Turley, C. 2008. Impacts of changing ocean chemistry in a high-CO2 world. Mineralogical Magazine 72(1):359-362. February 2008.

USFWS (U.S. Fish and Wildlife Service). 2002. Spawning areas of green sturgeon *Acipenser medirostris* in the upper Sacramento River California. U.S. Fish and Wildlife Service, Red Bluff, CA.

Van Eenennaam JP, Linares-Casenave J, Deng X, Doroshov SI. 2005. Effect of incubation temperature on green sturgeon embryos, *Acipenser medirostris*. Environmental Biology of Fishes 72:145–154

Van Eenennaam, J. P., J. Linares, S. I. Doroshov, D. C. Hillemeier, T. E. Willson, and A. A. Nova. 2006. Reproductive conditions of the Klamath River green sturgeon. Transactions of the American Fisheries Society 135:151-163.

Van Eenennaam, J.P., J. Linares-Casenave, J. Muguet, and S.I. Doroshov. 2008. Induced Spawning, Artificial Fertilization, and Egg Incubation Techniques for Green Sturgeon. North American Journal of Aquaculture 70:434–445.

Waples, R.S. 1991. Pacific Salmon, *Oncorhynchus spp.*, and the definition of a species under the Endangered Species Act. Marine Fisheries Review 53:11-21.

WCGOP, NWFSC. 2011. Biological data (unpublished), provided on June 8, 2011. Fishery Resource Analysis and Monitoring, West Coast Groundfish Observer Program. NWFSC, 2725 Montlake Blvd East, Seattle, WA.

Whitman, R.P., T.P. Quinn and E.L. Brannon. 1982. Influence of suspended volcanic ash on homing behavior of adult Chinook salmon. Transactions of the American Fisheries Society 113:142-150.

Williams, T.H. S.T. Lindley, B.C. Spence, and D. A. Boughton. 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest 17 May 2011 – Update to 5 January 2011 report. National Marine Fisheries Service Southwest Fisheries Science Center. Santa Cruz. CA.

Wurtsbaugh, W. A. and G. E. Davis. 1977. Effects of temperature and ration level on the growth and food conversion efficiency of *Salmo gairdneri*, Richardson. Journal of Fish Biology 11:87-98.

Yelverton, J.T., D.R. Richmond, W. Hicks, K. Saunders, E.R. Fl*et*cher. 1975. The relationship between fish size and their response to underwater blast. Report DNA 3677T, Director, Defense Nuclear Agency, Washington, DC.

B. Federal Register Notices Cited

62 FR 43937: National Marine Fisheries Service. Final Rule Listing of Several Evolutionary Significant Units of West Coast Steelhead. Federal Register 62:43937-43954. August 18, 1997.

70 FR 17386. National Marine Fisheries Service. Endangered and Threatened Wildlife and Plants: Proposed Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 70(65):17386-17401. 2005

70 FR 37160. National Marine Fisheries Service. Final Rule. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. June 28, 2005.

70 FR 52488: National Marine Fisheries Service. Final critical habitat designations for 19 West Coast salmon and steelhead ESUs. Federal Register 70:52488–52627. September 2, 2005.

71 FR 834: National Marine Fisheries Service. Final Listing Determinations for Ten Distinct Population Segments of West Coast Steelhead; Final Rule. Federal Register 71:834-862. January 5, 2006.

71 FR 17757: National Marine Fisheries Service. Final Rule: Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 73:17757-17766. April 7, 2006.

74 FR 52300: National Marine Fisheries Service. Final Critical Habitat Designation for

Threatened Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 74:52300-52351. October 9, 2009.

76 FR 50447: National Marine Fisheries Service. Endangered and Threatened Species; 5-Year Reviews for 5 Evolutionarily Significant Units of Pacific Salmon and 1 Distinct Population Segment of Steelhead in California. Federal Register 76: 50447-50448. August 2011.

C. Personal Communications Cited

Mike Holm, commercial herring fisherman. Spring 2004 to present. Personal communication with Joe Heublein, NMFS Biologist, regarding juvenile green sturgeon bycatch in SF Bay herring gillnet fishery.

Jeffrey Jahn, NMFS Biologist. August 2011 and January 2012. Personal communication with Joe Heublein, NMFS Biologist regarding recent CCC steelhead abundnace trends.

