Endangered Species Act
Section 7 Consultation - Biological Opinion and Conference Opinion

Agency: U.S. Environmental Protection Agency

Activity: Implement a long-term strategy (LTMS) that will guide the regional management agencies' dredged material management decisions in the San Francisco Bay Area over the next fifty years.

Consultation Conducted By:
National Marine Fisheries Service
Southwest Region, Habitat Conservation Division
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Background/Proposed Activity (EPA, 1998)

As of 1972, dredged materials from San Francisco Bay area dredging projects were disposed of at five sites where dispersion and eventual transport to the ocean was expected. In 1975, two sites in the South Bay were de-designated because they were not dispersive, leaving the Carquinez Strait, San Pablo Bay, and Alcatraz in-Bay disposal sites. In addition to these three sites, there were two disposal sites for clean sand materials (Suisun Bay and San Francisco Bar Channel) and an ocean disposal area (B1B) located about 20 miles offshore of Half Moon Bay.

By the mid-seventies, fishing groups, fish and wildlife agencies, environmental groups, and others were raising concerns about the potential impacts of dredging and dredge disposal activities on bay and ocean habitat. The concerns included disturbance or burial of benthic organisms, reduction in fishing success due to increased turbidity, and release of contaminants bound in sediments as a result of dredging disturbance. At the same time, it was discovered that the Alcatraz disposal site was beginning to mound, suggesting that it might not be adequately dispersive. The competing needs and concerns of industry, ports, fishermen, and the environment peaked in 1989 when a flotilla of fishing boats and other vessels physically blockaded the Alcatraz disposal site for a short time.

In response to this gridlock, or "mudlock", the Corps of Engineers (COE) in 1990 initiated a long range interagency planning process for dredged material management. The resulting effort- the LTMS for San Francisco Bay Area Dredged Material- was organized to address dredging-related issues and to develop a comprehensive dredged material management plan. The proposed action evaluated in the programmatic EIS for the project is "*to select a long-term strategy that will guide the regional agencies' dredged material management decisions over the next 50 years*" (EPA, 1998, p.2-14). The action is intended to:

1. Ensure adequate, suitable disposal capacity for projected volumes of dredged material;

2. Ensure appropriate environmental protection;

3. Improve coordination and integration of agency policies governing the management of dredged material in the region;

4. Develop a regional framework to facilitate the use of dredged material for beneficial purposes; and

5. Identify appropriate funding mechanisms to address these issues and to facilitate the overall goals of the LTMS.

The LTMS will manage annual dredging and disposal of approximately 6 million cubic yards per year of sediment for fifty years in the San Francisco Bay LTMS program area. Under the preferred alternative, "Alternative 3", as described in the LTMS' January 1998 draft Environmental Impact Statement (EIS), approximately 20% of total disposal would occur at in-Bay sites, with 40% at an approved ocean disposal site, and 40% for upland/wetland reuse placement. These disposal goals would be phased in over time, since limited capacity exists for reuse today.

As identified in the EIS (p.2-16), potential impacts from disposal of material at in-Bay sites include the following:

1) Redistribution of pollutants and/or release of contaminants during dredging and disposal;

2) Burial of bottom-dwelling organisms;

3) Resuspension of sediment particles and resulting turbidity;

4) Changes in the native sediment characteristics near disposal sites and shifts in the sediment budget and/or dynamics within embayments;

5) Impacts on migrating special status species such as the winter-run chinook salmon; and

6) Degradation of pelagic and near-bottom habitat around disposal sites that may lead to reduced fishing success.

In order to maximize the benefits and minimize the potential harm from wetland habitat conversion and creation with recycled sediments, the LTMS includes the following policies (p. 2-20):

1) Proposed habitat restoration projects using dredged material should be evaluated in the context of regional habitat goals developed independently (i.e., by the San Francisco Bay Regional Water Quality Control Board, the San Francisco Estuary Institute, and the North Bay Initiative).

2) Only habitat restoration/creation projects having overall net benefits will be supported as LTMS projects.

3) Projects whose purpose is not habitat restoration or habitat creation and that would effectively result in a permanent loss of existing habitat values (such as would occur with new re-handling facilities and confined disposal facilities) must avoid adverse impacts to the maximum extent practicable, and must fully mitigate for the unavoidable adverse impacts they cause.

In order to ensure that sediments are adequately characterized before they are dredged or disposed of, the LTMS program includes the following policies (p 2-20):

1) The use of tiered sediment evaluation procedures that generate adequate and appropriate information without generating unnecessary costs;

2) The use of an evaluation approach designed to appropriately address potential contaminant exposure pathways of concern on a project-by-project or disposal-site by disposal-site basis;

3) The development of a Regional Implementation Manual (RIM) covering evaluation and testing needs in all placement environments;

4) Sediment data tracking that may allow streamlining of testing needs in the future;

5) The development of a comprehensive sediment classification framework as a basis for potential further streamlining of future testing needs;

6) Improved agency coordination through establishment of an interagency Dredged Material Management Office (DMMO) [of which NMFS is a member]; and

7) Other permit streamlining efforts.

Certain factors were not considered in detail in the programmatic EIS for the LTMS program:

1) Only general analysis of the impacts of dredging (vs. dredge disposal) was given; specific impacts of individual dredging projects are more appropriately considered at a site-specific and project-specific level;

2) Designation of any new disposal or placement sites will require site-specific environmental review;

3) The need for a particular dredging project or for specific channel depths was not evaluated on an individual project basis;

4) Site management and monitoring, an essential component of any dredged material management strategy, was considered in general terms only. The impacts characteristic for the various disposal site environments will be used to develop LTMS program guidance for site management and monitoring for specific projects.

Once the EIS is finalized, the LTMS agencies will develop an LTMS Comprehensive Management Plan that will contain the specific guidance used by each of the LTMS agencies to make decisions about dredging management activities. Specific issues to be addressed in the Comprehensive Management Plan include the following (p. 2-23 - 2-24):

1) Site monitoring and management requirements and actions for each of the existing dredged material disposal and placement sites;

2) Allowable disposal or placement volume limits, as needed for existing sites;

3) Descriptions of new site designation efforts, as appropriate;

4) Description of the coordination measures under which the LTMS agencies will jointly manage dredging project proposals;

5) Description of processes to ensure public input and review opportunities;

6) Discussion of related planning efforts such as wetlands planning, the regional monitoring program, and regional implementation manual for testing; and

7) The process for the periodic review and update of subsequent management plans and LTMS policies.

Listed Species and Critical Habitat

For general background information on the status of listed and proposed salmon and steelhead populations that may be present in the LTMS program area, please refer to Attachment 1.

Assessment of Impacts

In general, dredging and dredged material disposal may result in the following impacts to salmon and steelhead and their habitat:

1) Redistribution of pollutants and/or release of contaminants during dredging and disposal, which may result in chronic or acute toxicity impacts to salmon and steelhead, particularly those that rear for prolonged periods in affected areas.

2) Burial of bottom-dwelling organisms, which may reduce feeding opportunities for rearing juvenile salmon or juvenile/adult steelhead.

3) Resuspension of sediment particles and resulting turbidity during dredging and dredged material disposal operations, which may interfere with visual foraging, abrade gill tissues, or interfere with migration. Increased turbidity may also interfere with primary productivity by reducing rates of photosynthesis.

4) Changes in the native sediment characteristics near disposal sites and shifts in the sediment budget and/or dynamics within embayments, which may alter available food supply for rearing salmon and steelhead juveniles.

Hirsch, DiSalvo, and Peddicord (1978) reviewed a number of studies on the effects of dredging (and disposal) on aquatic organisms. These studies, which focused on worst-case experimental conditions, nonetheless in general showed a lack of effects, leading them to conclude that both direct and indirect effects of dredging are likely to be minimal. As long as dredged materials are not contaminated, their effects are typically transitory, except for coral reef communities.

Oliver et al (1977) noted two phases of succession in benthic communities after disturbance (such as dredging or burial by dredged material disposal). In the first phase, opportunistic species such as polychaetes move into a disturbed area. In the second phase, organisms surrounding the disturbed area re-colonize the affected site. Reilly et al. (1992) concluded that dredging-induced habitat alterations are minor compared to the large-scale disturbance of habitat in San Francisco Bay occurring from natural physical forces, such as seasonal and storm-generated waves.

Impacts on fish vary to some degree with life stage, life history, and other factors. Adult fish in general are expected to avoid areas of dredging or dredge disposal activity, while juvenile may be less able to leave affected areas, or may expose themselves to increased predation risk by moving out of an affected area.

