National Marine Fisheries Service
Endangered Species Act Section 7 Consultation

Biological Opinion

Agency:	Endangered Species Division of the Office of Protected Resources, National Marine Fisheries Service
Activities Considered:	Reinitiation of a Protected Species Conservation and Recovery Grant to the Yurok Tribe (Award File NA10NMF4720374) to Conduct Research on Eulachon Smelt in northern California.
Consultation Conducted by:	Endangered Species Division of the Office of Protected Resources, National Marine Fisheries Service
Approved by:	
Date:	FEB 23 2011

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 *et seq.*) requires each federal agency to insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency "may affect" a threatened or endangered species or critical habitat that has been designated for them, that agency is required to consult with either the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the species that may be affected by the action. For the actions described in this document, NMFS' Office of Protected Resources – Endangered Species Division proposes to fund the Yurok Tribal Fishery Program (YTFP) to conduct research on the threatened southern distinct population segment (DPS) of eulachon smelt in northwestern California.

This document represents NMFS' biological opinion (Opinion) on the effects of the proposed action on threatened southern DPS of eulachon smelt. This Opinion, following formal consultation, has been prepared in accordance with section 7 of the ESA, as implemented by 50 CFR 402.14(d)-(j). It is based on our review of the environmental assessment (EA); the updated status review for eulachon; past and current research and population dynamics modeling efforts for this species; monitoring reports from prior research; monitoring reports from similar previous research; and reflects consideration of the best scientific and commercial data available.

Consultation History
On June 9, 2010, NMFS began pre-consultation work on this project.

On June 14, 2010, NMFS received an EA from the Species Recovery Grants Program and initiated formal consultation.

On July 15, 2010. NMFS completed formal consultation, concluding that the proposed action would not likely jeopardize Pacific eulachon.

On January 12, 2011, the YTFP conducted three seine hauls in the Klamath River, which resulted in the unanticipated capture of three Southern Oregon/Northern California Coast (SONCC) evolutionalrily significant unit (ESU) coho salmon.

On January 19, 2011, the YTFP notified NMFS of the incidentally captured SONCC coho salmon.

On January 24, 2011, NMFS decided future incidental takes were likely, despite no incidental takes in previous sampling. At this time, the project was placed on hold while NMFS reinitiated consultation.

BIOLOGICAL OPINION

Description of the Proposed Action

Up to 100 pre-spawned adult eulachon per year would be sampled from the Klamath River, Redwood Creek and Mad River (up to 300 per year total for all three systems). A small fin clip would be taken from the pre-spawned adults for genetic analysis and the fish would be visually sexed (McCarter and Hay 2003) and immediately released. This sampling protocol would take no more than 5 minutes. If 100 pre-spawned adults are not captured, sampling will continue and whole post-spawned fish would also be collected for genetics, age composition via otolith analysis, and sex ratio through visual examination. Sampling of adult eulachon, using seines, dipnets, larval tows, and fixed larval nets in the Klamath River would occur between January 1, and April 30, in 2011, 2012, and 2013. Seine sampling in Mad River and Redwood Creek would occur from January 1, through April 1, in 2011, 2012, and 2013. Additional sampling methods of plankton tows, fixed plankton nets, and dip netting will take place between January 1, and April 30, of the same three year period. Sampling would occur approximately 3 days per week for 8 hours per day at sampling locations yet to be determined but below river mile 30 in the Klamath. In the Mad River, sampling would occur 1 time per week for 8 hours at sampling locations in the tidally influenced portion of the river (lower 5 miles). In Redwood Creek sampling would occur 1 times per week for 8 hours in Redwood Creek estuary (lower three miles of Redwood Creek). The adult eulachon would be collected using a combination of seine nets or dip nets (measuring no more than 36 inches across the bag frame). Sampling would be stratified by depth, distance from shore, and time of day. Some night sampling would occur as winter conditions and safety allow. If eulachon are found the applicant would design and conduct spawning stock biomass (SSB) estimate planktonic surveys using the methods described in Hay (2002, 2003).

If eulachon in significant numbers are found in the Klamath Basin, the applicant is proposing the use of the daily egg production method (DEPM) (Parker 1985, Jackson and Cheng 2001) to

develop a robust SSB estimate for eulachon smelt. One minute plankton tows would be conducted near the top, middle, and bottom of a station along a transect position. The major Klamath River transect is located at approximately river mile 4, near the Highway 101 bridge. The transect position (perpendicular to the river flow) would have at least one station near each shoreline and one in the middle of the channel, for a total of three stations. Up to 90 tows would be made each year, 9 per week for approximately 10 weeks, dependent upon the duration of the eulachon larvae outmigration period. It is estimated that fewer than 5,000 eulachon larvae would be captured per year, although actual numbers could be far lower. A General Oceanic flow meter, mounted on the net frame, would be used to determine the volume filtered during sampling. Samples would be preserved in 95% ethanol (dilutes to approximately 50% alcohol during rinsing of sample into the bottle). In the laboratory, Rose Bengal would be added to make the larvae more visible for counting. The larval count data would be combined with daily river discharge and eulachon fecundity data to determine an estimate of SSB. The lower Klamath River discharge data would be derived from U.S. Geological Survey (USGS) river discharge data.

Additional fixed plankton net sampling to document eulachon larvae presence in Redwood Creek and Mad River would occur between January 1, and April 30, 2011-2013. Estimated numbers of plankton net sets by river per year are 10 each in Redwood Creek and Mad River. Plankton net sets in both Mad River and Redwood Creek would take place in the lower tidally-influenced portion of the river; generally below river mile 5 in Mad River and river mile 3 in Redwood Creek.

Approach to the Assessment

NMFS approaches its section 7 analyses of research permits through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect physical, chemical, or biotic effects on listed species or on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The results of this step defines the *action area* for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. Once we identify which listed resources are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our *response analyses*).

The final steps of our analyses — establishing the risks those responses pose to listed resources — are different for listed species and designated critical habitat (these represent our *risk analyses*). Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species.

Because the continued existence of species depends on the fate of the populations that comprise them, the continued existence of these "species" depends on the fate of the populations that comprise them. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individual risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using changes in the individuals' "fitness" or an individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable lethal, sub-lethal, or behavioral responses to an action's effects (responses that we identify during our response analyses) are likely to have consequences for the individual's fitness.

When individual listed plants or animals are likely to experience reductions in fitness (as defined in the preceding paragraph) in response to an action, those fitness reductions are likely to reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individual's represent (see Stearns 1992). Reductions in at least one of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. As a result, when listed plants or animals exposed to an action's effects are *not* expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (for example, see Stearns 1977, Brandon 1978, Mills and Beatty 1979, Stearns 1992, Anderson 2000). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

Although reductions in the fitness of individuals is a *necessary* condition for reductions in a population's viability, reducing the fitness of individuals in a population is not always *sufficient* to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed plants or animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individual's represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this opinion) as our point of reference. If we conclude that reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

Reducing the viability of a population is not always *sufficient* to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses, we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers distribution, estimates of extinction risk or probability of being conserved. In this step of our analyses, we use the species' status (established in the *Status of the Species* section of this opinion) as our point of reference. Our final determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

To conduct these analyses, we relied on all of the evidence available to us. As discussed in the introduction to this biological opinion, this evidence consisted of the EA, the updated status review for eulachon, past and current research and population dynamics modeling efforts for this species, monitoring reports from prior research, and monitoring reports from similar previous research.

During this consultation, we conducted several electronic searches of the general scientific literature using *Biosis*, *Article First*, and *Aquatic Sciences and Fisheries Abstracts* search engines. We supplemented these searches with electronic searches of doctoral dissertations and master's theses. These searches focused on identifying recent information on the biology, ecology, distribution, status, and trends of the southern DPS eulachon; recent studies on the response of marine ecosystems and marine biota to shrimp trawls; and different methods for assessing risks of extinction.

We ranked the results of these searches based on the quality of their study design, sample sizes, level of scrutiny prior to and during publication, and study results. Carefully-designed field experiments (for example, experiments that control potentially confounding variables) are rated higher than field experiments that are not designed to control those variables. Carefully-designed field experiments are generally ranked higher than computer simulations. Studies that produce large sample sizes with small variances are generally ranked higher than studies with small sample sizes or large variances.

Action Area

The action area for this biological opinion is the lower 30 miles of Klamath River, the lower 5 miles of Mad River, and the lower three miles of Redwood Creek in northwest California.

Status of Listed Resources

NMFS has determined that the process of seine netting considered in this Opinion may affect the southern DPS of Pacific eulachon, Southern Oregon/Northern California Coast coho salmon, California Coastal Chinook salmon, and Northern California steelhead. Eulachon were listed as threatened under the ESA on March 18, 2010 (75 FR 13012). A section 4(d) regulation

including take prohibitions has not been promulgated for Pacific eulachon. Critical habitat has been proposed for this species.

Southern Oregon/Northern California Coast (SONCC) coho salmon were listed as threatened under the ESA on May 6, 1997 (62 FR 24588), and their status as threatened was reaffirmed on June 28, 2005 (70 FR 37160). Protective regulations and take prohibitions were established at the time their listing status was reaffirmed. Critical habitat was designated on May 5, 1999 (64 FR 24049).

California Coastal (CC) Chinook salmon were listed as threatened on September 19, 1999 (64 FR 50394), and reaffirmed as threatened on June 28, 2005 (70 FR 37160). Protective regulations and take prohibitions were established at the time their listing status was reaffirmed. Critical habitat was designated on September 2, 2005 (70 FR 52488).

Northern California (NC) steelhead were listed as threatened on June 7, 2000 (65 FR 36074), and reaffirmed as threatened on January 5, 2006 (71 FR 834). Protective regulations and take prohibitions were established on June 28, 2005 (70 FR 37160). Critical habitat was designated on September 2, 2005 (70 FR 52488).

