In Reply Refer To:
SWR-01-SA-6117:JSS

Mr. James N. Seiber
United States Department of Agriculture
Pacific West Area, Western Regional Research Center
Agricultural Research Service
800 Buchanan Street
Albany, California 94710-1105

Dear Mr. Seiber:

This document transmits the National Marine Fisheries Service's (NOAA Fisheries) biological opinion based on our review of the proposed Water Hyacinth Control Program (WHCP) in the Sacramento-San Joaquin Delta (Delta) in the state of California, and its effects on endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha)*, and threatened Central Valley steelhead (*O. mykiss*) in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq*.). Your submission of a completed request package for re-initiation of formal consultation was received on December 16, 2002.

This biological opinion (Enclosure 1) is based on information provided during the July 8, 2002, August 1, 2002, and November 19, 2002, meetings between staff from NOAA Fisheries, the United States Department of Agriculture-Agricultural Research Service (USDA-ARS), and California Department of Boating and Waterways (DBW) for the proposed WHCP project, monthly monitoring reports (July, August, September, and October 2002), and a revised description of the WHCP (November 2002), as well as other sources of information. A complete administrative record of this consultation is on file at the Sacramento, California field office of NOAA Fisheries.

The biological opinion concludes that the WHCP as proposed by the DBW and permitted by the USDA-ARS is not likely to jeopardize the continued existence of the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, nor is it likely to result in the adverse modification of Sacramento River winter-run Chinook salmon critical habitat. Because NOAA Fisheries believes that there will be some incidental take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, as a result of the project's implementation, an incidental take statement is also included with the biological opinion. This statement includes reasonable and
prudent measures that NOAA Fisheries believes are necessary and appropriate to reduce,

minimize, and monitor project impacts. Terms and conditions to implement the reasonable and prudent measures are presented in the incidental take statement and must be adhered to in order for the take exemptions of section 7 (o)(2) of the ESA to apply (16 U.S.C. 1536 (o)(2)). The incidental take exemption provided by this biological opinion expires at the end of the 2005 WHCP treatment season.

The biological opinion also provides conservation recommendations for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead. These include studies designed to explore migration and habitat utilization by salmonids in the Delta, activities to restore and maintain Delta riparian and aquatic habitat, the development of treatment methodologies that avoid or minimize deleterious effects on salmonids, programs to educate the public about the dangers of introduced non-native invasive species, and the promotion of legislation to control the importation and sale of water hyacinth and other invasive species.

Also enclosed are NOAA Fisheries' Essential Fish Habitat (EFH) Conservation Recommendations for Pacific salmon (*Oncorhynchus* species), starry flounder (*Platicthys stellatus*), and English sole (*Parophrys vetulus*) as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq*.; Enclosure 2).

The USDA-ARS has a statutory requirement under section 305(b)(4)(B) of the MSA to submit a detailed response in writing to NOAA Fisheries that includes a description of the measures proposed for avoiding, mitigating, or offsetting the impact of the activity on EFH, as required by section 305(b)(4)(B) of the MSA and 50 CFR 600.920 (j) within 30 days. If unable to complete a final response within 30 days of final approval, the USDA-ARS should provide an interim written response within 30 days before submitting its final response.

If you have any questions regarding this response, please contact Jeffrey Stuart in our Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814. Mr. Stuart may be reached by telephone at (916) 930-3607 or by Fax at (916) 930-3629.

Sincerely,

Rodney R. McInnis
Acting Regional Administrator

Enclosures (2)

cc:

NOAA Fisheries-PRD, Long Beach, CA
Stephen A. Meyer, ASAC, NOAA Fisheries, Sacramento, CA
USDA-ARS, Lars Anderson, Weed Science Program, UC-Davis - One Shields Avenue, Davis, CA 95616
DBW, Marcia Carlock, 2000 Evergreen Street, Suite 100, Sacramento, CA 95815
U.S. Fish and Wildlife Service, Justin Ly, 2800 Cottage Way, Suite W-2605, Sacramento, CA 95825
California Regional Water Quality Control Board, Rudy J. Schnagl, 3443 Routier Road, Suite A, Sacramento, CA 95827
DeltaKeeper, Bill Jennings, 3536 Rainier Avenue, Stockton, CA 95204

Enclosure 1

BIOLOGICAL OPINION

AGENCY: U.S. Department of Agriculture, Agricultural Research Service, Pacific West Area, Western Regional Research Center

ACTIVITY: Water Hyacinth Control Program: 2003 to 2005

CONSULTATION CONDUCTED BY: Southwest Region, National Marine Fisheries Service

DATE ISSUED:

I. CONSULTATION HISTORY

On June 8, 2001, the biological opinion for the 2001 Water Hyacinth Control Program (WHCP) was issued by the Southwest Region of the National Marine Fisheries Service (NOAA Fisheries) for the 2001 application season. This opinion concluded that the proposed action was not likely to jeopardize the continued existence of the Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and the Central Valley steelhead (*O. mykiss*), nor was it likely to result in adverse modification of Sacramento River winter-run Chinook salmon critical habitat.

On June 11, 2002, the biological opinion for the 2002 WHCP was issued by NOAA Fisheries for the 2002 application season. This opinion concluded that the proposed action was not likely to jeopardize the continued existence of the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and the Central Valley steelhead, nor was it likely to result in adverse modification of Sacramento River winter-run Chinook salmon critical habitat.