Turbidity levels measured as TSS (total suspended solids) in the water column in San Francisco Bay and estuary range from as low as 10 mg/l to as high as 600 mg/l in the estuarine "null zone", with concentrations commonly between 50 and 200 mg/l (Buchanan and Schoellhamer 1995). The disposal of dredged material, or disturbance of sediments during dredging operations, may result in a temporary increase in turbidity in the local area. Much of the material settles out quickly, but finer materials may remain in the water column. During disposal operations, a more dense cloud of material may form near the bottom after dynamic collapse of released material (SAIC 1987). This near-bottom plume of highly concentrated suspended solids spreads horizontally until its momentum has dissipated.

The turbidity plume resulting from disposal typically disperses quickly, with water column turbidity levels returning to near-background levels within 15 to 20 minutes of release (Reilly et al. 1992). At a depth of 1 meter, during a disposal episode near Alcatraz, suspended sediment concentrations rose from a background concentration of 25 mg/l to a peak of 275 mg/l at about 50 meters from the release point, and then declined to near background levels by 400 meters from the release point (USACE, 1976).

In comparison, Sigler et al. (1984) exposed juvenile coho and juvenile steelhead to suspended sediment concentrations ranging from approximately 260 to 380 mg/l, for periods of up to 336 hours. Survival rates were close to 100%, although there was some reduction in growth rate for both species. Also, given the opportunity, both species would migrate to clearer water. There was no readily discernible gill damage until after at least 3 to 5 days of exposure.

Newcombe and MacDonald (1991) conducted a thorough survey of the literature on the impacts of suspended sediments to aquatic systems, with a focus on anadromous salmonids and steelhead. They concluded that concentration alone is a relatively poor indicator of impact, while concentration x duration of exposure provides a good indicator of impact. Among the research cited by the authors included Noggle (1978). Noggle (1978) found 45% reduction in feeding rate for coho salmon at 100 mg/l, and 90% reduction in feeding rate at 250 mg/l; histological damage to chinook salmon gills at concentrations of 1,547 mg/l over 96 hours, and 50% mortality of juvenile coho salmon when exposed to 1,200 mg/l over 96 hours. Lawrence and Scherer (1974) found 50% mortality of juvenile rainbow trout at concentrations of 49,000 mg/l over a duration of 96 hours.

Little direct information is available for the effects of S.F. bay and estuary turbidity or toxicity (natural or human-caused) to juvenile or adult salmon and steelhead. However, preliminary analyses of juvenile chinook salmon captured during 1995-1997 surveys conducted by the National Marine Fisheries Service Tiburon Research Laboratory (MacFarlane, pers. comm. 1998) tend to indicate the following:

1) Juvenile chinook salmon migrate 66 km from the delta to beyond the Golden Gate in about three weeks (based on otolith ring growth analysis). Limited net growth during migration through the estuary suggests that feeding and rearing activities in the estuary approximately replace energy spent to reach the ocean. Extended rearing and growth of juvenile chinook salmon in the bay and estuary has not been observed.

2) Whole body and organ concentrations of metals, PCB's, PAH's, pesticides, and other toxic materials show a slight increase as juvenile fish move from delta through the bay, but body burden levels are well below published concentration levels that would be expected to cause chronic toxicity problems. Body and organ-tissue contaminant levels seem to drop once fish leave the Bay and spend time in the Gulf of the Farallones.

A number of measures proposed by the LTMS program are intended to reduce the incidence and severity of dredging and dredge-disposal related impacts to salmon, steelhead, and their habitat over the next fifty years. First, and most importantly, the underlying objectives of the LTMS program include a large reduction in total in-bay disposal of dredged materials, increased sediment testing and restrictions on aquatic disposal of contaminated sediments, and increased creation of tidal and seasonal wetland habitat using acceptable dredged materials.

Second, Appendix J of the programmatic EIS (EPA, 1998: see Attachment 2) describes additional programmatic features that are intended to reduce potential impacts from dredging and dredge disposal to salmon and steelhead resources migrating through bay and estuary. These measures were included in the LTMS program by EPA after a series of informal consultation meetings with NMFS and the U.S. Fish and Wildlife Service from 1997 until June of 1998. Any dredging projects deviating from the conditions in these tables will not be approved by the LTMS agencies unless, through a separate section 7 consultation process, project sponsors obtain project-specific concurrence from the appropriate resource agencies.

Summary of Appendix J Mitigation Measures for Salmon and Steelhead

Dredging Activities

I. Dredging would not occur in fish migratory corridors east of Sherman Island from October 1 to May 31, when salmon and steelhead juveniles and adults would be expected to be most abundant. Any dredging during this period would require individual section 7 consultation with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service, as well as approval from the California Department of Fish and Game (CDFG).

II. Dredging in San Pablo Bay, Carquinez Strait, and Suisun Bay, including sloughs, would be generally not be permitted from January 1 to May 31, without an individual project consultation. Any dredging in these areas would also require the following:

A. Clamshell dredging shall be required whenever practicable in areas within 250 feet of a shoreline or in depths less than 20 feet.

B. If hydraulic dredging in depths less than 20 feet, dredge head must be maintained at or below substrate surface. Head may not be raised more than 3 feet off bottom for flushing; shut off pump when raising head more than 3 feet off bottom (e.g. at end of dredging).

C. For new-work projects where eelgrass will be unavoidably affected, a compensatory mitigation plan must be submitted and approved by USFWS, NMFS, CDFG, USACE (Army Corps of Engineers), and EPA prior to permitting.

D. If the project will cause unavoidable or indirect effects to submerged or emergent aquatic vegetation, compensatory mitigation at 3:1 ratio is required for lost functions and values. Other proposed mitigation ratios would require consultation with USFWS and CDFG.

E. Best management practices to reduce turbidity (including silt curtains or other physical or operational measures) shall be required for these projects.

III. Dredging in the Napa River, Petaluma River, and Sonoma Creek would generally not be permitted from October 15 to July 31. Any dredging during this period would require individual section 7 consultation with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service, as well as approval from the California Department of Fish and Game (CDFG).

IV. Dredging in Central San Francisco Bay would generally not be permitted from December 1 to May 31. Any dredging during this period would require individual section 7 consultation with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service, as well as approval from the California Department of Fish and Game (CDFG). In addition, conditions A through E (see section II., above) would also apply.

Disposal Activities

I. Disposal at the Suisun Bay Disposal Site (SF-8) and the Carquinez Strait Disposal Site (SF-9) would be minimized to the extent possible from January 1 to May 31.

II. Disposal at the San Pablo Bay Disposal Site (SF-10) and the Alcatraz Disposal Site (SF-11) would be minimized to the extent possible from January 1 to October 31.

III. Disposal in the fish migratory corridors east of Sherman Island would be restricted to the extent feasible during October 1 to May 31. Best management practices to reduce turbidity (including silt curtains or other physical or operational measures) shall be required for these projects.

Cumulative Effects Virtually all actions affecting salmonids or their habitat that are reasonably certain to occur in the action area during the term of this biological opinion are subject to federal section 7 consultation. New dredging, filling, dock construction, and shoreline repair actions would be subject to section 7 before issuance of a Corps of Engineers Section 404 permit under the Clean Water Act. New point discharges would be subject to regulation under the EPA's NPDES permit program, and would also be subject to section 7 consultation.

New, non-federal actions which are reasonably certain to occur in the action area during the term of this biological opinion, and which do not fall under section 7 consultation through either EPA or the Corps of Engineers include small-scale modifications to local infrastructure, including new housing developments, changes to existing local water project operations, and changes to sewage treatment operations. None of these actions are expected to result in significant adverse effects to listed or proposed salmonid species. Nor are these actions expected to add significantly to the existing environmental baseline.

Conclusion

Based on the best available information and the analysis in this opinion, NMFS concludes that implementation of the LTMS program for the placement of dredged material in the San Francisco Bay Region is not likely to jeopardize the continued existence of any listed or proposed salmonid ESU's (evolutionarily significant units), including the Sacramento River winter-run chinook salmon (endangered), the Central Valley steelhead (threatened), the Central California Coast steelhead (threatened), the Central California Coast coho (threatened), Central Valley spring-run chinook salmon (proposed-endangered), Central Valley fall/late-fall run chinook salmon (proposed- threatened), and Southern Oregon/California Coastal chinook salmon (proposed-threatened). Implementation of the LTMS program is also not expected to result in the destruction or adverse modification of winter-run critical habitat, or other proposed critical habitats. (Critical habitat has not yet been designated for any of the other listed or proposed salmonids in California.)

Dredging and disposal activities in the bay and estuary will be timed to avoid periods when salmon and steelhead are likely to be in the project areas to the extent practicable, as per Appendix J. Even if salmon and steelhead are present in project areas, in most cases the turbidity levels generated are likely to be low enough in concentration and short enough in duration to avoid significant effects on fish health, foraging ability, or migration. In open areas such as San Francisco and San Pablo Bay, it is likely that salmon and steelhead will avoid active dredging and disposal areas and utilize other similar areas nearby.