Ethan Mora. PhD candidate, UC Davis, Davis, CA. January 10, 2012. Personal communication, via phone call with Susan Wang (NMFS), regarding estimates of green sturgeon abundance in Southern DPS rivers in 2010 and 2011.

Enclosure 2

Bon Air Bridge Replacement Project
Corte Madera Creek, Marin County, California

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

I. STATUTORY AND REGULATORY INFORMATION

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996, establishes a national program to manage and conserve the fisheries of the United States through the development of federal Fishery Management Plans (FMPs), and federal regulation of domestic fisheries under those FMPs, within the 200-mile U.S. Exclusive Economic Zone ("EEZ"). 16 U.S.C. §1801 *et seq*. To ensure habitat considerations receive increased attention for the conservation and management of fishery resources, the amended MSA required each existing, and any new, FMP to "describe and identify essential fish habitat for the fishery based on the guidelines established by the Secretary under section 1855(b)(1)(A) of this title, minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat." 16 U.S.C. §1853(a)(7). Essential Fish Habitat (EFH) is defined in the MSA as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" 16 U.S.C. §1802(10). The components of this definition are interpreted at 50 C.F.R. §600.10 as follows: "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

Pursuant to the MSA, each federal agency is mandated to consult with NMFS (as delegated by the Secretary of Commerce) with respect to any action authorized, funded, or undertaken, or proposed to be, by such agency that may adversely affect any EFH under this Act. 16 U.S.C. §1855(b)(2). The MSA further mandates that where NMFS receives information from a Fishery Management Council or federal or state agency or determines from other sources that an action authorized, funded, or undertaken, or proposed to be, by any federal or state agency would adversely affect any EFH identified under this Act, NMFS has an obligation to recommend to such agency measures that can be taken by such agency to conserve EFH. 16 U.S.C. §1855(4)(A). The term "adverse effect" is interpreted at 50 C.F.R. §600.810(a) as any impact that reduces quality and/or quantity of EFH and may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce quantity and/or quality of EFH. In addition, adverse effects to EFH may result from

actions occurring within EFH or outside EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

If NMFS determines that an action would adversely affect EFH and subsequently recommends measures to conserve such habitat, the MSA proscribes that the Federal action agency that receives the conservation recommendation must provide a detailed response in writing to NMFS within 30 days after receiving EFH conservation recommendations. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS EFH conservation recommendations, the Federal agency must explain its reasons for not following the recommendations. 16 U.S.C. §1855(b)(4)(B).

II. BACKGROUND AND CONSULTATION HISTORY

The December 7, 2011, letter from California Department of Transportation's (CalTrans) requested consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). However, the Bon Air Bridge location includes areas identified as EFH for various life stages of species managed under the Pacific Fishery Management Council. The MSA requires all Federal agencies to consult with NMFS on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect EFH. Per agreement with the Federal Highways Administration (FHWA), the California Department of Transportation (Caltrans) will be acting as the Federal action agency. Because EFH for salmonids, groundfish, and coastal pelagic species could be affected by the project, NMFS provides the following EFH consultation and EFH Conservation Recommendation to avoid, minimize, or otherwise offset potential adverse effects to EFH.

A complete consultation history can be found in the preceding biological opinion (BO; see Section I).

III. PROPOSED ACTION

The proposed action involves replacement of the existing Bon Air Bridge. Two temporary trestles, approximately 400 ft x 35 ft each, are proposed alongside the north and south sides of the existing bridge to facilitate bridge replacement. Construction of the north trestle is proposed for fall of 2013, would be in place an estimated 2 years and the south trestle would occur fall of 2014 and be in place approximately 1.5 years. Construction of the trestles would require installation of 128 steel H-piles, driven by vibratory and impact hammer taking about 10-12 days for each trestle over a period of about 2 months for each trestle. Upon completion of the new bridge, trestles would be removed and pilings would be vibrated out with the goal of complete removal. However, if pilings cannot be extracted completely they will be cut a few feet below the channel bottom. Removal of each pile should take 30 minutes to several hours each unless cut, which is a shorter process. The contractor will be required to avoid extreme high tides. Besides this restriction, the timing for pile removal will be at the option of the contractor.