On July 1, 2002, NOAA Fisheries received notice that the California Regional Water Quality Control Board-Central Valley Region (Regional Board) was considering a request from the State of California, Department of Boating and Waterways (DBW) to rescind the National Pollution Discharge Elimination System (NPDES) Individual Permit CA0084654, (Order Number WQ 2001-07) (Individual Permit).

On July 8, 2002, the DBW requested a meeting to discuss various aspects of the WHCP between the staff of DBW, Dr. Lars Anderson of the US Department of Agriculture-Agricultural Research Service (USDA-ARS), Jeff Stuart of NOAA Fisheries, and Shaun Hyde of SePRO Corporation.

On July 12, 2002, NOAA Fisheries received a facsimile (Fax) of the Regional Board letter, dated July 9, 2002, indicating that DBW's hearing before the Regional Board to consider a recission of the individual permit for the WHCP was postponed until further notice. DBW wished to rescind the individual permit and acquire an emergency statewide NPDES General Permit Number CAG990003 (General Permit) for the application of herbicides under the authority of the WHCP.

On August 1, 2002, a meeting was held at the DBW offices in Sacramento to discuss various aspects of the WHCP for 2002. Staff from DBW, USDA-ARS, NOAA Fisheries, and the SePRO Corporation were in attendance. Items discussed included earlier start dates for treatment applications, the request for an emergency General Permit for the WHCP, and monitoring results. The monthly monitoring report for July was distributed.

On August 30, 2002, NOAA Fisheries received a request for re-initiation of formal section 7 consultation for the WHCP from Dr. Lars Anderson, USDA-ARS.

On September 19, 2002, NOAA Fisheries responded to the August 30, 2002 letter requesting re-initiation, indicating that the USDA-ARS had provided insufficient information to start the consultation.

On October 1, 2002, a meeting was held at the Sacramento offices of the DBW to discuss the information needs of NOAA Fisheries for the re-initiation of section 7 consultation.

On November 19, 2002, NOAA Fisheries received, via Fax, additional information requested from the USDA-ARS for the re-initiation of formal consultation for the WHCP. A meeting was held at the Sacramento offices of DBW to discuss the current status of the WHCP and the monitoring reports. Information also was given to NOAA Fisheries concerning nonchemical methods for water hyacinth control for use during the fall and winter seasons. An unsigned copy of a supplemental biological report was submitted to staff of NOAA Fisheries in response to the September 19, 2002 insufficiency letter. The cover letter was marked draft.

On December 16, 2002, NOAA Fisheries received correspondence from the USDA-ARS with appropriate signature confirming the re-initiation of the WHCP formal consultation.

II. DESCRIPTION OF THE PROPOSED ACTION

The USDA-ARS has requested formal section 7 consultation pursuant to the Endangered Species Act (ESA) in order to implement years three through five of a five-year aquatic weed control program within the geographic boundaries of the Sacramento-San Joaquin Delta (Delta), including portions of the Sacramento Deep Water Ship Channel (SDWSC) and associated sloughs, portions of the Stanislaus, Tuolumne, and Merced Rivers from their respective confluences with the San Joaquin River upstream to the first dam, and the San Joaquin River mainstem from the city of Stockton upstream to

Friant Dam. This program will apply different herbicides to the waterways of the Delta and the San Joaquin watershed to control the non-native invasive plant, *Eichhornia crassipes* (water hyacinth). The USDA-ARS, in fulfillment of their directive to control and eradicate agricultural pests, has contracted with the DBW to implement the control program and to conduct research activities in association with the WHCP while providing oversight during the program's implementation.

The USDA-ARS and DBW propose to conduct a program aimed at chemically controlling the growth and spread of water hyacinths with the aquatic herbicides diquat dibromide (diquat), 2,4-Dichlorophenoxyacetic acid dimethylamine salt (2,4-D), and glyphosate. Furthermore, USDA-ARS anticipates conducting research on the use of biological agents for the control of water hyacinths within infested waters. Finally, the DBW is implementing a separate mechanical and manual method for control of water hyacinths during the non-spraying seasons of the year, which is covered under a separate consultation (SWR-03-SA-8373:JSS). The objectives of the WHCP are to: (1) limit future growth and spread of water hyacinths in the Delta; (2) improve boat and vessel navigation in the Delta; (3) utilize the most efficacious methods available with the smallest environmental impacts; (4) prioritize navigational, agricultural, and recreational sites with a high degree of infestation; (5) employ a combination of control methods to allow maximum flexibility; (6) improve the WHCP as more information becomes available on control methods used in the Delta; (7) monitor results of the WHCP to fully understand impacts of the WHCP on the environment; (8) improve shallow-water habitat for native fish species by controlling water hyacinth; (9) decrease WHCP control efforts, if sufficient efficacy of water hyacinth treatment is realized; and (10) minimize use of methods that could cause adverse environmental impacts.