Available information on toxins indicate that body burdens of juvenile salmon and steelhead in the bay and estuary are below levels that would cause concern for chronic toxicity impacts, even under the existing dredging and disposal regime. Objectives of the LTMS program should tighten control of sediments that are disturbed by dredging or authorized for aquatic disposal. In-water disposal would only be authorized for sediments that meet reference standards designed to protect biological resources, including bioassay and chemical concentration standards. Increased use of the ocean disposal site and increased use of dredged materials for habitat creation should also reduce any impacts of aquatic disposal over the long-term.

Dredging in areas with depths less than 20 feet may pose an entrainment risk to smaller salmon and steelhead juveniles. However, the use of seasonal windows to avoid dredging during periods when smaller juveniles are present, and the restrictions on the operation of suction dredge cutter heads (as per Appendix J) should effectively minimize the risk of incidental entrainment.

Although increased use of the ocean disposal site may increase impacts to the ocean environment, available information indicates that habitat similar to that found at the S.F. Bay Deep Ocean Disposal Site (DODS) is not currently limiting salmon production or survival. Therefore, salmon and steelhead are not expected to be significantly affected by use of the DODS site.

New dredging projects in shallow water areas have the potential to reduce available shallow water rearing habitat. However, as described in the program EIS, the need for individual new projects would have to be evaluated separately, prior to approval for inclusion in the LTMS program. Therefore, new dredging projects would be subject to individual section 7 consultation. On balance, it is likely that the LTMS program will facilitate the restoration and creation of new shallow water rearing habitat through the beneficial reuse of dredged materials.

Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. These "conservation recommendations" include discretionary measures that EPA can take to minimize or avoid adverse effects of a proposed action on a listed species or critical habitat or regarding the development of information. In addition to the terms and conditions in of the Incidental Take Statement, NMFS provides the following conservation recommendations that would reduce or avoid adverse impacts to salmon and steelhead:

(1) EPA and/or the USACE should conduct monitoring studies to evaluate the potential effects of dredging and dredged material disposal on salmon and steelhead, and their bay, estuary, and ocean habitats. These studies may be conducted in cooperation with other research efforts, such as studies being performed by the Interagency Ecological Program (IEP), the Cal-Fed Bay-Delta monitoring and research program, the San Francisco Estuary Project, or NMFS Tiburon Lab juvenile salmon migration research.

(2) EPA and/or the USACE should consider juvenile salmon and steelhead rearing habitat requirements when considering habitat creation options available through the beneficial reuse of dredged materials. In particular, tidal wetland habitat may provide an important food supply and rearing area for juvenile salmonids.

Reinitiation of Consultation

Reinitiation of formal consultation is required if (1) the amount or extent of incidental taking in any incidental take statement is exceeded; (2) new information reveals effects of the action may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

Incidental Take Statement

Section 7(b)(4) of the ESA provides for the issuance of an incidental take statement for the agency action if the biological opinion concludes that the proposed action is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. In such a situation, NMFS will issue an incidental take statement specifying the impact of any incidental taking of endangered or threatened species, providing for reasonable and prudent measures that are necessary to minimize impacts, and setting forth the terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures. Incidental takings resulting from the agency action, including incidental takings caused by activities authorized by the agency, are authorized under the incidental take statement only if those takings are in compliance with the specified terms and conditions.

This statement authorizes minimal incidental take of winter-run chinook salmon, Central California coast coho, and Central California coast steelhead. No specific quantity of incidental take is specified, since the amount of incidental taking can neither be predicted in advance, nor measured after it occurs. However, it is expected that incidental take, if any, should be minimal- perhaps no more than a few hundred juveniles per year, for all listed and unlisted salmonid ESU's.

Reasonable and Prudent Measures

(1) EPA will actively manage the LTMS program along with the other LTMS program agencies to minimize impacts to salmon, steelhead, and their habitat. Active management shall include implementation of all proposed mitigation and seasonal windows; annual compilation and reporting of the annual, cumulative effects of the LTMS program; and development and implementation of in-bay disposal reduction goals.

Terms and Conditions

The *de minimis* level of incidental take identified above is authorized provided that EPA ensures that it and the other LTMS agencies comply with the following terms and conditions, which are non-discretionary:

(1) EPA will actively manage the LTMS program along with the other LTMS program agencies to minimize impacts to salmon, steelhead, and their habitat. Active management shall include implementation of all proposed mitigation and seasonal windows; annual compilation and reporting of the annual, cumulative effects of the LTMS program; and development and implementation of in-bay disposal reduction goals.

(a) All projects shall adhere to the mitigation and seasonal window requirements described in Appendix J of the EIS. Any deviations from these requirements cannot occur without the prior notification and approval of NMFS. NMFS-approved deviations should be reflected in subsequent LTMS Management Plan revisions.

(b) NMFS will be given an annual report summarizing all permitted dredging and dredge disposal activities evaluated by DMMO and permitted by any of the LTMS agencies. This report shall include the locations, volumes, and timing of all permitted dredging and dredge disposal events, and summary information on sediment composition (including sediment contaminant and bioassay information). This report may be provided in electronic database or GIS format, or other formats that facilitate comprehensive analysis and management review. DMMO annual reports may fulfill this requirement provided they include the information listed above.

(c) NMFS will have standing membership on the DMMO (Dredged Materials Management Office), and shall be given the opportunity to provide input on sediment testing guidelines and aquatic disposal requirements, as new information on sediment impacts to fisheries is developed.

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Attachment 1

I. Species Life History, Biological Requirements, and Population Trends

A. Chinook Salmon

General life history information for chinook salmon (*Oncorhynchus tshawytscha*) is summarized below. Further detailed information on chinook salmon ESUs are available in the NMFS listing of winter-run chinook as threatened under emergency provisions of the ESA (54 FR 32085), the NMFS formal listing of the winter-run chinook salmon (55 FR 46515), the NMFS reclassification of the winter-run chinook as an endangered species (59 FR 440), the NMFS status review of chinook salmon from Washington, Idaho, Oregon, and California (Myers et al. 1998), and the NMFS proposed rule for listing several ESUs of chinook salmon (63 FR 11482).

Adult freshwater migration and spawning.

Spring-run chinook salmon typically migrate upstream between March and July. This run timing was adapted for gaining access to the upper reaches of river systems, 1,500 to 5,200 feet in elevation, prior to the onset of high water temperatures and low flows that would inhibit access to these areas during the fall. Spawning typically occurs between late-August and early October with a peak in September.

Fall-run-chinook salmon upstream migration occurs from June through December with a peak in September and October. Spawning occurs from late-September through December with a peak in late-October. Fall-run chinook salmon typically spawn in the lower reaches of rivers and tributaries at elevations of 200 to 1000 feet.

Central Valley late fall-run chinook salmon upstream migrations occur between October and April with a peak in December. Spawning occurs January through early-April with a peak in early-February. Late-fall-run chinook salmon tend to spawn in the upper mainstem of rivers at elevations of 1000 to 2000 feet.

Sacramento River winter-run chinook salmon upstream migration occurs between December and July. On the upper Sacramento River, the first upstream migrants appear during December (Vogel and Marine 1991). The upstream migration of winter-run chinook typically peaks during the month of March, but may vary with river flow, water-year type, and operation of Red Bluff Diversion Dam. Keswick Dam completely blocks any further upstream migration, forcing adults to migrate to and hold in deep pools downstream, before initiating spawning activities.

Since the construction of Shasta and Keswick Dam, winter-run chinook spawning has primarily occurred between Red Bluff Diversion Dam and Keswick Dam. The spawning period of winter-run chinook generally extends from mid-April to mid-August with peak activity occurring in June (Vogel and Marine 1991). Aerial surveys of spawning redds have been conducted annually by CDFG since 1987. Survey results have shown that the majority of winter-run chinook spawning occurs between the upper Anderson Bridge at RM 284 and the Anderson-Cottonwood Irrigation District (ACID) dam at RM 298. Winter-run chinook may also spawn below Red Bluff (RM 245) in some years. In 1988, for example, winter-run chinook redds were observed as far downstream as Woodson Bridge (RM 218).

Juvenile rearing and outmigration. Pre-emergent fry remain in the redd and absorb the yolk stored in their yolk-sac as they grow into fry. This period of larval incubation lasts approximately 6 to 8 weeks depending on water temperatures. Emergence of spring-run chinook salmon occurs from November through March. Emergence of fall and late-fall-run chinook salmon occurs between December and June. Winter-run chinook salmon in the Sacramento River typically emerge from July through October.

Emergence typically occurs at night. At the time of emergence from the redd, there is usually an extensive downstream dispersal of fry, although some fry are able to remain within the natal stream and even at the spawning area. For populations that spawn near tidal areas, this downstream migration may take the fry directly to estuarine rearing areas. In other populations, this migration serves to disperse the fry to suitable freshwater rearing habitat. In the first spring, there appears to be a second dispersal which carries some populations to the sea or redistributes the population in the freshwater river system. For populations that migrate to the sea as yearlings, there may be a third redistribution in the fall to suitable over-wintering habitat (usually from the tributaries to the mainstem). And then finally in the next spring there is a migration of yearling smolts to the sea. In ocean type populations this journey to the sea usually occurs several months after emergence (Healey in Groot C. 1991).