Green sturgeon are only expected to be present in the Klamath River estuary. The Klamath River spawning population is part of the non-listed Northern DPS of green sturgeon; however, in estuaries along the coast both Northern and Southern DPS green sturgeon share habitat. Green sturgeon spend one to three years of their lives in freshwater before migrating to the ocean at over 24 inches long (Nakamoto *et al.* 2005). Freshwater stage juvenile green sturgeon also spend much of their time hiding in interstitial spaces and displaying nocturnal movements (Adams *et al.* 2002). No green sturgeon are expected to be encountered with any of the gear types because the gear and sampling locations are not selective for them. Furthermore, Southern DPS green sturgeon sub-adults and adults are the only life stages that may be present in the Klamath River estuary and those fish are large and fast enough to be able to avoid the sampling gear in this proposed action.

While seine netting may affect incidentally captured listed species, NMFS has determined that dip netting for Pacific eulachon may effect, but is not likely to adversely affect threatened SONCC coho salmon, CC Chinook salmon, or NC steelhead because the researchers must see the fish they are sampling. Because researchers will only dip net eulachon and not juvenile salmonids, this sampling method poses an insignificant threat to these listed species or their critical habitats.

Southern DPS Pacific eulachon

Distribution. Eulachon are smelt native to eastern North Pacific waters from the Bering Sea to Monterey Bay, California, or from 61º N to 31º N (Hart and McHugh 1944, Eschmeyer *et al.* 1983a, Minckley *et al.* 1986, Hay and McCarter 2000). The southern DPS of Pacific eulachon

extends from the Nass River of British Columbia to the Mad River of California. However, the southern extent of their distribution has receded northward over the past several decades.

Growth and reproduction. Eulachon are semelparous and anadromous, spending most of their lives in marine environments before returning to freshwater to spawn once and die. Because larvae exit the freshwater systems almost immediately, they likely retain homing only to the estuarine system that their natal river drains to. Based upon this, the smallest stock unit is likely the estuary that natal streams drain (Hay and McCarter 2000, Beacham *et al.* 2005). Specific spawning rivers within the natal system are likely selected based upon environmental conditions at the time of return (Hay and Beacham 2005).

Adult eulachon have been observed in California's Humboldt Bay, Klamath, Mad, Russian, and Sacramento Rivers as well as Redwood Creek, the Umpqua and Rogue Rivers in Oregon, and Washington's Puget Sound, Hood Canal, Bear, Naselle, Nemah, Wynoochee, Quinault, Queets, and Nooksack Rivers (Odemar 1964, Moyle 1976, Minckley *et al.* 1986, Emmett *et al.* 1991, Jennings 1996, Wright 1999, Larson and Belchik 2000, Musick *et al.* 2000, WDFW and ODFW 2001). Spawning has been documented in the Elwha River and the Strait of Juan de Fuca, but sightings or spawning in these Oregon and Washington rivers is very limited or unknown (Wright 1999, Shaffer *et al.* 2007). For southern DPS eulachon, most spawning is believed to occur in the Columbia River and its tributaries (Grays, Skamokawa, Elochoman, Kalama, Lewis, and Sandy rivers), with less production from the Mad and Klamath Rivers, as well as sporadic production in other Oregon and Washington rivers (Emmett *et al.* 1991, Musick *et al.* 2000, WDFW and ODFW 2001). Eulachon from southern rivers generally spawn at a younger age than eulachon from more northern rivers (Clarke *et al.* 2007).

Spawn timing depends upon the river system involved (Willson *et al.* 2006). In the Columbia River and further south, spawning occurs from late January to May, although river entry occurs as early as December (Hay and McCarter 2000). The peak of eulachon runs in Washington State is from February through March. Fraser River spawning is significantly later, in April and May (Hay and McCarter 2000).

The timing of euchalon entry into spawning rivers is likely tied to water temperature and tidal cycles (Ricker *et al.* 1954, Bishop *et al.* 1989, WDFW and ODFW 2001, Lewis *et al.* 2002, Spangler 2002). Spawning normally occurs when water temperature is between 39º and 50º F. Adults may migrate up to 100 miles upstream to reach spawning grounds (Hart and McHugh 1944). Males tend to arrive on spawning grounds earlier than females and tend to stay longer, making them more susceptible to commercial and recreational fisheries (Hart and McHugh 1944). However, males outnumber females by a roughly 2:1 margin. Eulachon sperm is viable for only minutes and a key factor of eulachon spawning may be male grouping *en mass* to broadcast their sperm. Once milt reaches downstream females, each female releases 7,000 to 31,000 eggs (in the Columbia River) at which time fertilization occurs (WDFW and ODFW 2001). Females lay eggs over sand, course gravel, or detrital substrate. This reproductive strategy requires high eulachon density to ensure fertilization. Eggs attach to gravel or sand and

incubate for 30 to 40 days after which larvae drift to estuaries and coastal marine waters (Wydoski and Whitney 1979) and after three to five years, migrate back to natal basins to spawn.

Eulachon generally die following spawning (Scott and Crossman 1973, Clarke *et al.* 2007). Maximum known lifespan is 9 years of age, but 20 to 30% of individuals live to 4 years and most individuals survive to 3 years of age, although spawning has been noted as early as 2 years of age (Wydoski and Whitney 1979, Barrett *et al.* 1984, Hugg 1996, Hay and McCarter 2000, WDFW and ODFW 2001). However, the age distribution of spawners varies between river and from year-to-year (Willson *et al.* 2006).

Adult eulachon are found in coastal and offshore marine habitats possibly to 2,000 feet deep, but more frequently between 50 and 600 feet deep (Allen and Smith 1988, Hay and McCarter 2000, Willson *et al.* 2006). Following hatching in freshwater, larvae and juveniles become thoroughly mixed in coastal waters generally less than 50 feet deep and move deeper as they grow (Barraclough 1964, Hay and McCarter 2000). Larval and post larval eulachon prey upon phytoplankton, copepods, copepod eggs, mysids, barnacle larvae, worm larvae, and other eulachon larvae until they reach adult size (WDFW and ODFW 2001). At this time, the primary prey of eulachon are copepods and euphausiids, including *Thysanoessa* spp., unidentified malacostracans, and cumaceans (Smith and Saalfeld 1955, Barraclough 1964, Wydoski and Whitney 1979, Drake and Wilson 1991, Sturdevant *et al.* 1999, Hay and McCarter 2000).

Status and trends. The southern DPS of eulachon was listed as threatened on March 18, 2010 (75 FR 13012). It is threatened by decreased abundance, natural predation, commercial and recreational fishing pressure (directed and bycatch), and loss of habitat. Population decline is anticipated to continue as a result of climate change and bycatch in commercial shrimp fisheries. However, as highly fecund fish, eulachon have the ability to rebound quickly if given the opportunity, a feature that is likely necessary to withstand significant predation pressure and high mortality likely experienced by pelagic larvae (Bailey and Houde 1989).

Eulachon formerly experienced widespread, abundant runs and have been a staple of Native American diets for centuries along the northwest coast. However, such runs that were formerly present in several California rivers as late as the 1960s and 1970s (i.e., Klamath River, Mad River, and Redwood Creek) are thought to no longer occur (Larson and Belchik 2000). This decline likely began in the 1970s and continued until the last Klamath River run was observed in 1999 (Larson and Belchik 2000, Moyle 2002). Eulachon have not been identified in the Mad River and Redwood Creek since the mid-1990s, although sampling effort here may be low or non-existent (Moyle 2002).

Critical habitat. Critical habitat has been proposed for the southern DPS of eulachon. Mad River, Redwood Creek, and Klamath River contain migratory and spawning habitat and therefore have been proposed as critical habitat for Pacific eulachon.

Southern Oregon Northern California Coast Coho Salmon

Distribution. Southern Oregon/Northern California coast coho salmon consists of all naturally spawning populations of coho salmon that reside below long-term, naturally impassible barriers in streams between Punta Gorda, California and Cape Blanco, Oregon, as well as three artificial propagation programs: the Cole Rivers Hatchery, Trinity River Hatchery, and Iron Gate Hatchery coho hatchery programs. The three major river systems supporting SONCC coho salmon are the Rogue, Klamath (including the Trinity), and Eel rivers.

Growth and reproduction. Coho salmon adults spawn at age 3, spending just over 1 year in fresh water and a year and a half in the ocean. Adult coho salmon reach sexual maturity at 3 years, and die after spawning. Precocious 2 year olds, especially males, also make up a small percentage of the spawning population. Coho salmon adults migrate and spawn in small streams that flow directly into the ocean, or tributaries and headwater creeks of larger rivers (Sandercock 1991, Moyle 2002). Adults migrate upstream to spawning grounds from September through late December, peaking in October and November. Spawning occurs mainly in November and December, with fry emerging from the gravel in mid February, peaking in late March or early April (Moyle *et al.* 2008). Fry initially move to shallow margins of their natal streams, then deeper pools, and eventually rear at the confluence of their natal streams and larger systems downstream (Moyle *et al.* 2008). They may spend 1 to 2 years rearing in freshwater (Bell and Duffy 2007), or emigrate to an estuary shortly after emerging from spawning gravels (Tschaplinski 1988). Coho salmon juveniles are also known to "redistribute" into non-natal rearing streams, lakes, or ponds, often following rainstorms, where they continue to rear (Peterson 1982). At a length of 38 to 45 mm, fry may migrate upstream a considerable distance to reach lakes or other rearing areas (Nickelson *et al.* 1992). Emigration from streams to the estuary and ocean generally takes place from March through June, with the peak period being the end of April through May (Moyle *et al.* 2008).