Caltrans has deemed full removal of existing concrete piles infeasible and proposes to cut the piles approximately one foot below the channel bottom. The contractor will be required to avoid

extreme high tides. Besides this restriction, the timing for pile removal will be at the option of the contractor.

New bridge foundation columns will be constructed within the creek bed sediment, requiring a total of 8 temporary 10-foot diameter steel casing driven into the channel bed to a depth of approximately 70 feet. Drilling of sediments will occur within the casing, which will act as a coffer dam to separate the work area from the creek and to control impacts to water turbidity. Tailings will be removed into a bucket or by slurry. After drilling, the bridge foundation columns will be constructed within the casings. Eight foot diameter steel casings for the upper piers will be inserted into the outer casing. The outer casings will be vibrated upon completion.

The existing bridge deck (420 feet x 44 feet) will be replaced with a larger single span (388 feet x 63 feet) with widening along the north side of about 13 feet, resulting in an increase of 5964 square feet of overwater structure. The new bridge will be built at the same height as the existing structure.

To minimize turbidity associated with project activities, Caltrans proposes turbidity monitoring and the contractor will adhere to a maximum threshold for turbidity established by the Regional Water Quality Control Board. In addition, the contractor will be required to avoid in-water work at extreme high tides.

IV. ACTION AREA

For purposes of this EFH consultation, the action area spans Corte Madera Creek, where the creek is approximately 337 feet wide. Subtidal habitat beneath the bridge is open water with depths varying from less than 10 feet to 15 feet deep in the middle of the channel under summer-fall flow conditions. During low tides, the wetted channel beneath the bridge can be narrow (less than 2 meters wide) with wide mud flat margins. The bed is composed mostly of clay with an occasional layer of silty-sand. Shorelines of each bank consist of a narrow fringe of riverine wetland with some tidally influenced saline emergent wetland located northeast of the bridge adjacent to Corte Madera Creek.

V. EFFECTS OF THE ACTION

The installation and removal of temporary trestles and the bridge dismantling and replacement could adversely affect EFH, including estuary HAPC due to: (1) temporary and permanent increase of shading of benthic and open water habitat from overwater structures, (2) temporary turbidity/suspended sediment effects, (3) temporary elevated levels of underwater sound, and (4) permanent increase of fill and temporary disturbance of benthic habitat.

The new bridge will result in at least 5,964 square feet (0.14 acre) of additional shading of benthic and open water channel habitat in the creek. Two trestles will be installed alongside the existing structure and will result in a temporary shading of 28,000 square feet (0.64 acres) of EFH. Shading is known to decrease primary productivity, alter predator-prey interactions, change invertebrate assemblages, and reduce the density of benthic invertebrates (Helfman 1981; Glasby 1999; Struck, Craft *et al*. 2004; Stutes, Cebrian *et al*. 2006); all of which lead to an overall reduction in the quality of EFH.

Installation and pulling of temporary piles will result in short-term localized increases in turbidity. Resuspension of bottom sediments into the water column can reduce light penetration and lower the rate of photosynthesis for subaquatic vegetation (Dennison 1987). If sediment loads remain high for an extended period of time, the primary productivity of an aquatic area may be reduced (Cloern 1987). Turbidity is expected to dissipate quickly in the project area. However, the cumulative impact may be significant as large numbers of pilings are proposed for installation and removal. Some fish may suffer reduced feeding ability (Benfield and Minello 1996) and be prone to fish gill injury (Nightingale and C.A. Simenstad 2001) if exposed to excessive high levels of turbidity. Fish are expected to move out of areas of high suspended sediment.

As described in the BO, pile driving can generate intense underwater sound pressure waves that have been shown to injure and kill fish. In addition, increased levels of noise at sublethal levels may adversely affect the ecological functioning of EFH and may cause fish to temporarily leave the area.

Approximately 200 square feet of permanent fill will result from the new bridge foundations. Trestles supported by H-piles will result in a relatively small area of temporary fill. Areas with temporary pilings will also experience additional disturbance upon piling removal. The fine grain sediment that is characteristic of the creek bottom in the project area is considered good foraging habitat for fish, providing a substrate for infaunal and bottom-dwelling organisms, such as polychaete worms, crustaceans, and other EFH prey types (NMFS 2007). Rates of recovery listed in the literature range from several months to several years for estuarine muds (McCauley 1976; Oliver 1977; Currie 1996; Tuck 1998; Watling 2001). Thus, forage resources for fish that feed on the benthos may be reduced during the 3-4 years of construction and recovery time. Some permanent fill may also occur below the mudline if temporary pilings or old bridge supports cannot be fully extracted. These piling fragments will be cut off below what is typically considered the biologically active surface zone of benthic mud.