A. Project Activities

1. Treatment Methods and Application Sites

The WHCP is a program intended to control water hyacinth, an invasive, nonnative aquatic weed in the Delta. The Federal nexus for this activity is the USDA-ARS, which has the responsibility to conduct research and provide technical input into the control of nuisance weeds and agricultural pests. The DBW is the state lead for this project, with whom the USDA-ARS has contracted to conduct the application of the program. Currently, the primary WHCP treatment methods utilize three chemical herbicides:

- Reward® (active ingredient [a.i.] diquat, U.S. Environmental Protection Agency [EPA] Registration Number 10182-404)

- Weedar 64® (a.i. 2,4-D, EPA Registration Number 71368-264)

- Rodeo® and Aquamaster® (a.i. glyphosate, EPA Registration Number 524-00343)

The DBW estimates that 2000 gallons of chemicals will be used during the 2003 spray season on approximately 2000 acres of water hyacinth. Of the three aquatic herbicides selected for use in the program during the 2002 application season, only two (*i.e.*, 2,4-D and glyphosate) were used in the actual application of the program. These will remain the two preferred herbicides for use during the 2003 application season, pending completion of chemical toxicity tests and a thorough risk assessment. The compound 2,4-D accounted for 97% of the herbicides utilized in the 2002 program and glyphosate for the rest of the applications. DBW has not determined whether diquat will be used during the 2003 application season.

In addition to the herbicides described above, two different adjuvants will be used to improve application efficiency:

- R-11® Spreader-Activator (R-11®) (a.i. alkyl aryl polyethoxylates, compounded silicone, and linear alcohol, California State Registration Number 2935-50142-AA)

- Agri-Dex® (a.i. paraffin base petroleum oil and polyoxyethylate polyol fatty acid esters, California State Registration Number 5905-50017-AA)

R-11® (Wilbur-Ellis) is a combined spreading-activating compound used for increasing the efficiency of action for agricultural chemicals where quick wetting and uniform coverage are required. It is used with all three herbicides at the rate of two quarts per 100 gallons of spray solution.

Agri-Dex® (Helena) is a non-ionic blend of surfactants and spray oil that improves pesticide application by modifying the wetting and deposition characteristics of the application solution. Agri-Dex® will be used with all three herbicides at a rate of one to four pints per 100 gallons of spray solution, not to exceed 0.25% volume/volume (v/v) concentration.

Within the project area there are 367 possible treatment sites, which average between one and two miles in length (see Table 1[attached]). These sites include those that were listed in the 2002 WHCP, sites that were omitted from the action area in 2002, and additional sites that have been added to the WHCP for 2003. Each year, sites will be prioritized after DBW crews complete a spring survey and determine which sites will be of the greatest concern. Such sites generally will have the greatest impacts to navigation, create extensive obstructions to pumping facilities, or have high levels of infestation.

There are two groups of omitted sites: those selectively omitted from the program in 2002 and those that were omitted by accident. Selectively omitted sites include sites 173-175 (Frank's Tract - central portion). Sites omitted by accident include:

132	Sherman Lake
212	Snodgrass Slough/ Delta Cross Channel

420	San Joaquin River
906-908	Firebaugh

The following sites were added to the WHCP starting in 2003 and are located in the northwestern portion of the action area:

241-250	Sacramento River
251-255	Steamboat Slough
256-259	Sutter Slough
262-266	Miner Slough
267	Prospect Slough
268-269	SDWSC
270-271	Tox Drain, Liberty Slough
273-276	Shag Slough
260-261, 272, 277-278, 280	Cache Slough
279	Hass Slough
281-284	Lindsey Slough
285-289	Georgiana Slough

These additional sites are expected to be treated with 2,4-D and R-11. Treatment sites 251-255 located in Steamboat Slough have been identified as priority sites for treatment in 2003.

During the 2002 treatment season, it was found that a duplication of a site number had occurred. This is site 414, which was given to both a site on the San Joaquin River near the boundary of Stanislaus County and Merced County and to another site at Poso and Salt Sloughs in Merced County. The San Joaquin River remains site 414, whereas the site at Poso and Salt Sloughs has been renumbered as 414(a).

The USDA-ARS and DBW are conferring with the California Department of Food and Agriculture (DFA) to develop and implement biological control methods for the WHCP. The DBW has contracted with the DFA to search for populations of weevils belonging to the genus *Neochetina* within the Delta. These weevils are naturally occurring consumers of the water hyacinth, endemic to the plant's native South American habitat. This genus of weevils was previously released into the Delta several decades ago, but had not established a large enough population to achieve control of the water hyacinth infestation. Remnant populations of these earlier releases still remain in the Delta, but are scattered and small in size. If populations of these weevils are found, DFA will determine if they are infected with a microsporidian disease that could interfere with biological control efforts. DBW intends to utilize these weevils to colonize water hyacinth nurseries and establish self sustaining populations of the insect as an ongoing control of water hyacinth infestation in these locales. Pending the results of the DFA investigations, DBW intends to submit a final biological control study proposal to NOAA Fisheries to be included as an amendment to this biological opinion, which will fulfill earlier requirements of NOAA Fisheries 2002 biological opinion on the WHCP to establish an integrated pest management program for water hyacinth in the Delta. Therefore, biological control operations will not be addressed further in this biological opinion.