Status and trends. NMFS (2001) concluded that population trend data for SONCC coho salmon from 1989 to 2000 show a continued downward trend throughout most of the California portion of the SONCC coho salmon ESU. Since the 2005 status review, SONCC coho populations have continued to decline. The apparent decline in wild production in these rivers, in conjunction with significant hatchery production, suggests that natural populations of coho salmon are not self-sustaining (Weitkamp *et al.* 1995, Good *et al.* 2005). In the latest status review by NMFS, Good *et al.* (2005) concluded that SONCC coho salmon were likely to become endangered in the foreseeable future. More recently, it appears that many populations within the ESU are at risk of extinction, suffering the effects of small population dynamics (NMFS 2010).

In the Klamath River, the estimated escapement has dropped from approximately 15,400 in the mid-1960s to about 3,000 in the mid 1980s, and more recently to about 2,000 (Good *et al.* 2005). Brown *et al*. (1994) found survey information on 115 streams within the SONCC coho salmon ESU, of which 73 (64%) still supported coho salmon runs while 42 (36%) did not. The streams Brown *et al*. (1994) identified as presently lacking coho salmon runs were all tributaries of the Klamath River and Eel River systems. While there is no estimate of juvenile production in the Klamath River, both wild and hatchery produced juveniles are present in the system.

The Redwood Creek drainage appears to have a limited carrying capacity for juvenile SONCC coho salmon. Mainstem Redwood Creek above Prairie Creek does not support many juvenile SONCC coho salmon. In a decade of monitoring, no young of year (YOY) coho salmon were captured between 2000 and 2006; however, six YOY were captured in 2007, 32 in 2008, but again none in 2009 (Sparkman 2010). Juvenile outmigration from Prairie Creek, a tributary to lower Redwood Creek, has fluctuated between 3,500 and 6,500 juveniles over the past decade, with an annually declining trend since 2006 (workshop notes). Below the confluence of Redwood and Prairie Creeks, in the estuary, monitoring in 2005 managed to capture seven coho salmon with no recaptures.

In Mad River, adult returns have declined from 2000 in the mid-1960s to 500 in the mid-1980s to approximately 460 in 1991. Adult returns through the 1990s up to 1999 averaged only 38 coho with approximately 16 of those each year being female (Good *et al.* 2005). To supplement the dwindling population, the Mad River hatchery had been releasing juvenile coho salmon annually. However, 1999 was the last year coho salmon were spawned in a hatchery and in 2001, over 82,000 juvenile coho salmon were released into the Mad River (Good *et al.* 2005). Tributaries such as Lindsay, Noisy, Hall and Mill Creeks, the North Fork Mad River sub-watershed, and the lower mainstem Mad River are all important rearing habitats for salmonids, especially for coho salmon, due to the tributary streams' low gradients and cooler water temperatures.

Critical habitat. NMFS designated critical habitat for SONCC coho salmon on May 5, 1999 (64 FR 24049). Critical habitat for this species encompasses all accessible river reaches between Cape Blanco, Oregon, and Punta Gorda, California. Critical habitat consists of the water, substrate, and river reaches (including off-channel habitats) in specified areas. Accessible reaches are those within the historical range of the ESU that can still be occupied by any life stage of coho salmon. These river habitats are important for a variety of reasons, such as supporting the feeding and growth of juveniles and serving as spawning habitat for adults. Limiting factors identified for this species include: loss of channel complexity, connectivity and sinuosity, loss of floodplain and estuarine habitats, loss of riparian habitats and large in-river wood, reduced stream flow, poor water quality, temperature and excessive sedimentation, and unscreened diversions and fish passage structures.

Designated critical habitat for SONCC coho salmon overlaps the project action area. In designating critical habitat for SONCC coho salmon, NMFS focused on the known physical and biological features within the designated area that are essential to the conservation of the species. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation. Within the essential habitat types (spawning, rearing, migration corridors), essential features of coho salmon critical habitat include adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions (64 FR 24049, May 5, 1999). The current condition of critical habitat for SONCC coho salmon is discussed in the factors affecting the species below.

California Coastal Chinook Salmon

Distribution. The CC Chinook salmon ESU includes all naturally spawned populations of Chinook salmon from rivers and streams south of the Klamath River to the Russian River, Califoria. Seven artificial propagation programs are part of this ESU: The Humboldt Fish Action Council (Freshwater Creek), Yager Creek, Redwood Creek, Hollow Tree, Van Arsdale Fish Station, Mattole Salmon Group, and Mad River Hatchery fall-run Chinook hatchery programs. These artificially propagated populations are no more divergent relative to the local natural populations than would be expected between closely related populations within this ESU.

Growth and reproduction. Adult Chinook salmon reach sexual maturity usually at 3 to 5 years, and die soon after spawning. Precocious 2 year olds, especially male jacks, make up a relatively small percentage of the spawning population. Healey (1991) describes two basic life history strategies for Chinook salmon, stream-type and ocean-type. Spring-run Chinook salmon are often stream-type (Healey 1991, Moyle 2002). Fall-run Chinook salmon are unambiguously ocean-type (Moyle 2002); specifically adapted for spawning in lowland reaches of big rivers and their tributaries (Moyle 2002, Quinn 2005). Only fall-run Chinook salmon currently occur in the CC Chinook salmon DPS. Adults move into rivers and streams from the ocean in the fall or early winter in a sexually mature state and spawn within a few weeks or days upon arrival on the spawning grounds (Moyle 2002). Juveniles emerge from the gravel in late winter or early spring and within a matter of months, migrate downstream to the estuary and the ocean (Moyle 2002, Quinn 2005). Juvenile Chinook salmon outmigrate between April and August of their first year, with 96% of the emigration occurring between the end of May and the end of July (Sparkman 2010).

Status and trends. Good *et al.* (2005) found that historical and current information indicates that CC Chinook salmon populations are depressed in basins where they are being monitored. Uncertainty about abundance, natural productivity, introduction of hatchery fish, and distribution continues to substantially contribute to risks facing this ESU. Concerns about current abundances relative to historical abundances, mixed trends in the few time series available, and potential extirpations in the southern part of the range contributed to the conclusion that CC Chinook salmon are likely to become endangered in the foreseeable future (Good *et al.* 2005).

Myers *et al.* (1998) provided an estimate of historic CC Chinook salmon abundance. The ESU was estimated to support approximately 73,000 fish, predominantly in the Eel River (55,500) with smaller populations in Redwood Creek, Mad River, Mattole River (5,000 each), Russian River (500), and several small streams in Del Norte and Humboldt Counties. Spring-run populations of CC Chinook salmon were likely present in the Mad, Eel, and Russian Rivers, but have since been extirpated.

Information on CC Chinook salmon suggests mixed trends in populations. Recently improved ocean conditions likely factor into recently observed increases in abundance, but the persistence of this trend is unknown. Data for CC Chinook salmon indicate that many of the populations are small and occur sporadically. This raises concern over the future stability of the spatial structure of this ESU. Little information exists on the current diversity of CC Chinook salmon. Trends

and abundance information for CC Chinook salmon suggest that the diversity of the ESU is threatened by continued declines in abundance.

Chinook salmon spawn in upper, middle, and lower Redwood Creek mainstem, Redwood Creek tributaries, and Prairie Creek and its tributaries, during November to January. Mainstem Redwood Creek may be where the majority of spawning occurs (Cannata *et al.* 2006). While historically as many as 5,000 CC Chinook salmon spawned in Redwood Creek, fewer adults have returned since recent monitoring began. Duffy (pers. comm., 2007) believes that Chinook salmon have declined in Prairie Creek during the past 6-7 years of monitoring, as they have gone from 400 adults to about 10-15. No reliable estimate of the current adult population size of Chinook salmon in Redwood Creek is available. While the numbers of returning adults has decreased recently, the number of outmigrating juveniles has remained relatively constant around 100,000 between 2005 and 2009 following a 2004 cohort failure.

In Mad River, a 1958 survey (CDWR 1958) estimated the adult population of CC Chinook salmon was slightly more than 5,000. In redd surveys since 2004, fewer than 100 redds have been located, suggesting considerably lower adult populations than historic levels. A 2001 juvenile CC Chinook salmon study between April and mid-July produced an estimate of nearly one million age 0 Chinook salmon outmigrating from Mad River.

Critical habitat. NMFS designated critical habitat for California Coastal Chinook salmon on September 2, 2005 (70 FR 52488). Specific geographic areas designated include the following CALWATER hydrological units: Redwood Creek, Trinidad, Mad River, Eureka Plain, Eel River, Cape Mendocino, Mendocino Coast, and the Russian River. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this ESU identifies primary constituent elements that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The critical habitat designation (70 FR 52488) contains additional details on the sub-areas that are included as part of this designation, and the areas that were excluded from designation.

Critical habitat in this ESU consists of limited quantity and quality summer and winter rearing habitat, as well as marginal spawning habitat. Compared to historical conditions, there are fewer pools, limited cover, and reduced habitat complexity. The limited instream cover that does exist is provided mainly by large cobble and overhanging vegetation. Instream large woody debris, needed for foraging sites, cover, and velocity refuges is especially lacking in most of the streams throughout the basin. NMFS has determined that these degraded habitat conditions are, in part, the result of many human-induced factors affecting critical habitat including dam construction, agricultural and mining activities, urbanization, stream channelization, water diversion, and logging, among others.

Northern California steelhead

Distribution. The NC steelhead DPS includes all naturally spawning populations of steelhead in California coastal river basins from Redwood Creek, Humboldt County to just south of the Gualala River, Mendocino County (Spence *et al*. 2007). This distribution includes the Eel River, the third largest watershed in California, with its four forks (North, Middle, South, and Van Duzen) and their extensive tributaries. With few exceptions, NC steelhead are present wherever streams are accessible to anadromous fishes and there are sufficient flows.