Downstream movement of fry occurs mainly at night, although small numbers of fry move during daylight hours. Night downstream movement is inhibited by bright moonlight (Reimers 1971). Once downstream migration has begun, chinook fry continue to migrate down towards the estuary or they may stop and take up residence in the stream for a few weeks or even up to a year or more. The fry seek out shallow, nearshore areas with slow current and good cover, and begin feeding on small terrestrial and aquatic insects and aquatic crustaceans. As they grow to 50 to 75 mm in length, the juvenile salmon move out into deeper, swifter water, but continue to use available cover to minimize the risk of predation and reduce energy expenditure.

The emigration of juvenile chinook may be dependent on streamflow conditions and water year type. Once fry have emerged, storm events may cause en masse emigration pulses.

Downstream migration may also be stimulated by inter-specific conflicts. Reimers (1968) observed lateral displays, chasing, fighting, fleeing, and submission among juvenile fall-run chinook salmon. This agonistic behavior of a few dominant fish seemed to stimulate the downstream movement of subordinate fish. If available freshwater rearing area is limiting, these subordinate fry may be displaced all the way down river into the estuaries.

Intraspecific interactions may also stimulate downstream migration of juvenile chinook. Stein (1972) observed that juvenile coho were apparently dominant over juvenile chinook instream tanks, though this hierarchy may have more to do with emergence timing, size and habitat preference at interaction. Everest and Chapman (1972) found that underyearling chinook in summer occupied habitats of all substrate types, at all depths, and in water of all velocities up to 1.2 meters-per-second. The chinook were larger than the coho and steelhead due to an earlier emergence time. There was little evidence of competition between species and this may have been a result of differing habitat preferences at the time of interaction. Whatever the causes of chinook fry downstream migration, it is probably a dispersal mechanism that helps distribute the fry among suitable rearing habitats.

In large rivers, fry tend to migrate along the margins of the river rather than in the higher velocity water near the center of the channel. When the river is deeper than about 3 meters, they tend to prefer the surface waters (Healey and Jordan 1982). The fry inhabit areas in back eddies, behind fallen trees, undercut tree roots, and other areas of bank cover. As they grow larger, the juveniles tend to move away from shore into midstream and higher velocity areas. Fish size appears to be positively correlated with water velocity and depth (Chapman and Bjornn 1969, Everest and Chapman 1972).

Day and night distributions of chinook juveniles are different. At night, chinook tended towards inshore areas of quiet water over sandy substrates or into pools, where they would settle at the bottom. During daylight hours, the chinook would return to occupy the same riffle or glide areas they had occupied the previous day (Edmundson et al. 1968, Don Chapman Consultants 1989).

With the approach of winter, chinook tend to relocate downstream or move from tributaries into a river mainstem (Bell 1958, Chapman and Bjornn 1969). Fingerling migrants, juveniles ranging from 50 to 120 mm in forklength, migrate at night and appear to prefer the shoreline, though some studies have found fingerlings in the center, higher velocity portions of the river (Healey and Jordan 1982).

Estuaries provide important rearing habitat for recently emerged fry. Recently emerged fry are known to rear in the Sacramento River estuary. The peak of fry arrival in the Sacramento-San Joaquin Delta is January through March. These fish tend to rear in the upper delta area for about two months (Kjelson et al. 1981, 1982) Chinook fry will typically rear where the salinity is up to 15 to 20 parts-per-million (Healey 1980, 1982, Levings et al. 1986). In an estuarine environment, juvenile chinook salmon forage in intertidal and shallow subtidal areas, such as marshes, mudflats, channels, and sloughs. These habitats provide protective cover and a rich food supply (McDonald 1960, Dunford

1975). The distribution of the juvenile fish appears to change tidally in an estuarine environment. Juvenile chinook have been observed moving with the flood tide from deeper tidal channels into the tidally flooded nearshore areas for feeding (Healey 1991, Levy and Northcote 1981, Levings 1982). With the receding tide these juveniles retreat back into tidal channels. Large fry and smolts tend to congregate in the surface waters of main and subsidiary sloughs and channels, moving into shallow subtidal areas only to feed (Allen and Hassler 1986). Fry and fingerling distribution in the estuary may also change from day to night. Kjelson et al. (1982) reported that fry concentrated in nearshore areas during the day, but moved offshore at night. Larger fish tended to be further offshore than fry. At night, fry were randomly distributed throughout the water column, but were concentrated in the upper three meters of the water column during the day.

Principal foods of chinook while rearing in freshwater and estuarine environments are larval and adult insects and zooplankton such as Cladocerans, Diptera, or Copepoda (Kjelson et al. 1982) of stonefly nymphs or beetle larvae (Chapman and Quistdorff 1938) as well as other estuarine and freshwater invertebrates. Chinook seem to prefer slightly larger organisms and larval and adult insects than other Pacific salmon in the intertidal region of most estuaries.

Juvenile chinook spend three months to two years in freshwater after emergence and before undergoing smoltification.

California chinook salmon are primarily 'ocean-type' and tend to use estuaries and coastal areas more extensively than stream-type chinook for rearing. The brackish water areas in estuaries moderate the physiological stress that occurs during parr-smolt transitions. Winter-run chinook salmon typically migrate to the sea after 5 to 10 months of freshwater residence. Spring-run chinook salmon typically emigrate as fry, sub-yearlings, and yearlings (three to 15 months freshwater residence). Fall and late-fall-run chinook salmon tend to emigrate as fry and sub-yearlings (four to seven months of freshwater residence for fall-run and seven to 13 months of freshwater residence for late-fall run).

Fry tend to remain in estuarine area until they are about 70 mm in fork length (FL). Ocean entry timing data available for the Central Valley indicate that spring-run chinook salmon emigrate to the ocean from early November through June, though this period is likely divided between fry and yearlings. Fall-run chinook salmon emigrate from March through July. Late fall-run chinook salmon emigrate from October through May, and winter-run chinook salmon emigrate from November through May (Myers et al. 1998).

Ocean Migration. Chinook salmon typically remain at sea for two to four years. California chinook salmon are 'ocean-type' and migrate along the coast. Available information on California chinook salmon populations indicates that the fish tend to stay along the California and Oregon coasts.

Biological Requirements. Adult winter-run chinook salmon require water temperatures between 57° and 67° F during upstream migration. When the adults reach spawning areas, they need cold pools to stage in prior to spawning to conserve energy and maintain egg viability as they mature for spawning (Berman and Quinn 1991). Maximum temperatures for holding adults are 59° to 60° F but better egg viability is achieved at 55° to 56° F (Boles 1988).

Chinook salmon spawning generally occurs in swift, relatively shallow riffles or along the edges of fast runs at depths greater than 6 inches, usually 1-3 feet to 10-15 feet. Preferred spawning substrate is clean loose gravel, mostly 0.75-4.0 inch diameter, with no more than 5% fines. Gravels are unsuitable when they have been cemented with clay or fines or when sediments settle out onto redds reducing intergravel percolation (NMFS 1997). Optimum spawning velocity is 1.5 feet-per-second (fps) but can range from 0.33 - 6.2 fps (Healey 1991). Minimum intra-gravel percolation rate depends on flow rate, water depth, and water quality. The rate must be adequate to maintain oxygen delivery to the eggs and remove metabolic wastes. Chinook have the largest egg size of the *Oncorhynchus* species and therefore their eggs have a small surface-to-volume ratio (Rounsefell 1957). Chinook eggs are more sensitive to reduced oxygen levels and require a more certain rate of irrigation. The chinook's need for a strong, certain level of subsurface flow may indicate that suitable spawning habitat is more limited in most rivers than superficial observation would suggest. Chinook forced to spawn in areas of low suitability will suffer high rates of egg mortality.

Chinook salmon eggs hatch, depending on water temperatures, between 90 and 150 days after deposition. Winter-run chinook salmon eggs hatch after 40 to 60 days depending on ambient water temperatures. Stream flow, gravel quality, and silt load all influence the survival of the eggs. Maximum survival of incubating eggs and pre-emergent fry occurs at water temperatures between 42° F and 56° F with a preferred temperature of 52° F. Mortality of eggs and pre-emergent fry commences at 57.5° F and reaches 100 percent at 62° F (Boles 1988). Other potential sources of mortality during the incubation period include redd dewatering, insufficient oxygenation, physical disturbance from predators or floods, and water-borne contaminants.