VI. CONSERVATION RECOMMENDATION

To minimize the potential adverse impacts to EFH from increased levels of turbidity, NMFS recommends the following:

1. Whenever possible, perform in-water work at low tides, particularly the removal of pilings located within the wide mud flat margins of the creek that may be fully exposed at low tide.

VII. EFH CONCLUSION

As described in the above effects analysis, NMFS has determined that the proposed project would adversely affect EFH for various federally-managed species within the Pacific Groundfish, Coastal Pelagic, and Pacific Salmonid FMPs. With the additional EFH Conservation Recommendation provided here, potential adverse effects to EFH are expected to be adequately minimized.

This concludes EFH consultation for the proposed Bon Air Bridge Replacement Project in Corte Madera Creek, Marin County, California.

VIII. FEDERAL AGENCY STATUTORY REQUIREMENTS

Please be advised that regulations (50 CFR 600.920(k)) to implement the EFH provisions of the MSA require your office to provide a written response to this letter within 30 days of its receipt and prior to the final action. A preliminary response is acceptable if final response cannot be completed within 30 days. Your final response must include a description of how the EFH Conservation Recommendation will be implemented and any other measures that will be required to avoid, mitigate, or offset the adverse impacts of the activity. If your response is inconsistent with our EFH Conservation Recommendation, you must provide an explanation for not implementing this recommendation at least 10 days prior to final approval of the action.

Pursuant to 50 CFR 600.920(l), Caltrans must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conclusion or Conservation Recommendation.

LITERATURE CITED

Benfield, M. C. and T. J. Minello (1996). "Relative effects of turbidity and light intensity on reactive distance and feeding of an estuarine fish." Environmental Biology of Fish 46(2): 211-216.

Cloern, J. E. (1987). "Turbidity as a control on phytoplankton biomass and productivity in estuaries." Continental Shelf Research 7(11/12):1367-1381.

Currie, D. G. P. (1996). "Effects of scallop dredging on soft sediment community: a large-scale experimental study." Marine Ecology Progress Series 134: 131-150.

Dennison, W. C. (1987). "Effect of light on seagrass photosynthesis, growth and depth distribution." Aquatic Botany 27(1):15-26.

Glasby, T. M. (1999). "Effects of shading on subtidal epibiotic assemblages." Journal of Experimental Marine Biology and Ecology 234: 275-290.

Helfman, G. S. (1981). "The advantage to fishes of hovering in shade." Copeia 2: 392-400.

McCauley, J. E., R.A. Parr, & D.T. Hancock (1976). "Benthic infauna and maintenance dredging: a case study." Water Research 11:233-242.

Nightingale, B. and J. C.A. Simenstad (2001). Dredging activities: marine issues. Seattle, WA 98105, University of Washington.

Oliver, J. S., P.N. Slattery, L.W. Hulberg, and J.W. Nybakken (1977). "Patterns of succession in benthic infaunal communities following dredging and dredged material disposal in Monterey Bay." U.S. Army Corps of Engineers, Technical Report D-77-27.

Struck, S. D., C. B. Craft, *et al*. (2004). "Effects of bridge shading on estuarine marsh benthic invertebrate community structure and function." Environmental Management 34(1): 99-111.

Stutes, A. L., J. Cebrian, *et al*. (2006). "Effects of nutrient enrichment and shading on sediment primary production and metabolism in eutrophic estuaries." Marine Ecology Progress Series 312: 29-43.

Tuck, I. D., S.J. Hall, M.R. Robertson (1998). "Effects of physical trawling disturbance in a previously unfished sheltered Scottish sea loch." Marine Ecology-Progress Series 162: 227-242. .

Watling, L., R.H. Findlay, L.M. Lawrence, and D.F. Schick (2001). "Impact of a scallop drag on the sediment chemistry, microbiota, and faunal assemblages of a shallow subtidal marine benthic community." Journal of Sea Research 46 (3-4): 309-324.