Growth and reproduction. There are two basic steelhead life history patterns, winter-run and summer-run (Moyle 2002, Quinn 2005). Winter-run steelhead enter rivers and streams from December to March in a sexually mature state and spawn in tributaries to mainstem rivers, often ascending long distances. Summer steelhead (also known as spring-run steelhead) enter rivers in a sexually immature state during receding flows of spring and migrate to headwater reaches of tributary streams where they hold in deep pools until spawning the following winter or spring (Moyle 2002). Spawning for all runs generally takes place in the late winter or early spring. Eggs hatch in 3 to 4 weeks and fry emerge from the gravel 2 to 3 weeks later (Moyle 2002). Steelhead spend anywhere from 1 to 5 years in saltwater, however, 2 to 3 years are most common (Busby *et al.* 1996). Some steelhead in the Mad River also return as "half pounders," representing a unique diversity strategy in which individuals over-winter one season in freshwater before returning to the ocean in the spring. The diversity strategy of both a summer and winter spawning run helps to protect the population from stochastic events and helps to ensure redd success over a range of flows, habitats and conditions.

Status and trends. Long-term data sets are limited for the NC steelhead. Estimates of historic abundance from dam counts in Mad River (Sweasey Dam) averaged about 3,100 in the 1930s, 4,700 in the 1940s, 2,900 in the 1950s, and 2,000 in the 1960s (Good *et al.* 2005). Juvenile sampling between 1994 and 2002 led to estimates of an adult spawning population of between 162 and 384 in Mad River. A mark recapture study conducted in 2001 and 2002 estimated adult winter-run steelhead numbered approximately 17,164 but fewer than 1,500 were wild fish (Zuspan and Sparkman 2002). The estimate of adult summer-run steelhead ranged from 34 to 564. A 2009 snorkel survey in a 700 foot portion of Mad River identified 400 juvenile steelhead rearing in that stretch. There are no abundance estimates for Mad river, but steelhead are thought to be widely distributed in the basin; furthermore, every year approximately 250,000 yearling hatchery-reared steelhead are released.

Northern California steelhead in Redwood Creek have likely decreased in numbers from historical abundances (Cannata *et al.* 2006). The most recent population estimates from California Department of Fish and Game's (CDFG's) outmigrant trapping study in Redwood Creek are from the 2006 outmigration data from the upper trap (Sparkman, pers. comm., 2007). Each season, CDFG found that large numbers of 0+ steelhead emigrated from upper Redwood Creek, as evidenced by total annual trap catches ranging from 55,126 to 128,885 individuals over 6 years (Sparkman 2005). Sparkman (2006) described that between the years 2000 and 2006, there has been a negative trend in juvenile smolt production. The 2006 sampling effort saw

reductions in all age classes over the last 6 years, and fewer fish in all age classes compared to those trapped in 2005 (Sparkman 2006).

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52488). The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more life stages of steelhead. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity.

Environmental Baseline

By regulation, environmental baselines for Opinions include the past and present impacts of all state, Federal, 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 impact of State or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this Opinion includes the effects of several activities that affect the survival and recovery of Pacific eulachon, NC steelhead, CC Chinook, and SONCC coho salmon in the action area.

Very little is known about the presence of Pacific eulachon within the action area, while considerably more is known about the salmonids species. The purpose of this project is to gather information on patterns of distribution or abundance of eulachon in northern California rivers. The following information summarizes the primary human and natural phenomena in northern California that are believed to affect the status and trend of listed eulachon, NC steelhead, CC Chinook salmon, and SONCC coho salmon as well as their probable responses to these phenomena.

Fisheries

There are currently no harvest regulations for eulachon in the Klamath River, Mad River, or Redwood Creek. However, eulachon abundance has declined so dramatically in these rivers that there is little, if any, fishing effort for eulachon. In the Pacific Ocean, eulachon can be harvested year-round using any method otherwise authorized to harvest food fish in the open ocean.

Bycatch of eulachon in commercial marine fisheries poses a moderate threat to eulachon in Oregon and Washington and California. In the past, protection of forage fishes has not been a priority when developing ways to reduce shrimp fishing bycatch. Eulachon are particularly vulnerable to capture in shrimp fisheries in the United States and Canada as the marine areas occupied by shrimp and eulachon often overlap. In Oregon, the bycatch of various species of smelt (including eulachon) has been as high as 28 percent of the total catch of shrimp by weight (Hay and McCarter 2000, Hannah and Jones 2007).

In-river sport fishing in the action area has contributed to the decline of salmonids. River recreational fishing effort, and associated hook and release mortality on wild fish, would be

expected to be higher in rivers with a significant hatchery steelhead component, such as the Klamath and Mad River. Despite restrictions on the retention of Chinook salmon once they enter freshwater, a catch and release fishery for Chinook salmon remains popular. Based on surveys, an estimated average of 631 Chinook were caught-and-released by anglers annually between 1999 and 2003 (Sparkman 2003). It is assumed that this level of fishing for Chinook salmon continues and therefore, the number of Chinook salmon caught and released by anglers would be similar for the permit duration. There is likely a relatively higher level of incidental hooking of listed steelhead because the presence of the Mad River hatchery results in increased fishing effort for hatchery steelhead. These freshwater fisheries are reasonably expected to cause some mortality of adult salmonids, and thus decrease the number of CC Chinook salmon and steelhead spawners in the Mad River. With the exception of some authorized harvest by the Yurok, Hoopa Valley and Karuk tribes for subsistence, ceremonial and commercial purposes, the retention of coho salmon is prohibited in California river fisheries.

The degree to which recreational and commercial harvest have contributed to the overall decline of Pacific salmonids is difficult to assess because of the confounding effects of habitat deterioration, drought, and poor ocean conditions on salmon survival. However, capture and retention of Pacific salmonids in mixed-stock ocean and freshwater fisheries directly reduce the number of adults that return to spawn. In 1993, the Interior Department Solicitor issued an opinion concluding that the reserved fishing rights of the Yurok and Hoopa Tribes of the Klamath Basin entitle Tribes to 50% of the total available harvest of Klamath Basin salmon. Application of Tribal fishing rights has required significant reductions in the ocean harvest rate on Klamath River fall-run Chinook salmon, and permanently constrains California and Oregon commercial troll seasons relative to seasons before 1993. NMFS (2002) considered the effects of ocean salmon fishing and concluded that harvest rates of fall-run Chinook salmon in the Klamath River are the best available indicator (or surrogate) of harvest rates of CC Chinook salmon. Due to the predicted low abundance of Sacramento River Basin fall-run Chinook salmon, severe ocean salmon fishing closures were adopted for 2008.

Global Warming

Changing ocean conditions, caused by global climate change, in the Pacific Northwest present an unclear, yet potentially severe threat to eulachon and salmonids survival and recovery. Increases in ocean temperatures have already occurred and will likely continue to impact listed fish and their habitats. For example, changes in climate along the entire Pacific Coast and along the northern California and southern Oregon coasts will further change hydrologic patterns and ultimately pose challenges to eulachon and salmonids spawning because of decreased snowpack, increased peak flows, decreased base flow, and increased water temperatures (Morrison *et al.* 2002). In the marine environment, eulachon and salmonids rely upon cool or cold ocean regions and the prey communities therein (Willson *et al.* 2006). As with El Niño and La Niña events, warming ocean temperatures will likely alter these communities, making it more difficult for eulachon and their larvae to locate or capture prey (Roemmich and McGowan 1995, Zamon and Welch 2005). Warmer waters could also allow for the northward expansion of eulachon predator and competitor ranges, increasing an already high predation pressure on the species (Rexstad and Pikitch 1986, McFarlane *et al.* 2000, Phillips *et al.* 2007).

Dams

Construction projects have also had a negative impact on eulachon and salmonids stocks. Dams, such as the Iron Gate Dam, have blocked eulachon and salmonids from moving into former spawning habitat (Smith and Saalfeld 1955), while additional dams upstream affect salmonids access to historic spawning grounds. Such damming projects also alter sedimentation, river substrate, and flow dynamics that these listed fish have evolved with. Impounding water tends to raise its temperature, which is problematic for spawning eulachon and rearing salmonids (NMFS 2008). Sediment retention structures, constructed to limit sediment transport downstream, have been correlated with reduced eulachon runs in subsequent years (Lou Reebs, pers. comm. *in* 74 FR 10857).

Effects of the Proposed Action

In this section of the Opinion, we assess the probable direct and indirect effects of funding the proposed research on eulachon in Klamath River, Mad River, and Redwood Creek as well as any indirect effect to incidentally captured SONCC coho salmon, CC Chinook salmon, or NC steelhead. As discussed in the approach to the assessment, in order to determine the likelihood and extent of exposure, we rely on the recent population trends identified in the status of the species section of this Opinion. After determining the likely exposure for both eulachon and salmonids, we summarize the results of studies that have examined the direct and indirect effects of each sampling procedure. We rely on these summaries of the literature to determine how individual eulachon and salmonids are likely to respond upon being exposed to a particular sampling procedure. Based on this body of information, we then assess the risks these proposed activities pose, first to particular eulachon and salmonid populations, then to the DPSs.

The specific stressors associated with the proposed project are capture and handling of mature adult eulachon and juvenile salmonids, capture and mortality of post-spawn adult eulachon, and capture and mortality of larvae and eggs in plankton nets and sampling nets. The following sections provide specific details of the stressors and summarize the available data on the responses of individuals that have been exposed to the sampling design.

Proposed and designated critical habitat for the species being considered will not be affected by seine netting or dip netting. These sampling techniques are temporary and isolated. Spawning and migratory habitat will not be altered or affected in any way by these nets.