After emergence, most fry disperse downstream, hiding in the gravel or stationing in calm, shallow waters with fine sediments substrate and bank cover such as tree roots, logs, and submerged or overhead vegetation. As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Optimal temperature ranges for both fry and fingerlings range from 53.6° to 57.2° F with maximum growth rates at 55° F (Boles 1988). Along the emigration route, submerged and overhead cover in the form of rocks, submerged aquatic vegetation, logs, riparian vegetation, and undercut banks provide food, shade and protect juveniles from predation.

Optimal water temperatures for the growth of juvenile chinook salmon in an estuary are 54-57° F (Brett 1952). In Suisun and San Pablo Bays water temperatures reach 54° F by February in most years. Other Delta waters do not reach 54° F until March. The specific cues that trigger juvenile chinook salmon to migrate from the Sacramento-San Joaquin Estuary are not well understood, but water temperatures of 59° F and higher have been observed to induce migration in Northwest estuaries (Dunford 1975, Reimers 1973: cited from Cannon 1981).

1. Sacramento River winter-run chinook salmon - Endangered

The Sacramento River winter-run chinook salmon is a unique population of chinook salmon in the Sacramento River. It is distinguishable from the other three Sacramento River chinook runs by the timing of its upstream migration and spawning season.

Prior to construction of Shasta and Keswick dams in 1945 and 1950, respectively, winter-run chinook were reported to spawn in the upper reaches of the Little Sacramento, McCloud, and lower Pit rivers (Moyle et al. 1989). Specific data relative to the historic run sizes of winter-run chinook prior to 1967 are sparse and anecdotal. Numerous fishery researchers have cited Slater (1963) to indicate that the winter-run chinook population may have been fairly small and limited to the spring-fed areas of the McCloud River before the construction of Shasta Dam. However, recent DFG research in California State Archives has cited several fisheries chronicles that indicate the winter-run chinook population may have been much larger than previously thought. According to these qualitative and anecdotal accounts, winter-run chinook reproduced in the McCloud, Pit and Little Sacramento rivers and may have numbered over 200,000 (Rectenwald 1989).

Completion of the Red Bluff Diversion Dam in 1966 enabled accurate estimates of all salmon runs to the upper Sacramento River based on fish counts at the fish ladders. These annual fish counts document the dramatic decline of the winter-run chinook population. The estimated number of winter-run chinook passing the dam from 1967 to 1969 averaged 86,509. During 1990, 1991, 1992, 1993, 1994, 1995, 1996, and 1997 the spawning escapement of winter-run chinook past the dam was estimated at 441, 191, 1180, 341, 189, 1361, 940, and 841 adults (including jacks), respectively.

2. Central Valley ESU spring-run chinook salmon - Proposed-as-Endangered

Historically, spring-run chinook salmon were the dominant run in the Sacramento and San Joaquin River Basins (Clark 1929). Native populations in the San Joaquin River and its tributaries have apparently all been extirpated. The only streams considered to have wild spring-run chinook salmon production are Mill and Deer Creeks, and possibly Butte Creek, all east-side tributaries to the Sacramento River. These populations are relatively small with sharply declining trends.

Spring-run chinook salmon cannot access most of their historical spawning and rearing habitats in the Sacramento and San Joaquin River Basins due to impassable dams. Spawning is now restricted to the mainstem Sacramento River and the few tributaries mentioned above. The remaining spawning and rearing habitat is severely degraded by elevated water temperatures, agricultural and municipal diversions, most of which are unscreened, restricted and regulated flows, levee and bank stabilization, and poor quality and quantity of riparian and shaded riverine aquatic habitat.

There are also serious threats to the genetic integrity of this ESU posed by hatchery programs. Most of the spring-run production in this ESU is of hatchery origin, and naturally spawning populations may be inter-breeding with both fall/late-fall-run and spring-run chinook hatchery stock.

3. Central Valley ESU fall/late fall-run chinook salmon - Proposed-as-Threatened

The total population abundance within this ESU is relatively high. However, the abundance of natural fall-run chinook salmon in the San Joaquin River Basin is low.

Habitat blockage for the fall and late fall-run chinook salmon in this ESU is not as serious as the blockages to winter- and spring-run chinook salmon because fall- and late fall-run chinook salmon tend to spawn at lower elevations than the other runs and much of this area is still accessible below the large, impassable dams that block winter- and spring-run chinook salmon. However, the remaining habitat used by the fall- and late fall-run chinook is severely degraded by elevated water temperatures, agricultural and municipal diversions, most of which are unscreened, restricted and regulated flows, levee and bank stabilization, and poor quality and quantity of riparian and shaded riverine aquatic habitat. Recent ocean and freshwater harvest rates may be unsustainable for the natural population given the current natural production levels under present habitat conditions.

Hatchery programs are also affecting this ESU. High straying rates, due to off-site release of hatchery fish, result in a high proportion of hatchery fish present within the naturally-spawning population. Also, high rates of hatchery fish production make assessments of the status of natural production difficult.

4. Southern Oregon and California Coastal ESU chinook salmon - Proposed-as-Threatened

This ESU includes chinook populations from the Elk River in Oregon south to the northern cape forming San Francisco Bay. Spawning abundance within this ESU is highly variable between populations. The fall-run chinook populations in California and the spring-run chinook salmon populations throughout the ESU are of particular concern. Little to no information is available for most of the river systems in the southern portions of the ESU. This lack of population monitoring leads to a high degree of uncertainty regarding the status of most of the California populations in the ESU.

Habitat loss and degradation are prevalent throughout this ESU. Habitat blockages, logging activities, agricultural activities, gravel mining, bank stabilization, urbanization, and water withdrawals are among the most serious of the problems facing these chinook populations.

Current hatchery contribution to this ESU is low overall, however, the Chetco and Eel River Basins and Redwood Creek have received substantial hatchery releases of primarily local stocks.

B. Coho Salmon

General life history information for coho salmon (*Oncorhynchus kisutch*) is summarized below, followed by information on population trends for each coho salmon ESU. Further detailed information on these coho salmon ESUs are available in the NMFS Status Review of coho salmon from Washington, Oregon, and California (Weitkamp et al. 1995), the NMFS proposed rule for listing coho (50 FR 38011), and the NMFS final listings for the Central California Coast coho ESU (61 FR 56138) and the Southern Oregon/Northern California Coast coho ESU(62 FR 24588).

Adult freshwater migration and spawning. Most coho salmon adults are 3-year-olds, having spent approximately 18 months in freshwater and 18 months in salt water (Gilbert 1912; Pritchard 1940; Briggs 1953; Shapovalov and Taft 1954; Loeffel and Wendler 1968). The primary exception to this pattern are 'jacks', which are sexually mature males that return to freshwater to spawn after only 5-7 months in the ocean.

Most west coast coho salmon enter rivers in October and spawn from November to December and occasionally into January. However, both run and spawn-timing of Central California coho salmon are very late (peaking in January) with little time spent in freshwater between river entry and spawning. This compressed adult freshwater residency appears to coincide with the single, brief peak of river flow characteristic of this area. Many small California systems have sandbars which block their mouths for most of the year except during winter. In these systems, coho salmon and other salmon species are unable to enter the rivers until sufficiently strong freshets break the sandbars (Sandercock 1991).

While central California coho spend little time between river entry and spawning, northern stocks may spend 1 or 2 months in fresh water before spawning (Flint and Zillges 1980, Fraser et al. 1983). In larger river systems like the Klamath River, coho salmon have a broad period of freshwater entry spanning from August until December (Leidy and Leidy 1984). In general, earlier migrating fish spawn farther upstream within a basin than later migrating fish, which enter rivers in a more advanced state of sexual maturity (Sandercock 1991).

Juvenile rearing and outmigration. Coho salmon fry usually emerge from the gravel at night from March to May. Coho salmon fry begin feeding as soon as they emerge from the gravel, and grow rapidly. In California, fry move into deep pools in July and August, where feeding is reduced and growth rate decreased (Shapovalov and Taft 1954). In smaller California streams, the water levels may drop so low during the summer that the pools are the only viable rearing habitat. No passage between pools can occur until river levels rise with the onset of the rainy season. Therefore, juvenile salmonids rearing in isolated summer pools are extremely vulnerable to disturbance or water quality impacts. Daytime temperatures in summer rearing pools may also be near lethal levels; riparian shading and the presence of sub-surface, cold water seeps are often essential to maintain pool temperatures at tolerable levels. Between December and February, winter rains result in increased stream flows and by March, following peak flows, fish feed heavily again on insects and crustaceans and grow rapidly.

The fry inhabit areas in back eddies, behind fallen trees, undercut tree roots, and other areas of bank cover. As they grow larger, the juveniles tend to move away from shore into mid-stream and higher velocity areas.

Peak outmigration timing generally occurs in May, about a year after they emerge from the gravel. In California, smolts migrate to the ocean somewhat earlier, from mid-April to mid-May. Most smolts measure 90-115 mm, although Klamath River Basin smolts tend to be larger, but this is possibly due to influences of off-station hatchery plants.