The DBW has received concurrence under a separate consultation (Southwest Region File Number: SWR-03-SA-8373:JSS) to implement manual and mechanical removal of water hyacinth infestations from Delta waterways during the non-spraying season. This period typically extends from the end of the herbicide spraying season in mid October (October 15) to the beginning of the permitted herbicide spray application season in spring (date varies depending on location). Personnel from the DBW will manually remove small infestations of water hyacinth with rakes in critical areas and deposit the vegetation on adjacent levee banks where the plants will desiccate naturally and perish. Mechanical removal will require DBW personnel to use motorized water-craft to "herd" mats of water hyacinth out into the main channels of the Delta where they will be carried by currents out of the Delta system and eventually perish in the higher salinity of Suisun Bay. Mechanical and physical removal operations will not be addressed further in this biological opinion.

2. <u>Treatment Protocol</u>

The proposed WHCP treatment season would extend from approximately March 1 through November 30. Four crews, each consisting of a Specialist and Technician, would carry out the spraying of herbicides in an assigned region of the Delta. Spraying would be conducted five days per week at one to three sites in a given day. The maximum area that could be treated in a day could range as high as 50 acres a day per crew in the summer, when crews work overtime and weather and tidal conditions are conducive to treatment. A Field Supervisor would manage daily operations from the DBW Field Office in Stockton, California, and would be responsible for determining daily spraying needs and assign teams to sites based on local conditions, available personnel, and equipment resources. The Field Supervisor will also assure that the Notice of Intent (NOI) requirements are met by reporting the locations of the treatment sites to the respective county Agricultural Commissioner no later than the

Friday prior to the week of treatment. The application of herbicides mixed with surfactants will be conducted with hand held sprayers operated from 19 to 21 foot aluminum air or outboard boats. The boats are equipped for direct metering of herbicides, adjuvants and water into the pump system of the spraying unit. The herbicide/adjuvant mixture will be sprayed directly onto the floating mats of water hyacinth. Waste products, including both active and inert components of the herbicidal mixtures, degraded components of the herbicidal mixtures, and dead and decaying vegetable matter, would be left to sink to the bottom or be carried downstream by the river and tidal currents. Operating protocols will prohibit treatments when wind conditions exceed a maximum threshold (10 mph) or when water flow or wave action is excessive.

B. Proposed Conservation Measures

DBW is obliged to follow the Department of Pesticide Regulation (DPR) procedures for pesticide application, and to file a Notice of Intent (NOI) with the County Agricultural Commissioner of each county where they will be spraying. DBW staff will perform maintenance protocols that will minimize the chance of a potential chemical spill and adopt response plans that have been developed to contain chemical spills on land and in the water in the advent of a spill. In the event of an WHCP chemical herbicide spill, DFG, the County Agricultural Commissioners (CAC), the Regional Board, the Office of Emergency Services, and if applicable, the California Highway Patrol, County Health Departments, and the County Sheriff's Office will all be notified as needed.

In addition, DBW is required to adhere to the water quality monitoring protocols approved by the Regional Board per the criteria set forth in the NPDES General Permit which expires January 31, 2004. The General Permit does not specify numeric limits for water quality criteria, but rather gives narrative guidelines for dischargers to follow. The General Permit allows for temporary excursions above the numeric criteria listed in the California Toxics Rule (CTR) and EPA water quality criteria, as long as full restoration of water quality and beneficial uses of the receiving waters are returned to pre-treatment levels following completion of the action. However, DBW anticipates following both the EPA aquatic species toxicity limits and drinking water standards that follow:

- Reward® --the maximum labeled rate for water column concentration (*i.e.*, aquatic species toxicity limit) is 370 parts per billion (ppb). The EPA drinking water concentration standard (Maximum Contaminant Level [MCL]) is 20 ppb. The DBW anticipates treating within the labeled rates the day of treatment and returning to EPA criteria within 24 hours after treatment.

- Rodeo® and Aquamaster®--application rates will be limited to ensure a MCL that does not exceed 700 ppb in water bodies designated as municipal and domestic water supplies. The DBW anticipates treating within the labeled rates the day of treatment and returning to EPA criteria within 24 hours after treatment.

- Weedar 64®--the application rate will be limited to ensure a MCL that does not exceed 70 ppb in water bodies designated as municipal or domestic water supplies. The Regional Board has further restricted the level of permissible 2,4-D concentrations in receiving waters to 20 ppb in the individual NPDES permit (Section A-14, Receiving Water Limitations). The DBW anticipates treating within the labeled rates the day of treatment and returning to EPA criteria within 24 hours after treatment.

DBW also has Memoranda of Understanding with regional water agencies outlining additional application restrictions relating to drinking water intakes. Prior to any work within close proximity of drinking water intakes, DBW will develop a protocol for sampling post-treatment chemical residue around the intakes. Currently, all three herbicides have restrictions for acceptable levels in drinking water as mandated by the state and federal regulations.

As a requirement of the General Permit, the DBW would follow monitoring protocol terms imposed by the Regional Board. The general goals of the monitoring program plan are to:

1. Document compliance with the requirements of the General Permit;

2. Support the development, implementation, and effectiveness of the implementation of Best Management Procedures (BMPs);

3. Demonstrate the full recovery of water quality and protection of beneficial uses of the receiving waters following completion of resource or pest management projects;

4. Identify and characterize aquatic pesticide application projects conducted by the DBW; and

5. Assure that the monitoring plan provides for monitoring of projects that are representative of all pesticides and application methods used by the DBW.