Capture of Adult Eulachon and Genetic Samples

The Yurok tribe researchers will use seine nets and 36 inch diameter dip nets to capture adult Pacific eulachon during their spawning migration. As many as 100 adults will be captured from each of the Klamath River, Mad River, and Redwood Creek. All adults that are captured during their upstream migration or prior to spawning will receive a fin clip and be returned to the water to complete their spawning activities. From the time pre-spawn eulachon are captured, total handling and fin clip removal will not exceed five minutes. The process of capture and handling the fish is not expected to result in mortality or impact their spawning in any way. Fin clips are

considered standard practice in fisheries science and are not thought to have any significant adverse effects (Wasko *et al.* 2003).

If 100 eulachon are not captured from each river during the upstream migration, researchers will continue to monitor Klamath and Mad Rivers and Redwood Creek for eulachon. Any post-spawn fish that are captured will be collected. Post-spawn adult eulachon will receive genetic fin clips the same as the pre-spawn fish. Additionally, the otoliths will be removed to determine the reproductive age of eulachon. The reproductive age of northern California eulachon appears to be younger than eulachon from farther north (Clarke *et al.* 2007), but very few fish have been captured from northern California in the past 20 years (Larson and Belchik 2000, Moyle 2002). Researchers will also visually inspect post-spawn fish to determine the sex ratio of spawning fish. Eulachon are considered semelparous and die after spawning, so the removal of up to 100 dying adults from each river will not have an adverse affect on the population.

While targeting eulachon, there is the potential that NC steelhead, SONCC coho salmon, and CC Chinook salmon could be incidentally captured during seining or larval tows. Larval tows are not expected to capture juvenile salmonids, however, salmonids may be harassed if they have to swim out of the way. Since the tows will occur in the open water column, it is assumed that any salmonids that are harassed would be migrating at the time and therefore no sub-lethal impacts would be expected. Despite the potential for exposure to larval tows, due to the minimal response, the risk to salmonids from larval tows is negligible.

In Klamath River, the only listed salmonid potentially exposed to incidental capture is SONCC coho salmon. In three seine samples taken on January 12, 2011, three juvenile SONCC coho salmon were incidentally captured. During these three samples, one eulachon was also captured. Downstream migration of coho salmon in the Klamath River generally begins in February and peaks after the conclusion of eulachon sampling (Good *et al.* 2005). Furthermore, peak migration of eulachon is generally between January and May, so catch rate for eulachon will likely increase (Hay and McCarter 2000). NMFS anticipates the catch rate of eulachon to increase as peak migration begins while the catch rate of coho salmon to decrease or remain the same during the pre-emigration period. Given that sampling will occur 3 days per week between January 1, and April 30; the recent trends in SONCC coho salmon outmigration; and the various sampling methods available to the Yurok Tribe, NMFS believes there is a chance that 60 juvenile SONCC coho salmon are encountered in the Klamath River each year during seining operations.

In Mad River and Redwood Creek, there is the potential that NC steelhead, SONCC coho salmon, and CC Chinook salmon could be incidentally captured. The eulachon population in each of Mad River and Redwood Creek is expected to be smaller than in Klamath River; however, sampling will be limited to once each week between January 1, and April 1. The population of all juvenile salmonids in the estuaries of both Mad River and Redwood Creek will also be very small at this time of year. Steelhead and coho salmon often spend over a year in freshwater, meaning juveniles could be present during every month, though larger juveniles would be better able to avoid seine nets. Outmigration of larger steelhead and coho salmon occurs in April or early May and young of year enter the estuary as late as June or July (Moyle *et*

al. 2008). CC Chinook, an ocean-type rearer, typically emigrate from freshwater between April and August with 96% of the emigration between the end of May and middle of July. It would be unlikely that any CC Chinook would be in the estuary during the sampling period, however, there is a chance some early migrating individuals are encountered during mid to late March.

Seine net sampling will be conducted in the lower five miles of Mad River for eight hours each week between January 1, and April 1. As noted above, Chinook salmon may be encountered in the estuary near the end of the sampling period. Generally, Chinook salmon and steelhead that are large enough to migrate towards the estuary prefer deeper faster water (Emmett *et al.* 2004, Moyle *et al.* 2008) than will be sampled by the Yurok Tribe with seine nets. However, based on the current emigration trends identified in the status of the species, they will be present in the action area during sampling times and due to the potential of an encounter in the Mad River, NMFS anticipates up to 40 CC Chinook salmon may be captured each year.

Steelhead and coho salmon may spend more than a year in freshwater before emigrating to the ocean; however, any steelhead or coho captured by this project will be fingerlings as newly hatched young of year of both species will still be upstream of the estuary in April (Rodriguez and Jones 1993, Moyle *et al.* 2008). The adult populations for both coho salmon and steelhead are currently unknown, but so low as to not be considered viable by NMFS (McElhany *et al.* 2000). While there is no population estimate from which to estimate the number of steelhead and coho salmon that may be captured incidentally, there are likely fewer coho salmon in Mad River than Klamath River. And based on summer monitoring in 2009, there are slightly less than twice as many juvenile coho salmon than steelhead in Mad River. NMFS estimates 40 SONCC coho salmon may be captured incidentally during seining and an additional 40 NC steelhead may be captured.

Redwood Creek, like Mad River, will be sampled for eight hours each week between January 1, and April 1. Chinook salmon may be encountered in the estuary as described for Mad River, but sampling will only be conducted in the lower three miles of Redwood Creek and the population of CC Chinook salmon is approximately one tenth the juvenile population in Mad River. Because of those differences, NMFS expects 15 CC Chinook salmon to be captured in Redwood Creek.

Steelhead and Coho salmon in Redwood Creek have similar life histories as those fish in Mad River. An estimated 100,000 steelhead emigrate from Redwood Creek each year, but as with Mad River, during the sampling period age-0 fish will be upstream of the action area (Good *et al.* 2005). There will be steelhead in the estuary during sampling at similar densities to Chinook salmon. The number of steelhead captured in Redwood Creek will be similar but slightly fewer than the number of steelhead captured in Mad River based on population densities. Most coho salmon reproduction occurs in Prairie Creek and the population is very small. In sampling conducted in 2005 and then between 2007 and 2009; 7, 6, 32, and 0 coho salmon were captured in the estuary, respectively. NMFS anticipates approximately 20 NC steelhead will be captured and with such low numbers of coho salmon, no more than 10 SONCC coho salmon will be captured during sampling.

NMFS expects all incidental captures of listed salmon and steelhead in Mad River and Redwood Creek will occur between January 1, and April l, while incidental captures of SONCC coho salmon in the Klamath River will be captured between January 1, and April 30. NMFS expects the response of incidentally captured salmon will be similar. Because of the favorable water temperatures early in the year, NMFS does not expect any incidentally caught salmonids to die. However, the act of capture, handling, and release is stressful to salmonids and will likely result in an increase in plasma cortisol and other stress hormones (Pankhurst and Dedualj 1994). Inducing a stress response in juvenile salmonids can cause physiological, immunological, or behavioral changes with potentially negative consequences or even reduced long-term survival. However, Olla *et al.* (1992) showed that coho salmon quickly recover survival skills following prolonged handling stress. Other research has suggested that acute increases in cortisol are relatively insignificant and chronic stressful experiences are what lead to negative consequences and reduced survivorship (Barton *et al.* 1987, Sigismondi and Weber 1988, Sharp *et al.* 1998).

Plankton Net Tows and Substrate Frames

An important aspect of understanding eulachon reproduction and population fluctuations is monitoring egg and larval production. All of the samples collected by both plankton tows and substrate nets will result in complete mortality of the sample specimens. There will be no sub-lethal effects associated with these procedures.

In Klamath River, Mad River, and Redwood Creek, there have been no recent attempts to document spawning behavior or spawning success. Larson and Belchik (2000) believe eulachon may have been extirpated from northern California rivers. In that case, there will be no eggs or larvae captured. However, if there is still a remnant population of eulachon, there is a chance for successful reproduction. Substrate frames will allow researchers to document the successful fertilization of eggs and plankton net tows will document the successful hatching of those eggs.

The eulachon population in northern California rivers, if existent, is likely extremely depressed. Plankton tows will last one minute and three tows will be made each week at three different stations for a total of nine tows each week over 10 weeks. This effort will amount to a one square meter net moving through the Klamath River for a total of 90 minutes over a 10 week period, which would ultimately capture a very small fraction of the entire drifting larval population. If a uniform density of larval eulachon were expected during the entire sampling period, this sampling strategy would sample one square meter of the entire river for 0.09% of the time the larval fish are drifting downstream. Likewise, the substrate nets being set up in the Mad River and Redwood Creek would be set out at a time, about four times per day, one day each week for 10 weeks sampling a small portion of both waterways for brief times, which would result in a very small fraction of the entire larval population being captured.

Most fish eggs and larvae are very small and difficult to differentiate from other captured eggs and larvae, so the most accurate means of identification is to preserve the entire sample for analysis in a laboratory. Plankton net tows and substrate frames will collect individual eggs and larvae to then be stored in alcohol. While the eulachon population in northern California rivers

is unknown, the sampling strategy will only sample a very small proportion of the waterways. Any larval eulachon that are captured will come from several samples of small proportions of the entire river through months of sampling. Any collection of larval fish obviously carries a cost, but eulachon eggs and larvae have high natural mortality rates in some months exceeding 50% (Hay *et al.* 2002). If there is any mortality of eggs and larvae, it should be minimal and provide the added benefit of documenting spawning and developing a spawning stock biomass (SBB), which is essential for management agencies to develop eulachon recovery strategies for northern California rivers.

Critical Habitat

Klamath River has been designated critical habitat for SONCC coho salmon. Mad River and Redwood Creek have been designated critical habitat for SONCC coho salmon, NC steelhead, and CC Chinook salmon. The actions of seining and conducting larval net tows will not alter or affect the primary constituent elements of these critical habitats in any way.

Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. 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.

During this consultation, NMFS searched for information on future State, tribal, local, or private actions that were reasonably certain to occur in the action area. NMFS conducted electronic searches of business journals, trade journals, and newspapers using *First Search*, Google, and other electronic search engines. Those searches produced no evidence of future private action in the action area that would not require federal authorization or funding and is reasonably certain to occur.

Integration and Synthesis of Effects

Eulachon are naturally prey to many different predatory species. As such, they have a reproductive strategy that has developed to produce many offspring, suffering massive casualties throughout their lives, and the few survivors reproduce to sustain the population. Eulachon take between three and five years to reach maturity before migrating back to fresh water to spawn (WDFW and ODFW 2001). As the population declines, each fish that reaches adulthood is increasingly important. Given that eulachon congregate before broadcast spawning both sperm and eggs, the more adults that are in the spawning location when spawning occurs, the better the chances of having more eggs released and having a higher proportion of those eggs get fertilized. The proposed research will not kill any pre-spawn adult eulachon from Klamath River, Mad River, or Redwood Creek. The population in these areas is unknown and to best protect any remaining spawning populations, no mortality is acceptable. Post-spawn adults die shortly after spawning and any post-spawn adults that are captured can be removed safely without an adverse effect to any remaining population in the northern California rivers. This sampling strategy would pose no threat to the spawning potential of any adult eulachon encountered in these rivers.

In addition to sampling the adults, plankton net tows and substrate nets will be used to capture eggs and early life stages of eulachon from Klamath River, Mad River, and Redwood Creek. Based on the sampling strategy that will target a small portion of the river for short periods of time over 10 weeks, NMFS does not expect the Yurok Tribe to capture 0.1% of the larval population. Each female eulachon from the Columbia River produces between 7,000 and 31,000 eggs (WDFW and ODFW 2001). Eulachon produce so many eggs that the probability of each egg surviving is less than 5% and in some cases less than 1% (Willson *et al.* 2006). Those eggs that do hatch and become larvae suffer high natural mortality rates as prey for many animals that feed on the pelagic larvae as they drift towards estuaries (Bailey and Houde 1989). The ecological consequences of removing less than 0.1% of larvae from each river would be insignificant compared to the rates of predation and natural mortality.

The incidental capture of NC steelhead, SONCC coho salmon, and CC Chinook salmon may also pose a temporary sub-lethal risk to those populations. Seine net sampling for eulachon in the spring reduces the chances of incidentally capturing because of smolt run timing. Those salmonids that are captured, while unlikely to be lethally stressed, may exhibit responses that can negatively affect physiology, behavior, or disease resistance. The short duration of capture and handling will avoid chronic stress responses, minimizing the risk posed to individual fish. While these short-term negative responses may reduce the ability of listed salmon and steelhead to avoid predators for a minute or less (Barton *et al.* 2000), the minimal effects of acute stress response are unlikely to lead to reduced survivorship of individual salmonids (Olla *et al.* 1992). These minimal responses by individual salmonids in these rivers would have an undetectable impact to the juvenile survivorship in Klamath River, Mad River, and Redwood Creek and have no detectable impact to SONCC coho salmon, CC Chinook salmon, and NC steelhead populations.

Conclusion

After reviewing the current status of the threatened southern DPS of Pacific eulachon, the environmental baseline for the action area, the effects of the proposed research activities, and the cumulative effects, it is NMFS' Opinion that the proposal to fund this research is not likely to jeopardize the continued existence of the southern DPS of Pacific eulachon. Critical habitat has been proposed in the proposed action area, but the action will have no effect on Pacific eulachon proposed critical habitat.

After reviewing the best available scientific and commercial information, the current status of SONCC coho salmon, CC Chinook salmon, NC steelhead and their designated critical habitats, the environmental baseline for the action area, effects of the entire proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of SONCC coho salmon, CC Chinook salmon, or NC steelhead. The proposed action will have no effect on SONCC coho salmon designated critical habitat, CC Chinook designated critical habitat, or NC steelhead designated critical habitat.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act 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 to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the USFWS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, 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 Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

Amount or Extent of Take

Threatened SONCC coho salmon are likely to be incidentally captured in the Klamath River by the Yurok Tribe. Threatened SONCC coho salmon, CC Chinook salmon, and NC steelhead are likely to be incidentally captured in Mad River and Redwood Creek by the Yurok Tribe.

From January 1, to April 30, each year between 2011 and 2013, a maximum of 60 SONCC coho salmon may be captured in Klamath River. From January 1, to April 1, in Mad River, NMFS expects 40 SONCC coho salmon, 40 CC Chinook salmon, and 40 NC steelhead to be captured each year. From January 1, to April 1, in Redwood Creek, NMFS expects 10 SONCC coho salmon, 15 CC Chinook salmon, and 20 NC steelhead to be captured each year.

Reasonable and Prudent Measures

NMFS believes that the following RPMs are necessary and appropriate to minimize take of SONCC coho salmon, CC Chinook salmon and NC steelhead listed fish resulting from implementation of this action.

The Yurok Tribe shall:

1. Ensure that the capture and release of listed salmonids is monitored and documented.

Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the action must be implemented in compliance with the following terms and conditions, which implement the RPMs described above for each category of activity. These terms and conditions are non-discretionary.

1. To implement reasonable and prudent measure 1 (monitoring), above, the Yurok Tribe shall:

1a. Maintain records of all capture, release, and condition of listed species during eulachon sampling. Records shall identify the location, date, species, and number of individuals.

1b. Cease seining if the take of any listed species is exceeded and notify NMFS Conservation and Recovery Grants Program within 24 hours.

1c. Submit, along with annual reports to the NMFS Conservation and Recovery Grants Program, the above information in a report, to:

Irma Lagomarsino
Northern California Office Supervisor
National Marine Fisheries Service
1655 Heindon Road
Arcata, California 95521

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act 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, to help implement recovery plans, or to develop information.

The following conservation recommendations would provide information for future consultations that may affect eulachon as well as reduce harassment related to research activities:

1. *Spawning substrate frames* should be monitored and bycatch reported to NMFS in an annual report.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

Introduction

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267, 16 U.S.C. 1801 *et seq*.), established new requirements for Essential Fish Habitat (EFH) descriptions in Federal fishery management plans and require Federal agencies to consult with NMFS on activities that may adversely affect EFH. EFH for Pacific Coast salmon has been described in Appendix A, Amendment 14 to the Pacific Coast Salmon Fishery Management Plan (Pacific Fishery Management Council 2000).

Only species managed under a Federal fishery management plan are covered under the MSFCMA. Coho salmon and Chinook salmon are managed under Federal fishery management

plans, whereas steelhead are not managed. Therefore, these EFH conservation recommendations address only coho salmon and Chinook salmon.

Effects of the Proposed Action on EFH
There are no effects to coho salmon or Chinook salmon EFH for the same reasons as those described for critical habitat.

Conclusions
After reviewing the effects of the project, NMFS has determined that the proposed action would have no effect to coho salmon and Chinook salmon EFH.

EFH Conservation Recommendations
NMFS has no additional conservation measures to recommend beyond what is currently proposed.

REINITIATION NOTICE

This concludes formal consultation on the States of Oregon and Washington's proposal to survey eulachon populations in their coastal waters. 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 take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of authorized take is exceeded, NMFS Conservation and Recovery Grants Program must immediately request reinitiation of section 7 consultation.

LITERATURE CITED

Adams, P.B., C.B. Grimes, J.E. Hightower, S.T. Lindley, and M.L. Moser. 2002. Status review of North American green sturgeon, *Acipenser medirostris*. Report to National Marine Fisheries Service, July 2002. 29p.

Allen, M.J. and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Department of Commerce, NOAA Technical Report NMFS-NWFSC-66.

Anderson, J.J. 2000. A vitality-based model relating stressors and environmental properties to organism survival. Ecological Monographs 70:445-470.

Bailey, K.M. and E.D. Houde. 1989. Predation on eggs and larvae of marine fishes and the recruitment problem. Advances in Marine Biology 25:1-83.

Bargmann, G., J. DeVore, and B. Tweit. 2005. Risk-averse management of eulachon in the Columbia River system. Pages 21–29 in Fisheries Assessment and Management in Data-Limited Situations, Alaska Sea Grant College Program, AK-SG-05-02.

Barraclough, W.E. 1964. Contributions to the marine life history of the eulachon (*Thaleichthys pacificus*). Journal of the Fisheries Research Board of Canada 21(5):1333-1337.

Barrett, B.M., F.M. Thompson, and S.N. Wick. 1984. Adult anadromous fish investigations: May-October 1983. Susitna Hydro Aquatic Studies, report No. 1, APA Document No. 1450. Alaska Department of Fish and Game, Anchorage, AK.

Barton, B.A., C.B. Schreck, and L.D. Barton. 1987. Effects of chronic cortisol administration and daily acute stress on growth, physiological conditions, and stress responses in juvenile rainbow trout. Diseases of Aquatic Organisms 2:173-185.

Beacham, T.D., D.E. Hay, and K.D. Le. 2005. Population structure and stock identification of eulachon (*Thaleichthys pacificus*), an anadromous smelt, in the Pacific Northwest. Marine Biotechnology 7:363-372.

Bell, E. and W.G. Duffy. 2007. Previously undocumented two-year freshwater residency of juvenile coho salmon in Prairie Creek, California. Transactions of the American Fisheries Society 136:966-970.

Bishop, D.M., R.L. Carstensen, and G.H. Bishop. 1989. Report on environmental studies concerning the proposed Haines airport reconstruction: [Revision of Section A, Hydrology], second phase. Alaska Department of Transportation and Public Facilities, Juneau, Alaska.

Brandon, R.N. 1978. Adaptation and evolutionary theory. Studies in History and Philosophy of Science 9(3):181-206.