Ocean Migration. After entering the ocean, immature coho salmon initially remain in near-shore waters close to the parent stream. In general, coded-wire tag (CWT) recoveries indicate that coho salmon remain closer to their river of origin than do chinook salmon, but coho may nevertheless travel several hundred miles (Hassler 1987).

Biological Requirements.
Adult coho salmon normally migrate when water temperatures are 44.96° to 60.08° F, minimum water depth is seven inches and streamflow velocity does not exceed 2.44 m/s (Reiser and Bjornn 1979). If the conditions are not right, coho will wait at the mouth of the river or stream for the correct conditions. Most coho stocks migrate upstream during daylight hours

Coho can be found in almost all coastal streams, large rivers and tributaries. Generally, the coho build their redds at the head of riffles where there is good intra-gravel flow and oxygenation. Gribanov (1948) found that the coho appear to favor areas where the stream velocity is 0.30 to 0.55 m/s. Water quality can be clear or heavily silted with varying substrate of fine gravel to coarse rubble. California coho spawn in water temps of 42.08° to 55.94° F (Briggs 1953) with an optimum range of 39.2° to 51.8° F (Davidson and Hutchison 1938).

Coho salmon eggs hatch in approximately 38 days at 51.26° F, however, this duration may change depending on ambient water temperatures (Shopovalov and Taft 1954). Young fry hide in gravel and under large rocks during daylight hours. After several days growth, they move closer to the banks seeking out quiet backwaters, undercut banks, side channels, and small creeks, especially those with overhanging riparian Gribanov (1948). As they grow they move into areas with less cover and higher velocity flows (Lester and Genoe 1970). Most fry move out of the system with winter and early spring freshets; however, some level of emigration may occur all year long. Brett (1952) found that coho salmon juveniles had an upper lethal temperature of 77° F with a preferred rearing and emigration range of 53.6° to 57.2° F. Taking advantage of cooler ambient temperatures and the afforded protection from predators, the bulk of seaward migration occurs at night.

1. Southern Oregon/Northern California Coast coho salmon ESU - Threatened (note- this ESU is not expected to be present in the LTMS project area- either in-bay or near the ocean disposal site.)

Recently, most coho salmon production in the Oregon portion of this ESU has been in the Rogue River. Recent run-size estimates (1979-1986) have ranged from about 800 to 19,800 naturally-produced adults, and from 500 to 8,300 hatchery-produced adults (Cramer 1994). Average annual run sizes for this period were 4,900 natural and 3,900 hatchery fish, with the total run averaging 45 percent hatchery fish. Adult passage counts at Gold Ray dam provide a long-term view of coho salmon abundance in the upper Rogue River (Cramer et al. 1985). In the 1940s, passage counts averaged about 2,000 adults per year. Numbers declined and fluctuated during the 1950s and early 1960s, then stabilized at an average of fewer than 200 adults during the late 1960s and early 1970s. In the late 1970s, the run increased with returning fish produced at Cole Rivers Hatchery. The remaining data is angler catch, which has ranged from less than 50 during the late 1970s to a peak of about 800 in 1991. Average annual catch over the least 10 years has been about 500 fish.

In the northern California region of this ESU, CDFG reported that coho salmon including hatchery stocks could be less than 6 percent of their abundance during the 1940s and have experienced at least a 70 percent decline in numbers since the 1960s (CDFG 1994). The Klamath River Basin (including the Trinity River) historically supported abundant coho salmon runs. In both systems, runs have greatly diminished and are now composed largely of hatchery fish, although small wild runs may remain in some tributaries (CDFG 1994).

Of 396 streams within the range of this ESU identified as once having coho salmon runs, recent survey information is available for 117 streams (30 percent) (Brown et al. 1994). Of these 117 streams, 73 (64 percent) still support coho salmon runs while 42 (36 percent) have lost their coho salmon runs.

The rivers and tributaries in the California portion of this ESU were estimated to have average recent runs of 7,080 natural spawners and 17,156 hatchery returns, with 4,480 identified as native fish occurring in tributaries having little history of supplementation with non-native fish.

Combining recent run-size estimates for the California portion of this ESU with the Rogue River estimates provides a run-size estimate for the entire ESU of about 12,000 natural fish and 21,000 hatchery fish.

2. Central California coho ESU - Threatened

To examine recent spawner abundance, Brown and Moyle relied on a "20-fish rule". This "rule" is as follows: if a stream with historic accounts of coho salmon lacked recent data, it was assumed to still support a run of 20 adults; if coho salmon were present in recent stream surveys, they used 20 adults or the most recent run estimate, whichever was larger. While these estimates are crude, they are the best data available in most cases and are generally comparable with other estimates (Bryant 1994; CDFG 1994; Maahs and Gilleard 1994).

Statewide (including areas outside this ESU) coho salmon spawning escapement in California apparently ranged between 200,000 to 500,000 adults per year in the 1940s (Brown et al. 1994). By the mid-1960s, statewide spawning escapement was estimated to have fallen to about 100,000 fish per year (CDFG 1965, California Advisory Committee on Salmon and Steelhead Trout 1988), followed by a further decline to about 30,000 fish in the mid-1980s (Wahle and Pearson 1987; Brown et al. 1994). From 1987 to 1991, spawning escapement averaged about 31,000 with hatchery populations composing 57% of this total (Brown et al. 1994). Brown et al. (1994) estimated that there are probably less than 5,000 naturally-spawning coho salmon spawning in California each year, and many of these fish are in populations that contain less than 100 individuals.

Estimated average coho salmon spawning escapement in the central California ESU for the period from the early 1980s through 1991 was 6,160 naturally spawning coho salmon and 332 hatchery spawned coho salmon (Brown et al. 1994). Of the naturally-spawning coho salmon, 3,880 were from the tributaries in which supplementation occurs (the Noyo River and coastal streams south of San Francisco). Only 160 fish in the range of this ESU (all in the Ten Mile River) were identified as "native" fish, lacking a history of supplementation with the non-native hatchery stocks. Based on redd counts, the estimated run of coho salmon in the Ten Mile River was 14 to 42 fish during the 1991-1992 spawning season (Maahs and Gilleard 1994).

Of 186 streams in the range of the central California ESU identified as having historic accounts of adult coho salmon, recent data exist for 133 (72 percent). Of these 133 streams, 62 (47 percent) have recent records of occurrence of adult coho salmon and 71 (53 percent) no longer maintain coho salmon spawning runs. In addition to their occurrence in coastal streams, coho have been reported to occur in Mill Valley and Corte Madera creeks, tributaries to San Francisco Bay (61 FR 56138).

C. Steelhead Trout

General life history information for steelhead (*Oncorhynchus mykiss*) is summarized below, followed by more detailed information on each steelhead ESU, including any unique life history traits as well as their population trends. Further detailed information on these steelhead ESUs are available in the NMFS Status Review of west coast steelhead from Washington, Idaho Oregon, and California (Busby et al. 1996), the NMFS proposed rule for listing steelhead (61 FR 41541), the NMFS Status Review for Klamath Mountains Province Steelhead (Busby et al. 1994), and the NMFS final rule listing the Southern California Coast steelhead ESU, South Central California Coast steelhead ESU, and the Central California Coast steelhead ESU (62 FR 43937).

Adult freshwater migration and spawning. The most widespread run type of steelhead is the winter (ocean-maturing) steelhead, while summer (stream-maturing) steelhead (including spring and fall steelhead in southern Oregon and northern California) are less common. There is a high degree of overlap in spawn timing between populations, regardless of run-type. California steelhead generally spawn earlier than steelhead in northern areas. Both summer and winter steelhead in California generally begin spawning in December, whereas most populations in Washington begin spawning in February or March. Among inland steelhead populations, Columbia River populations from tributaries upstream of the Yakima River spawn later than most downstream populations.

The stream-maturing type enters fresh water in a sexually immature condition and requires several months in freshwater to mature and spawn. The ocean-maturing type enters fresh water with well-developed gonads and spawns shortly thereafter (Barnhart 1986).

Steelhead may spawn more than once before dying, in contrast to other species of the *Oncorhynchus* genus. It is relatively uncommon for steelhead populations north of Oregon to have repeat spawning, and more than two spawning migrations is rare. In Oregon and California, the frequency of two spawning migrations is higher, but more than two is unusual.

Juvenile rearing and outmigration. Juvenile steelhead live in freshwater between one and four years (usually one to two years in the Pacific Southwest) and then become smolts and migrate to the sea from November through May with peaks in March, April, and May. The smolts can range from 14 to 21 cm in length. Steelhead spend between one and four years in the ocean (usually two years in the Pacific Southwest) (Barnhart 1986). Fish size appears to be positively correlated with water velocity and depth (Chapman and Bjornn 1969, Everest and Chapman 1972).