The monitoring program includes a daily log of site-specific information (*e.g.,* location, wind, chemicals used, location of listed species/species habitat), and pre- and post-treatment measurements of variables such as dissolved oxygen (DO) level, water temperature, turbidity, water hyacinth biomass, and chemical residues and toxicity. Three times each year, monitoring will be initiated at two sites in each of the four water categories (tidal, slow-moving, fast-flowing, dead-end slough) for each of the chemicals applied. Each chemical used in the WHCP will be subject to additional water quality and toxicity monitoring at least once each year. Other monitoring protocols relevant to listed salmonid species include recording field observations for any dead fish or native vegetation; visual assessment of water quality and photo documentation of native vegetation pre- and post-chemical control applications. The WHCP technical crew is trained in fish species identification, and recognition of fish habitat in the Delta and associated waterways by the DBW environmental scientist assigned to the program.

The DBW proposes to employ an adaptive management strategy for conducting the WHCP. This strategy will allow the DBW to re-evaluate its project protocol as new data and information becomes available that enhances the efficiency of the program or minimizes its environmental impact. The proposed adaptive management strategies include:

- Evaluating the need for control measures on a site by site basis;
- Selecting appropriate indicators for pre-treatment environmental monitoring;
- Monitoring indicators following treatment and evaluating data to determine program efficacy and environmental impacts;
- Support ongoing research to explore the impacts of the WHCP and alternative control methodologies;
- Report findings from monitoring evaluations and research to regulatory agencies and stakeholders; and
- Adjust program actions, as necessary, in response to recommendations and evaluations by regulatory agencies and stakeholders.

C. Action Area

The WHCP includes portions of nine counties that encompass much of the Sacramento-San Joaquin Delta and its upland tributaries. The nine counties are: Contra Costa, Fresno, Madera, Merced, Sacramento, San Joaquin, Stanislaus, and Yolo. Merced and Fresno counties will be treated by the agricultural commissions of those counties under the direction of the DBW. The DBW will conduct the program in the other seven counties. The general boundaries for the treatment area in the Delta and its tributaries are as follows:

- West up to and including Sherman Island, at the confluence of the Sacramento and San Joaquin Rivers;
- West up to the Sacramento Northern Railroad to include water bodies north of the southern confluence of the Sacramento River and the SDWSC;
- North to the northern confluence of the Sacramento River and the SDWSC, plus waters of Lake Natoma ;
- South along the San Joaquin River and Kings River to Mendota, just west of Fresno;

- East along the San Joaquin River to Friant Dam on Millerton Lake; and
- East along the Tuolumne River to La Grange Reservoir; below Don Pedro Reservoir; and East along the Merced River to Merced Falls, below Lake McClure.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following listed endangered and threatened species and designated critical habitat occur in the action area and may be affected by the proposed WHCP:

Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha)*
Sacramento River winter-run Chinook salmon designated critical habitat
Central Valley spring-run Chinook salmon (*O. tshawytscha*)
Central Valley steelhead (*O. mykiss*)

A. Species Life History, Population Dynamics, and Likelihood of Survival and Recovery

1. <u>Sacramento River Winter-run Chinook Salmon ESU</u>

The Sacramento River winter-run Chinook salmon was formally listed as threatened in November 1990 (55 FR 46515), and was reclassified as endangered under the ESA on January 4, 1994 (59 FR 440). On June 16, 1993 (58 FR 33212), NOAA Fisheries designated critical habitat for the winter-run Chinook salmon. This area was delineated as the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta, including Kimball Island, Winter Island, and Browns Island; all waters from Chipps island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Straits; 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. In the areas westward from Chipps Island, including San Francisco Bay to the Golden Gate Bridge, north of the San Francisco-Oakland Bay Bridge, this designation includes the estuarine water column and essential foraging habitat and food resources utilized by Sacramento River winter-run Chinook salmon as part of their juvenile outmigration or adult spawning migrations. Within the Sacramento River this includes the river water, river bottom (including gravel for spawning), and adjacent riparian zone used by fry and juveniles for rearing.

The first adult winter-run Chinook salmon migrants appear in the Sacramento-San Joaquin River system during the early winter months (Skinner 1962). Within the Delta, winter-run adults begin to move through the system in early winter (*i.e.*, November-December), with the first upstream adult migrants appearing in the upper Sacramento River during late December (Vogel and Marine 1991). Adult winter-run presence in the upper Sacramento River system peaks during the month of March. The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Spawning occurs primarily from mid-April to mid-August with peak activity occurring in May and June in the river reach between Keswick Dam and the Red Bluff Diversion Dam (RBDD) (Vogel and Marine 1991). The majority of winter-run Chinook salmon spawners are three years old.

Chinook salmon spawning occurs predominately in clean, loose, gravel in swift, relatively shallow riffles or along the margins of deeper runs. The fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), generally at night. After emergence, fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris. When the juvenile salmon reach a length of 50 to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energetic expenditures. Emigration of juvenile winter-run Chinook past the RBDD may occur as early as late July or August, but generally peaks in September and can extend into the next spring in dry years (Vogel and Marine 1991). In the mainstems of larger rivers, juveniles tend to migrate along the margins of the river, rather than in the increased velocity found in the thalweg of the channel. When the channel of the river is greater than 9 to 10 feet in depth, the juvenile salmon inhabit the surface waters (Healy and Jordan 1982).
Juvenile winter-run Chinook salmon occur in the Sacramento-San Joaquin Delta from October through early May based on data collected from trawls, beach seines, and salvage records at the State and Federal water projects (DFG 1998). The peak of juvenile arrivals is from January to March. They tend to rear in the freshwater upper delta areas for about the first two months (Kjelson *et al.* 1981, 1982). Maturing Chinook fry and fingerlings prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 $^{0}/_{00}$ (parts per thousand; Healy 1980, 1982; Levings *et al.* 1986).

Juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels and sloughs (McDonald 1960; Dunford 1975). Cladocerans, copepods, amphipods and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982; Sommer *et al.* 2001). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Sacramento-San Joaquin Delta are 54º – 57º F (Brett 1952). In Suisun and San Pablo Bays water temperatures reach 54º F by February in a typical year. Other portions of the Delta do not reach this temperature until later in the year, often not until after spring runoff has ended.

Juvenile Chinook salmon follow the tidal cycle in their movements within the estuarine habitat, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1981; Levings 1982; Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tide into shallow water habitats to feed (Allen and Hassler 1986). Kjelson *et al.* (1982) reported that juvenile Chinook salmon also demonstrated a diurnal migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Fry remain in the estuary until they reach a fork length of about 118 mm (*i.e.*, 5 to 10 months of age). Emigration from the delta may begin as early as November and continue through May (Fisher 1994; Myers *et al.* 1998).

Winter-run Chinook salmon are particularly susceptible to extinction due to the limitations of access to suitable spawning grounds and the reduction of their genetic pool to one population (NOAA Fisheries 1997). The winter-run Chinook salmon also has lower fecundity rates than other races of Chinook salmon in the Central Valley (Fisher 1994), averaging 1000 to 2000 eggs less per female than the other runs (3,700 winter-run, 5,800 late fall, 4,900 spring-run, and 5,500 fall-run). Both environmental and anthropogenic mediated changes to the habitat have led to declines in the Sacramento River winter-run populations (see Figure 1 [attached]) over the past three decades. However, the past three years have shown a modest, but positive increase in the winter-run Chinook salmon population, based upon escapement estimates.

2. <u>Central Valley Spring-run Chinook Salmon ESU</u>

NOAA Fisheries listed Central Valley spring-run Chinook salmon as threatened on September 16, 1999 (50 FR 50394) Many of the same factors described above that have led to the decline of the Sacramento River winter-run Chinook salmon ESU are also applicable to the Central Valley spring-run ESU, particularly the exclusion from historical spawning grounds found at higher elevations in the watersheds. Historically, spring-run Chinook salmon were abundant throughout the Sacramento and San Joaquin River systems. They constituted the dominant run of salmon in the San Joaquin River system prior to being extirpated by the construction of low elevation dams on the main tributaries of the watershed. Spring-run Chinook salmon typically spawned in higher elevation watersheds such as the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit Rivers. Currently, spring-run Chinook salmon cannot access most of their historical spawning and rearing grounds in the Central Valley due to the construction of impassable dams in the lower portions of the Central Valley's waterways. Today, the only streams that are considered to harbor naturally spawning wild stocks of spring-run Chinook are Mill, Deer and Butte creeks. All of these creeks are east-side creeks that do not have a major dam or migration barrier. Some additional spawning occurs in the Feather River mainstem and the Sacramento River. However, the genetic characteristics of these fish suggest introgression with both spring-run and fall-run hatchery fish. Elevated water temperatures, agricultural and municipal water diversions, regulated water flows, entrainment into unscreened or poorly functioning screened diversions, and riparian habitat degradation all have negatively impacted the spring-run Chinook salmon ESU.

Adult Central Valley spring-run Chinook salmon migrate into the Sacramento River system between March and July, peaking in May through June. They hold in coldwater streams at approximately 1500 feet above sea level prior to spawning, conserving energy expenditures while their gonadal tissue matures. They spawn from late August through early October, peaking in September (Fisher 1994; Yoshiyama *et al*. 1998). Between 56 to 87% of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are three years old (Calkins *et al*. 1940; Fisher 1994). Spring-run Chinook salmon fry emerge from the gravel from November to March and spend about 3 to 15 months in freshwater habitats prior to emigrating to the ocean (Kjelson *et al*. 1981). Downstream emigration by juveniles occurs from November to April. Upon reaching the Delta, juvenile spring-run Chinook salmon forage on the same variety of organisms and utilize the same type of habitats as previously described for Sacramento River winter-run Chinook salmon juveniles.

Adult escapement/spawning stock estimates for the past thirty years have shown a highly variable population for the Central Valley spring-run Chinook ESU. Even though the abundance of fish may increase from one year to the next, the overall average population trend has a negative slope during this time period (see Figure 2 [attached]). These variations in annual population levels may result from differences in individual tributary cohort recruitment levels. Central Valley spring-run Chinook salmon, like Sacramento River winter-run Chinook salmon, have a lower fecundity than the larger Central Valley fall and late-fall runs of Chinook salmon. This coupled with the need for cold water to over-summer in while waiting for gonadal tissue to mature, places the Central Valley spring-run Chinook salmon population at a higher risk for population declines than the fall and late-fall runs. Warmer summer water temperatures increase the likelihood of disease and lowered fertility in fish that have to hold in sub-optimal conditions.