Brown, L. R., P. B. Moyle, and R. M. Yoshiyama. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management 14(2):237-261.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-27, Seattle, Washington.

Cannata, S., R. Henly, J. Erler, J. Falls, D. McGuire and J. Sunahara. 2006. Redwood Creek Watershed Assessment Report. Coastal Watershed Planning and Assessment

Program and North Coast Watershed Assessment Program. California Resources Agency and California Environmental Protection Agency, Sacramento, California.
CDWR (California Department of Water Resources). 1958. Office report on preliminary investigation of Mad River, March 1958, Appendix C: a preliminary evaluation of the effect of the Ruth Dam Project on fisheries of the Mad River. June, 1957 (Revised February, 1958).
Clarke, A.D., A. Lewis, and K.H. Telmer. 2007. Life history and age at maturity of an anadromous smelt, the eulachon *Thaleichthys pacificus* (Richardson). Journal of Fish Biology 71:1479-1493.
DFO (Department of Fisheries and Oceans Canada). 2008. Eulachon integrated fisheries management plan, April 1, 2008 to March 31, 2009. Department of Fisheries and Oceans Canada, Pacific Region. 21 p. Online at http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/plans08/2008_IFMP-Eulachon.pdf.
Drake, A. and L. Wilson. 1991. Eulachon, a fish to cure humanity. UBC Museum of Anthropology, Museum Note 32.
Emmett, R.L., S.A. Hinton, S.L. Stone, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in West Coast Estuaries, Volume II: Species life history summaries. ELMR Report Number 8, Strategic Assessment Branch, NOS/NOAA. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.
Emmett, R.L., R.D. Brodeur, and P.M. Orton. 2004. The vertical distribution of juvenile salmon (*Oncorhynchus spp*.) and associated fishes in the Columbia River plume. Fisheries Oceanography 13(6):392-402.
Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Company, Boston, Massachussetts.
Eulachon BRT (Biological Review Team). 2010. Status review update for eulachon in Washington, Oregon, and California.
Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66. 598 p.
Hannah, R.W., S.A. Jones, and V.J. Hoover. 1996. Evaluation of fish excluder technology to reduce finfish bycatch in the pink shrimp trawl fishery. Oregon Department of Fish and Wildlife, Information Rept. Ser., Fish. No. 96-4. 46p.
Hannah, R.W. and S.A. Jones. 2000. Bycatch reduction in an ocean shrimp (*Pandalus jordani*) trawl from a simple modification to the trawl footrope. Journal of Northwest Atlantic Fisheries Science 27:227-234.
Hannah, R.W. and S.A. Jones. 2003. Measuring the height of the fishing line and its effect on shrimp catch and bycatch in an ocean shrimp (*Pandalus jordani*) trawl. Fisheries Research 60:427-438.
Hannah, R.W., S.A. Jones, and K.M. Matteson. 2003. Observations of fish and shrimp behavior in ocean shrimp (*Pandalus jordani*) trawls. Oregon Department of Fish and Wildlife, Information Rept. Ser., Fish. No. 2003-03. 28p.
Hannah, R.W. and S.A. Jones. 2007. Effectiveness of bycatch reduction devices (BRDs) in the ocean shrimp trawl fishery. Fisheries Research 85:217-225.
Hart, J.L. and J.L. McHugh. 1944. The smelts (Osemeridae) of British Columbia. Fisheries Research Board of Canada 64. 27 p.

Hay, D.E. and P.B. McCarter. 2000. Status of the eulachon *Thaleichthys pacificus* in Canada. Department of Fisheries and Oceans Canada, Canadian Stock Assessment Secretariat, Research Document 2000-145. Ottawa, Ontario. Online at http://www.dfo-mpo.gc.ca/csas/csas/DocREC/2000/PDF/2000_145e.pdf.

Hay, D.E., P.B. McCarter, R. Joy, M. Thompson, and K.C. West. 2002. Fraser River eulachon biomass assessment and spawning distribution: 1995-2002. Fisheries and Oceans Canada, Science Branch, Stock Assessment Division, Nanaimo, British Columbia.

Hay, D.E., K.C. West, and A.D. Anderson. 2003. Indicators and 'response' points for management of Fraser River eulachon: a comparison and discussion with recommendations. Canadian Science Advisory Secretariat Research Document 2003/051. Online at http://www.dfo-mpo.gc.ca/csas/Csas/DocREC/2003/RES2003_051_E.pdf.

Hay, D.E. and T.D. Beacham. 2005. Stock identification of eulachon (*Thaleichthys pacificus*), an anadromous smelt in the eastern Pacific. Paper presented at ICES 2005 Annual Science Conference, Aberdeen, Scotland, UK. Online at http://www.ices.dk/products/CMdocs/2005/K/K1405.pdf.

Healey, M.C. 1991. Life history of Chinook salmon, Oncorhynchus tschawytscha. Pages 311-394 in Pacific Salmon Life Histories (C. Groot and L. Margolis, Eds.). University of British Columbia Press, Vancouver, British Columbia.

Hugg, D.O. 1996. MAPFISH georeferenced mapping database. Freshwater and estuarine fishes of North America. D.O. and S. Hugg, editors. Life Science Software, Edgewater, Maryland.

Jackson, J. and Y.W. Cheng. 2001. Improving parameter estimation for daily egg production method of stock assessment of pink snapper in Shark Bay, Western Australia. Journal of Agricultural, Biological and Environmental Statistics 6:243-257.

Jennings, M.R. 1996. Past occurrence of eulachon, *Thaleichthys pacificus*, in streams tributary to Humboldt Bay, California. California Fish and Game 82(6):147-148.

JCRMS (Joint Columbia River Management Staff). 2007. 2008 joint staff report concerning stock status and fisheries for sturgeon and smelt. Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife. Online at http://wdfw.wa.gov/fish/crc/crc2008_sturgeon_smelt_js_rpt.pdf.

Larson, Z.S. and M.R. Belchik. 2000. A preliminary status review of eulachon and Pacific lamprey in the Klamath River Basin. Yurok Tribal Fisheries Program, Klamath, California.

Lewis, A.F.J., M.D. McGurk, and M.G. Galesloot. 2002. Alcan's Kemano River eulachon (*Thaleichthys pacificus*) monitoring program 1988-1998. Consultant's report prepared by Ecofish Research Ltd. for Alcan Primary Metal Ltd., Kitimat, B.C.

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. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-42. 156 p.

McFarlane, G.A., J.R. King, and R.J. Beamish. 2000. Have there been recent changes in climate? Ask the fish. Progress in Oceanography 47:147–169.

McLean, J.E., D.E Hay, and E.B. Taylor. 1999. Marine population structure in an anadromous fish: Life history influences patterns of mitochondrial DNA variation in the eulachon, *Thaleichthys pacificus*. Molecular Ecology 8:S143-S158.

McLean, J.E. and E.B. Taylor. 2001. Resolution of population structure in a species with high gene flow: microsatellite variation in the eulachon (Osmeridae: *Thaleichthys pacificus*). Marine Biology 139:411-420.

Mills, S.K. and J.H. Beatty. 1979. The propensity interpretation of fitness. Philosophy of Science 46:263-286.

Minckley, W.L., D.A. Hendrickson, and C.E. Bond. 1986. Geography of western North American freshwater fishes: Description and relationship to intracontinental tectonism. In C. H. Hocutt and E. O. Wiley (eds.), The zoogeography of North American freshwater fishes, p. 519-613. New York, John Wiley and Sons.

Morgan, M.J., C.E. Wilson, and L.W. Crim. 2005. The effect of stress on reproduction in Atlantic cod. Journal of Fish Biology 54(3):477-488.

Morrison, J., M. Quick, and M.G.G. Foreman. 2002. Climate change in the Fraser River watershed: flow and temperature predictions. Journal of Hydrology 263:230–244.

Moyle, P.B. 1976. Inland fishes of California. University of California Press, Berkeley, California.

Moyle, P.B. 2002. Inland Fishes of California. Revised and Expanded. University of California Press, Berkeley and Los Angeles, California.

Musick, J.A., M.M. Harbin, S.A. Berkeley, G.H. Burgess, A.M. Eklund, L. Findley, R.G. Gilmore, J.T. Golden, D.S. Ha, G.R. Huntsman, J.C. McGovern, G.R. Sedberry, S.J. Parker, S.G. Poss, E. Sala, T.W. Schmidt, H. Weeks, and S.G. Wright. 2000. Marine, estuarine, and diadromous fish stocks at risk of extinction in North America (exclusive of Pacific salmonids). Fisheries 25(11): 6-30.

Myers, J.M, R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T.Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Deptartment of Commerce. NOAA Technical Memorandum NMFS-NWFSC-35. Northwest Fisheries Science Center, Seattle, Washington. 443 p.

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

Nickelson, T.E., J.W. Nicholas, A.M. McGie, R.B. Lindsay, D.L. Bottom, R.J. Kaiser, and S.E. Jacobs. 1992. Status of anadromous salmonids in Oregon coastal basins. Unpublished manuscript. Oregon Department of Fish and Wildlife, Research and Development Section, Corvallis, and Ocean Salmon Management, Newport. 83 p.

NMFS (National Marine Fisheries Service). 2001. Status review update for coho salmon (*Oncorhynchus kisutch*) from the Central California Coast and the California Portion of the Southern Oregon/Northern California Coast Evolutionarily Significant Units. Southwest Fisheries Science Center, Santa Cruz Laboratory. 43 p.

NMFS. 2002. Biological Opinion: Klamath Project Operations. National Marine Fisheries Service, Southwest Region, Long Beach, California. May 31.

NMFS. 2006. West Coast Groundfish Observer Program Manual. West Coast Groundfish Observer Program, Northwest Fisheries Science Center.