Ocean Migration. North American steelhead typically spend 2 years in the ocean before entering freshwater to spawn. The distribution of steelhead in the ocean is not well known. CWT recoveries indicate that most steelhead tend to migrate north and south along the Continental Shelf (Barnhart 1986). Steelhead stocks from the Klamath and Rogue rivers probably mix together in a nearshore ocean staging area along the northern California before they migrate upriver (Everest 1973).

Biological Requirements. The timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. Unusual stream temperatures during spawning migration periods can alter or delay migration timing, accelerate or retard mutations, and increase fish susceptibility to diseases. The minimum stream depth necessary for successful upstream migration is 18 cm (Thompson 1972). Reiser and Bjornn (1979) indicated that steelhead preferred a depth of 24 cm or more. The maximum velocity, beyond which upstream migration is not likely to occur, of 2.4 m/second (Thompson 1972).

Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity. Intermittent streams may be used for spawning (Barnhart 1986; Everest 1973). Reiser and Bjornn (1979) found that gravels of 1.3 cm to 11.7 cm in diameter and flows of approximately 40-90 cm/second (Smith 1973) were preferred by steelhead. The survival of embryos is reduced when fines of less than 6.4 mm comprise 20 - 25% of the substrate. Studies have shown a higher survival of embryos when intragravel velocities exceed 20 cm/hour (Phillips and Campbell 1961, Coble 1961). The number of days required for steelhead eggs to hatch varies from about 19 days at an average temperature of 60° F to about 80 days at an average of 42° F. Fry typically emerge from the gravel two to three weeks after hatching (Barnhart 1986).

After emergence, steelhead fry usually inhabit shallow water along perennial stream banks. Older fry establish territories which they defend. Streamside vegetation and cover are essential. Steelhead juveniles are usually associated with the bottom of the stream. In smaller California streams, the water levels may drop so low during the summer that pools are the only viable rearing habitat. No passage between pools can occur until river levels rise with the onset of the rainy season. Therefore, juvenile steelhead rearing in isolated summer pools are extremely vulnerable to disturbance or water quality impacts. Daytime temperatures in summer rearing pools may also be near lethal levels; riparian shading and the presence of sub-surface, cold water seeps are often essential to maintain pool temperatures at tolerable levels. In winter, they become inactive and hide in any available cover, including gravel or woody debris.

The majority of steelhead in their first year of life occupy riffles, although some larger fish inhabit pools or deeper runs. Juvenile steelhead feed on a wide variety of aquatic and terrestrial insects, and emerging fry are sometimes preyed upon by older juveniles. Water temperatures influence the growth rate, population density, swimming ability, ability to capture and metabolize food, and ability to withstand disease of these rearing juveniles. Rearing steelhead juveniles prefer water temperatures of 45° to 58° F and have an upper lethal limit of 75° F.

Dissolved oxygen (DO) levels of 6.5 to 7.0 mg/L affected the migration and swimming performance of steelhead juveniles at all temperatures (Davis et. al. 1963). Reiser and Bjornn (1979) recommended that DO concentrations remain at or near saturation levels with temporary reductions no lower than 5.0 mg/L for successful rearing of juvenile steelhead. Low DO levels decrease the rate of metabolism, swimming speed, growth rate, food consumption rate, efficiency of food utilization, behavior, and ultimately the survival of the juveniles.

During rearing, suspended and deposited fine sediments can directly affect salmonids by abrading and clogging gills, and indirectly cause reduced feeding, avoidance reactions, destruction of food supplies, reduced egg and alevin survival, and changed rearing habitat (Reiser and Bjornn 1979). Bell (1973) found that silt loads of less than 25 mg/L permit good rearing conditions for juvenile salmonids.

1. Central California Coast steelhead ESU - Threatened

Only winter steelhead are found in this ESU and those to the south. The relationship between anadromous and non-anadromous *O. mykiss*, including possibly residualized[1] fish upstream from dams, is unclear.

Only two estimates of historical (pre-1960s) abundance specific to this ESU are available: an average of about 500 adults in

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[1] *Residual O mykiss* are those that have an anadromous lineage but are themselves non-anadromous; the term was first proposed by Ricker (1938) in describing life history variations in *O. nerka*. The change in life history may be the result of a physical or physiological barrier to migration (e.g. a dam, or slow growth that precludes smoltification).

Waddell Creek in the 1930s and early 1940s (Shapovalov and Taft 1954), and 20,000 steelhead in the San Lorenzo River before 1965 (Johnson 1964). In the mid-1960s, 94,000 steelhead adults were estimated to spawn in the rivers of this ESU, including 50,000 and 19,000 fish in the Russian and San Lorenzo rivers, respectively (CDFG 1965). Recent estimates indicate an abundance of about 7,000 fish in the Russian River (including hatchery steelhead) and about 500 fish in the San Lorenzo River. These estimates suggest that recent total abundance of steelhead in these two rivers is less than 15 percent of their abundance 30 years ago. Recent estimates for several other streams (Lagunitas Creek, Waddell Creek, Scott Creek, San Vincente Creek, Soquel Creek, and Aptos Creek) indicate individual run sizes of 500 fish or less. Steelhead in most tributaries to San Francisco and San Pablo bays have been virtually extirpated (McEwan and Jackson 1996). Fair to good runs of steelhead still apparently occur in coastal Marin County tributaries. In a 1994 to 1997 survey of 30 San Francisco Bay watersheds, steelhead occurred in small numbers at 41 percent of the sites, including the Guadalupe River, San Lorenzo Creek, Corte Madera Creek, and Walnut Creek (Leidy 1997).

Little information is available regarding the contribution of hatchery fish to natural spawning, and little information on present run sizes or trends for this ESU exists. However, given the substantial rates of declines for stocks where data do exist, the majority of natural production in this ESU is likely not self-sustaining.

2. South/Central California Coast steelhead ESU - Threatened

Only winter steelhead are found in this ESU. The relationship between anadromous and Non anadromous *O. mykiss*, including possibly residualized fish upstream from dams, is unclear but likely to be important.

In the mid-1960s, total spawning populations of steelhead in the rivers in this ESU were estimated as 27,750 (CDFG 1965). Recent estimates for those rivers show a substantial decline during the past 30 years. Other estimates of steelhead include 1,000 to 2,000 in the Pajaro River in the early 1960s (McEwan and Jackson 1996), and about 3,200 steelhead for the Carmel River for the 1964-1975 period (Snider 1983). No recent estimates for total run size exist for this ESU. However, recent run-size estimates are available for five streams (Pajaro River, Salinas River, Carmel River, Little Sur River, and Big Sur River). The total of these estimates is less than 500 fish, compared with a total of 4,750 fish for the same streams in 1965.

Adequate adult escapement information was available to compute a trend for only one stock within this ESU (Carmel River above San Clemente Dam). This data series shows a significant decline of 22 percent per year from 1963 to 1993, with a recent 5-year average count of only 16 adult steelhead at the dam. In 1996, however, 700 adults were reported to have passed the ladder at San Clemente Dam.

Little information exists regarding the actual contribution of hatchery fish to natural spawning, and little information on present total run sizes or trends are available for this ESU. However, given the substantial reductions from historical abundance or recent negative trends in the stocks for which data exist, it is likely that the majority of natural production in this ESU is not self-sustaining.

3. Central Valley steelhead ESU - Threatened

A final listing determination for the Central Valley ESU steelhead was made on March 19, 1998 (63 FR 13347). All Central Valley steelhead are currently considered winter steelhead, although three distinct runs, including summer steelhead, may have occurred as recently as 1947 (CDFG 1995, McEwan and Jackson 1996). Steelhead within this ESU have the longest freshwater migration of any population of winter steelhead. There is essentially a single continuous run of steelhead in the upper Sacramento river. River entry ranges from July through May, with peaks in September and February; spawning begins in late December and can extend into April (McEwan and Jackson 1996).

There are two recognized forms of native *O. mykiss* within the Sacramento River Basin: coastal steelhead/rainbow trout (*O. m. irideus*, Behnke 1992) and Sacramento redband trout (*O. m. stonei*, Behnke 1992). It is not clear how the coastal and Sacramento forms of *O. mykiss* interacted in the Sacramento River prior to construction of Shasta Dam in the 1940s which blocked anadromous fish passage. Behnke (1992) reported that coastal and resident redband trout were spawned together at the McCloud River egg-taking station (1879-1888). Therefore, it appears the two forms co-occurred historically at spawning time, but may have maintained reproductive isolation. In addition, the relationship between anadromous and Non anadromous forms of coastal *O. mykiss*, including possible residualized fish upstream from dams, is unclear.