3. Central Valley Steelhead ESU

On March 19, 1998, NOAA Fisheries listed the Central Valley steelhead as threatened (63 FR 13347). Historically, Central Valley steelhead once were found throughout the Sacramento and San Joaquin drainages, where waterways were accessible to migrating fish. Steelhead historically were present in the upper San Joaquin River basin, above the current Friant Dam location. Steelhead commonly migrated far up tributaries and into headwater streams where cool, well oxygenated waters are present year-round. Currently, within the Central Valley, viable populations of naturally produced steelhead are found only in the Sacramento River and its tributaries (U.S. Fish and Wildlife Service [FWS] 1998). Wild steelhead populations appear to be restricted to tributaries on the Sacramento River below Keswick Dam, such as Antelope, Deer, and Mill creeks, and in the Yuba River, below Englebright Dam (McEwan and Jackson 1996). At this time, no significant populations of steelhead remain in the San Joaquin River basin (FWS 1998). However, small persistent runs still occur on the Stanislaus and perhaps the Tuolumne Rivers. Steelhead are found in the Mokelumne River and Cosumnes River, but may be of hatchery origin. It is possible that other naturally spawning populations exist in other Central Valley streams, but are not detected due to a lack of sufficient monitoring and genetic sampling of rainbow/steelhead resident fish (Interagency Ecological Program [IEP] Steelhead Project Work Team 1999).

Central Valley Steelhead are all considered to be winter-run steelhead (McEwan and Jackson 1996), which are fish that mature in the ocean before entering freshwater on their spawning migrations. Prior to the large scale construction of dams in the 1940s, summer steelhead may have been present in the Sacramento River system (IEP Steelhead Project Work Team 1999). The timing of river entry is often correlated with an increase in river flow, such as occurs during freshets and precipitation events with the associated lowering of ambient water temperatures. The preferred water temperatures for migrating adult steelhead are between 46º and 52º F. Entry into the river system occurs from July through May, with a peak in late September. Spawning can start as early as December, but typically peaks between January and March, and can continue as late as April, depending on water conditions (McEwan and Jackson 1996). Steelhead are capable of spawning more than once (iteroparous) as compared to other pacific salmonids which die after spawning (semelparous). However the percentage of repeat spawning often is low, and is predominated by female fish (Busby *et al.* 1996). Steelhead prefer to spawn in cool, clear streams with suitable gravel size, water depth, and water velocities. Ephemeral streams may be used for spawning if suitable conditions in the headwaters remain during the dry season and are accessible to juvenile fish seeking thermal refuge from excessive temperatures and dewatering in the lower elevation reaches of the natal stream (Barnhart 1986).

In Central Valley streams, fry emergence usually occurs between February and May, but can occur as late as June. After emerging from the gravel, fry migrate to shallow, protected areas associated with the margins of the natal stream (Barnhart 1986). Fry will take up and defend feeding stations in the stream as they mature, and force smaller, less dominant fry to lower quality locations (Shapovalov and Taft 1954). In-stream cover and velocity refugia are essential for the survival of steelhead fry, as is riparian vegetation, which provides overhead cover, shade, and complex habitats. As fry mature, they move into deeper waters in the stream channel, occupying riffles during their first year in fresh water. Larger fish may inhabit pools or deeper runs (Barnhart 1986). Juvenile steelhead feed on a variety of aquatic and terrestrial invertebrates, and may even prey on the fry and juveniles of steelhead, salmon, and other fish species. Steelhead juveniles may take up residence in freshwater habitat for extended periods of time prior to emigrating to the ocean. Optimal water temperatures for fry and juveniles rearing in freshwater is between 45^0 and 60^0 F. The upper lethal limit for steelhead is approximately 75º F (Bjornn and Reiser 1991); temperatures over 70º F result in respiratory distress for steelhead due to low dissolved oxygen levels.

Steelhead typically spend one to three years in freshwater before migrating downstream to the ocean. Most Central Valley steelhead will migrate to the ocean after spending two years in freshwater, with the bulk of migration occurring from November to May, although some low levels may occur during all months of the year. The out-migration peaks from April to May on the Stanislaus River whereas the American River has larger smolt-sized fish emigrating from December to February and smaller sized steelhead fry coming through later in the spring (March and April). Feather River steelhead smolts are observed in the river until September, which is believed to be the end of the outmigration period (Calfed Bay Delta Program [CALFED] 2000a).

Over the past 30 years, naturally spawning steelhead populations in the Upper Sacramento River have declined substantially (Figure 3 [attached]). Central Valley steelhead are susceptible to population declines due to the scarcity of cool summer water temperatures required for the survival of juvenile fish in the valley watersheds. Many of these watersheds have been dammed for irrigation and hydroelectricity purposes and block passage to higher elevation waters. Summer water flows for many tributaries are influenced by water diversions to support agriculture. The instream flows are frequently reduced, and the ambient water temperatures in the tailwater sections of the tributaries may exceed the tolerances of juvenile steelhead, thereby causing morbidity and mortality in the fish inhabiting these sections.