NMFS. 2008. Listing endangered and threatened species: Notification of finding on a petition to list Pacific eulachon as an endangered or threatened species under the Endangered Species Act. Federal Register (Docket Number 080229343–8368–01; 21 March 2008) 73(49):13185–13189.

NMFS. 2010. Mad River batched gravel mining biological opinion. National Marine Fisheries Service to the US Army Corps of Engineers. File Number 151422SWR2009AR00052. 169p.

Odemar, M.W. 1964. Southern range extension of the eulachon, *Thaleichthys pacificus*. California Fish Game 50:305-307.

ODFW and WDFW (Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife. 2007. Status report: Columbia River fish runs and fisheries, 1938-2002.

Olla, B.L., M.W. Davis, and C.B. Schreck. 1992. Notes: comparison of predator avoidance capabilities with corticosteroid levels induced by stress in juvenile coho salmon. Transactions of the American Fisheries Society 121:544-547.

Pacific Fishery Management Council. 2000. Amendment 14 to Pacific Coast Management Plan (1997). Incorporating the regulatory impact review/initial regulatory flexibility analysis and final supplemental environmental impact statement. 23 p.

Pankhurst, N.W. and M. Dedualj. 1994. Effects of capture and recovery on plasma levels of cortisol, lactate, and gonadal steroids in a natural population of rainbow trout. Journal of Fish Biology 45(6):1013-1025.

Parker, K. 1985. Biomass model for the egg production method. In: Lasker R. (Ed.) An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy *Engraulis mordax*. NOAA Technical Report No. 36, NMFS, 5-6.

Peterson, N.P. 1982. Population characteristics of juvenile coho salmon (*Oncorhynchus kisutch*) overwintering in riverine ponds. Canadian Journal of Fisheries and Aquatic Sciences 39: 1303-1307.

Phillips, A.J., S. Ralston, R.D. Brodeur, T.D. Auth, R.L. Emmett, C. Johnson, and V.G. Wespestad. 2007. Recent pre-recruit Pacific hake (M*erluccius productus*) occurrences in the northern California current suggest a northward expansion of their spawning area. CalCOFI Rep. 48:215-229.

Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. University of Washington Press, Seattle, Washington.

Rexstad, E.A., and E.K. Pikitch. 1986. Stomach contents and food consumption estimates of Pacific hake, *Merluccius productus*. Fisheries Bulletin 84:947-956.

Ricker, W.E., D.F. Manzer, and E.A. Neave. 1954. The Fraser River eulachon fishery, 1941-1953. Fisheries Research Board of Canada, Manuscript Report Number 583.

Rodriguez, A. and W. Jones. 1993. Investigations of salmon and steelhead trout downstream migrations in Caspar Creek and Little River, Mendocino County. Report to California Department of Fish and Game. 16p.

Roemmich, D. and J. McGowan. 1995. Climatic warming and the decline of zooplankton in the California Current. Science 267:1324–1326.

Romano, M.D., M.D. Howell, and T.A. Rien. 2001. Use of an artificial substrate to capture eulachon (*Thaleichthys pacificus*) eggs in the lower Columbia River. Draft

report by the Oregon Department of Fish and Wildlife and the Washington Department of Fish and Wildlife to the U. S. Army Corps of Engineers, Portland, Oregon.

Ryer, C.H. 2002. Trawl stress and escapee vulnerability to predation in juvenile walleye pollock: Is there an unobserved bycatch of behaviorally impaired escapees? Marine Ecology Progress Series 232:269-279.

Sandercock, F.K. 1991. Life history of coho salmon. Pages 397-445 in: Groot, C. and L. Morgolis (Eds.) Pacific Salmon Life Histories. UBC Press. Vancouver, British Columbia, Canada.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin Number 184.

Shaffer, J.A., D. Penttila, M. McHenry, and D. Vilella. 2007. Observations of eulachon, *Thaleichthys pacificus*, in the Elwha River, Olympic Peninsula Washington. Northwest Science 81:76-81.

Sharpe, C.S., D.A. Thompson, H.L. Blankenship, C.B. Schreck. 1998. Effects of routine handling and tagging procedures on physiological stress responses in juvenile Chinook salmon. The Progressive Fish-Culturist 60:81-87.

Sigismondi, L.A. and L.J. Weber. 1988. Changes in avoidance response time of juvenile Chinook salmon exposed to multiple acute handling stresses. Transactions of the American Fisheries Society 117:196-201.

Smith, W.E. and R.W. Saalfeld. 1955. Studies on Columbia River smelt *Thaleichthys pacificus* (Richardson). Washington Department of Fisheries, Fisheries Research Paper 1(3):3-26.

Soldal, A.V. and A. Engås. 1997. Survival of young gadoids excluded from a shrimp trawl by a rigid deflecting grid. ICES Journal of Marine Science 54:117-124.

Spangler, E.A.K. 2002. The ecology of eulachon (*Thaleichthys pacificus*) in Twentymile River, Alaska. M.S. Thesis. University of Alaska, Fairbanks.

Sparkman, M.D. 2003. Upper Redwood Creek Juvenile Salmonid Downstream Migration Study, 2000-2002. Project 2a5. 2002 Annual Report. California Department of Fish and Game. Steelhead Research and Monitoring Program. 62 pp.

Sparkman, M.D. 2005. Lower Redwood Creek juvenile salmonid (smolt) downstream migration study, 2004-2005 seasons. California Department of Fish and Game, Anadromous Fisheries Resource Assessment Monitoring Program. Project 2a7. 111 p.

Sparkman, M.D. 2006. Lower Redwood Creek juvenile salmonid (smolt) downstream migration study, study year 2005. California Department of Fish and Game, Anadromous Fisheries Resource Assessment Monitoring Program. Project 2a7. 105 p.

Sparkman, M.D. 2010. 2009 Annual report: upper Redwood Creek juvenile salmonids (smolt) abundance project 200-2009 seasons. Project 2a5. Anadromous Fisheries Resource Assessment and Monitoring Program, Fisheries Restoration Grant Program (Project Number 0810528). 125p.

Spence, B., E. Bjorkstedt, J.C. Garza, D. Hankin, J. Smith, D. Fuller, W. Jones, R. Macedo, T. Williams, and E. Mora. 2007. A framework for assessing the viability of threatened and endangered salmon and steelhead in North-Central California Coast Recovery Domain. Public Review Draft for NOAA Fisheries.

Stearns, S.C. 1977. The evolution of life history traits: a critique of the theory and a review of the data. Annual Review of Ecology and Systematics 8:145-171.

Stearns, S.C. 1992. The evolution of life histories. Oxford University Press, New York, New York.

Sturdevant, M.V., T.M. Willette, S. Jewett, E. Deberc. 1999. Diet composition, diet overlap, and size of 14 species of forage fish collected monthly in PWS, Alaska, 1994–1995. Chapter 1. Forage Fish Diet Overlap, 1994–1996. *Exon Valdez* Oil Spill Restoration final report 98163C, 12-36.

Tschaplinski, P.J. 1988. The use of estuaries as rearing habitats by juvenile coho salmon. Pages 123–142 in T.W. Chamberlin (Ed.) Proceedings of a Workshop: Applying 15 Years of Carnation Creek Results. Carnation Creek Steering Committee, Nanaimo, B.C.

Wasko, A.P., C. Martins, C. Oliveira, and F. Foresti. 2003. Non-destructive genetic sampling in fish. An improved method for DNA extraction from fish fins and scales. Hereditas 138(3):161-165.

WDFW (Washington Department of Fish and Wildlife) and ODFW (Oregon Department of Fish and Wildlife). 2001. Washington and Oregon eulachon management plan. Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. Online at http://wdfw.wa.gov/fish/creel/smelt/wa-ore_eulachonmgmt.pdf.

WDFW (Washington Department of Fish and Wildlife). 2009. Final season smelt update, Tuesday – March 31, 2009. Online at http://wdfw.wa.gov/fish/creel/smelt/2009/mar3109.pdf.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. U.S. Department of Commerce. NOAA Technical Memorandum NMFSNWFSC- 24, Northwest Fisheries Science Center, Seattle, Washington. 258 p.

Wilkins, M.E. and K.L. Weinberg. 2002. Appendices to the 2001 Pacific West Coast bottom trawl survey of groundfish resources: Estimates of distribution, abundance, and length and age composition. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-128. Online at http://www.afsc.noaa.gov/race/media/publications/archives/pubs2002/techmemo128_append.pdf.

Willson, M.F., R.H. Armstrong, M.C. Hermans, and K. Koski. 2006. Eulachon: a review of biology and an annotated bibliography. Alaska Fisheries Science Center Processed Report 2006-12. Auke Bay Laboratory, Alaska Fisheries Science Center, NOAA, National Marine Fisheries Service, Juneau, Alaska. Online at http://www.afsc.noaa.gov/publications/ProcRpt/PR%202006-12.pdf.

Wright, S. 1999. Petition to list eulachon *Thaleichthys pacificus* as threatened or endangered under the Endangered Species Act. Online at http://www.nwr.noaa.gov/Other-Marine-Species/upload/Smelt_Petition_7_99.pdf.

Wydoski, R.S. and R.R. Whitney. 1979. Inland fishes of Washington. University of Washington Press, Seattle, Washington.

Zamon, J.E. and D.W. Welch. 2005. Rapid shift in zooplankton community composition on the northeast Pacific shelf during the 1998–1999 El Niño- La Niña event. Canadian Journal of Fisheries and Aquatic Sciences 62:133–144.

Zuspan, M.G. and M.D. Sparkman. 2002. Mad River winter-run adult steelhead run-size estimate, 2000–2001 season. Annual report, Project 1a3. California Department of Fish and Game, Fisheries Society Western Division meetings, Albuquerque, New Mexico.