Historical abundance estimates are available for some stocks within this ESU, but no overall estimates are available prior to 1961. In the Sacramento River including San Francisco Bay, the total run-size of steelhead was estimated at 40,000 in 1961 (Hallock et al. 1961). In the mid-1960s, steelhead spawning populations in this ESU were estimated at 27,000 fish (CDFG 1965). The present total run size for this ESU is probably less than 10,000 fish based on dam counts, hatchery returns and past spawning surveys.

At the Red Bluff Diversion Dam, counts have averaged 1,400 fish over the last 5 years, compared with runs in excess of 10,000 in the late 1960s. In the American River, estimates of hatchery produced fish average less than 1,000 fish, compared to 12,000 to 19,000 in the early 1970s (McEwan and Jackson 1996). Data to estimate populations trend was available from counts at the Red Bluff Diversion Dam. These data showed a significant decline of 9 percent per year from 1966 to 1992.

The majority of native, natural steelhead production in this ESU occurs in the upper Sacramento tributaries (Antelope, Deer, Mill, and other creeks), but these populations are nearly extirpated. The American, Feather, and Yuba rivers (and possibly the upper Sacramento and Mokelumne rivers) also have naturally-spawning populations (CDFG 1995). However, these rivers have also had substantial hatchery influence, and their ancestry is unknown. In the San Joaquin River Basin, there are reports of: (1) a small remnant steelhead run in the Stanislaus River (McEwan and Jackson 1996); (2) observations of steelhead in the Tuolumne River; and (3) large rainbow trout (possibly steelhead) at the Merced River hatchery.

D. Sacramento River Winter-run Chinook Salmon Critical Habitat

On June 16, 1993, NMFS designated critical habitat for the winter-run chinook salmon (58 FR 33212). Critical habitat for the winter-run chinook salmon includes the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge.

In addition, the designated critical habitat includes the physical and biological features of the habitats described above that are essential to the conservation of the species. These features are (1) access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River, (2) the availability of clean gravel for spawning substrate, (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, (4) water temperatures between 42.5 and 57.5° F (5.8 and 14.1° C) for successful spawning, egg incubation, and fry development, (5) habitat areas and adequate prey that are not contaminated, (6) riparian habitat that provides for successful juvenile development and survival, and (7) access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean.

Within the Sacramento River, critical habitat includes the river water, river bottom (including those areas and associated gravel used by winter-run chinook salmon as a spawning substrate), and the adjacent riparian zone used by fry and juveniles for rearing. In areas westward from Chipps Island, including San Francisco Bay to the Golden Gate Bridge, it includes the estuarine water column, essential foraging habitat, and food resources used by the winter-run chinook salmon as part of their juvenile outmigration or adult spawning migration.

E. Coho Salmon Proposed Critical Habitat

On November 25, 1997 NMFS proposed the designation of critical habitat for the Central California Coast and the Southern Oregon/Northern California coho salmon ESUs (62 FR 62741). The proposed designation includes all accessible reaches of rivers between the Elk River in Oregon and the San Lorenzo River in Santa Cruz County, California. This designation also includes two rivers entering the San Francisco Bay: Mill Valley Creek and Corte Madera Creek. For both ESUs, critical habitat includes the water, substrate, and adjacent riparian zones. Adjacent riparian areas are defined as those areas within a horizontal distance of 300 feet from the normal line of high water of a stream channel or adjacent off-channel habitats. NMFS has identified the inaccessible reaches of these rivers to be those above longstanding, naturally impassable areas or twelve dams, listed below, which block access to historical habitats of coho salmon. NMFS has not proposed the reaches above these dams or naturally impassable barriers as critical habitat. The twelve dams identified by NMFS are:

- Newell Dam on the San Lorenzo River
- Peter's Dam on Lagunitas Creek
- Nicasio Dam on Nicasio Creek
- Warm Springs Dam on Dry Creek
- Coyote Dam on the Russian River
- Scott Dam on the Eel River
- Matthews Dam on the Mad River
- Lewiston Dam on the Trinity River
- Dwinnell Dam on the Shasta River
- Iron Gate Dam on the Klamath River
- Applegate Dam on the Applegate River
- Lost Creek Dam on the Rogue River

The essential features of the proposed critical habitat for both ESUs includes adequate (1) substrate; (2) water quality; (3) water quantity; (4) water temperature; (5) water velocity; (6) cover/shelter; (7) food; (8) riparian vegetation; (9) space; and (10) safe passage conditions. However, the proposed rule does not specify the exact values or conditions these features must meet in order to be deemed adequate due to the variety of habitats and diverse life stages that utilize the critical habitat throughout the entire range of proposed critical habitat.

F. Central Valley spring-run chinook salmon Proposed Critical Habitat

On March 9, 1998 NMFS proposed the designation of critical habitat for the Central Valley spring-run chinook salmon (63 FR 11482). Critical habitat consists of the water, substrate, and adjacent riparian zone of accessible estuarine and riverine reaches. Accessible reaches are those within the historical range of the ESU that can still be occupied by any life stage of chinook salmon. Inaccessible reaches are those above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years) and specific dams within the historical range of each ESU (identified below). Adjacent riparian zones are defined as those areas within a slope distance of 300 feet from the normal line of high water of a stream channel or adjacent off-channel habitats (600 feet when both sides of the channel are included).

Critical habitat is designated to include all river reaches accessible to chinook salmon in the Sacramento River and its tributaries in California. Also included are river and reaches and estuarine areas of the Sacramento-San Joaquin Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge. Excluded are areas above specific dams identified below or above longstanding naturally impassable barriers.

<u>Dams/Reservoirs at the Upstream Extent of Critical Habitat</u>

- San Pablo Reservoir - San Pablo Bay area
- Calaveras Reservoir - Coyote Creek
- Nimbus Dam - American River
- Camp Far West Dam - Bear River
- Oroville Dam - Feather River
- Englebright Dam - Yuba River
- Black Butte Reservoir - Stony Creek
- Keswick and Shasta Dams - Sacramento River
- Whiskeytown Lake - Clear Creek

G. Central Valley fall/late fall-run chinook salmon Proposed Critical Habitat

On March 9, 1998 NMFS proposed the designation of critical habitat for the Central Valley fall/late fall-run chinook salmon (63 FR 11482). Critical habitat consists of the water, substrate, and adjacent riparian zone of accessible estuarine and riverine reaches. Accessible reaches are those within the historical range of the ESU that can still be occupied by any life stage of chinook salmon. Inaccessible reaches are those above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years) and specific dams within the historical range of each ESU (identified below). Adjacent riparian zones are defined as those areas within a slope distance of 300 feet from the normal line of high water of a stream channel or adjacent off-channel habitats (600 feet when both sides of the channel are included).

Critical habitat is designated to include all river reaches accessible to chinook salmon in the Sacramento and San Joaquin Rivers and their tributaries in California. Also included are river and reaches and estuarine areas of the Sacramento-San Joaquin Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge. Excluded are areas upstream of the Merced River and areas above specific dams identified below or above longstanding naturally impassable barriers.

Dams/Reservoirs at the Upstream Extent of Critical Habitat

- San Pablo Reservoir - San Pablo Bay
- Calaveras Reservoir - Coyote Creek
- Crocker Diversion La Grange - Merced River
- New Hogan Dam - Calaveras River and Mormon Slough
- Camanche Dam - Mokelumne River
- Nimbus Dam - American River
- Camp Far West Dam - Bear River
- Oroville Dam - Feather River
- Englebright Dam - Yuba River
- Black Butte Reservoir - Stony Creek
- Keswick and Shasta Dams - Sacramento River
- Whiskeytown Lake - Clear Creek

H. Southern Oregon and California Coastal chinook salmon Proposed Critical Habitat

On March 9, 1998 NMFS proposed the designation of critical habitat for the Southern Oregon and California Coastal chinook salmon (63 FR 11482). Critical habitat consists of the water, substrate, and adjacent riparian zone of accessible estuarine and riverine reaches. Accessible reaches are those within the historical range of the ESU that can still be occupied by any life stage of chinook salmon. Inaccessible reaches are those above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years) and specific dams within the historical range of each ESU (identified below). Adjacent riparian zones are defined as those areas within a slope distance of 300 feet from the normal line of high water of a stream channel or adjacent off-channel habitats (600 feet when both sides of the channel are included).

Critical habitat is designated to include all river reaches and estuarine areas accessible to chinook salmon in the drainages of San Francisco and San Pablo Bays, westward to the Golden Gate Bridge, and includes all estuarine and river reaches accessible to chinook salmon on the California and Southern Oregon coast to Cape Blanco (inclusive). Excluded are the Klamath and Trinity Rivers upstream of their confluence. Also excluded are areas above specific dams identified below or above longstanding naturally impassable barriers.

Dams/Reservoirs at the Upstream Extent of Critical Habitat

- Kent Lake Dam Nicasio Reservoir - Nicasio Creek
- Lake Mendocino - Russian River
- Lake Pillsbury - Eel River
- Applegate Dam - Applegate River

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