B. Habitat Condition and Function

The freshwater habitat of salmon and steelhead in the Sacramento-San Joaquin drainage varies in function depending on location. Spawning areas are located in accessible, upstream reaches of the Sacramento or San Joaquin Rivers and their watersheds where viable spawning gravels and water conditions are found. Spawning habitat condition is strongly affected by water flow and quality, especially temperature, dissolved oxygen, and silt load, all of which can greatly affect the survival of eggs and larvae.

Migratory corridors are downstream of the spawning area and include the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams, unscreened or poorly screened diversions, and degraded water quality.

Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, or presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system (*e.g.*, the lower Cosumnes River, Sacramento River reaches with setback levees [*i.e.*, primarily located upstream of the City of Colusa]). However, the channelized, leveed, and rip-rapped river reaches and sloughs that are common in the Sacramento-San Joaquin Delta typically have low habitat complexity, low abundance of food organisms, and offers little protection from either fish or avian predators.

C. Factors Affecting the Species and Habitat

Sacramento River winter-run, Central Valley spring-run Chinook salmon, and Central Valley steelhead historically all utilized higher elevation watersheds for holding, spawning, and rearing. For example, winter-run Chinook salmon historically spawned in the headwater reaches of the little Sacramento, McCloud and Lower Pit River systems, which had cool, stable temperatures for successful egg incubation over the summer. Populations of winter-run Chinook may have numbered over 200,000 fish

(Moyle *et al.*1989; Rectenwald 1989; Yoshiyama *et al.*1998). Construction of Shasta Dam blocked access to all of the winter-run Chinook salmon's historical spawning grounds by 1942. Preservation of a remnant winter-run population was achieved through manipulation of the dam's releases to maintain a cold water habitat in the Sacramento River below the dam as far downstream as Tehama. Other large dams constructed on the natal streams (*e.g.*, the American, Feather and Yuba Rivers) of Central Valley spring-run Chinook salmon and Central Valley steelhead resulted in the loss of access to much of the historical spawning and rearing habitat of these species. Current spawning areas located downstream of dams often are subject to flow and temperature fluctuations and consequent egg and larval mortality resulting from reservoir operation.

Dam construction also has led to alterations in the hydrology of the Sacramento-San Joaquin River system. This has resulted both in reductions in the volume of water flowing through the system and the timing of peak flows that stimulate migratory behavior in both juvenile and adult fish. Currently, less than 40% of historical flows reach San Francisco Bay through the Delta. The reduction in the peak flows has lead to alterations in the cycling of nutrients and changes in the transport of sediment and organic matter, which can lead to distinct alterations in the historical distribution of animal and plant communities upon which the juvenile salmonids depend upon for their forage base and for protective cover. Alterations in flow patterns have also reduced freshwater outflows at the western margins of the Delta. This situation has led to fluctuating salinity levels within the western margin of the Delta and has changed the location and extent of the productive mixing zone between saline and fresh water bodies. Changes in the flushing rate and increased residence time of Delta water has also enhanced the degradative effects of an increased input of contaminants and pollutants to the water system.

Other factors affecting the species and habitat (*e.g.*, levee construction and loss of shallow water habitat, Central Valley Project (CVP) and State Water Project (SWP) operations, invasive species, etc.) are especially pertinent to the Sacramento-San Joaquin Delta (*i.e.*, the action area) and are discussed below under *IV. Environmental Baseline*.

IV. ENVIRONMENTAL BASELINE

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

A. Physical Habitat Alteration

The action area, the Sacramento-San Joaquin Delta, historically was dominated by freshwater marsh habitat. Nearly 1,400 km^2 of freshwater marsh in the Delta have been diked and drained primarily to create farmland. Industrialization and urbanization reclaimed even more acreage until today only about 6 % of the original 2,200 km^2 area of native wetlands remains (Conomos *et al*. 1985). The original wetlands served as significant foraging areas for numerous species, and enhanced nutrient cycling and retention as well as acting as natural filters to enhance ambient water quality.

A major impact of levee construction has been the conversion of shallow-water habitats that were found along the margins of waterways into deeper rip-rap lined channels. Shallow-water habitats are considered essential foraging habitats for juvenile salmonids, often supporting complex and productive invertebrate assemblages. The substrate that is provided by the stone rip rap is unsuitable for the colonization of native estuarine invertebrate species. Native species (*e.g.*, clams, oligochaetes, chironomids, and amphipods) typically utilize soft substrates for colonization in the estuary rather than hard substrates. Likewise, levee construction has disconnected the rivers and Delta from their historical floodplains. Juvenile salmonids utilize flood plains for foraging and as a refuge from high flow velocities during flood events. Maintenance dredging of the channels can result in increased levels of suspended sediment, the formation of anoxic bottom waters, and increased saltwater intrusion into upstream areas, all of which may cause stress to fish and trigger physiological or behavioral responses.

In the current environmental state of the Delta, juvenile salmonids have been found to use flooded bypasses, such as the Yolo Bypass, as a surrogate floodplain for refuge and off channel rearing (Sommer 2001). Further up the Sacramento River, the Sutter Bypass serves a similar function. The Cosumnes River floodplain, near its confluence with the Mokelumne River, may be the only naturally functioning floodplain left in the Central Valley, and salmonids from this watershed have been consistently found utilizing it during flooding events. In contrast, the dredging of deep shipping channels in the Delta have created situations where the water column becomes hypoxic or even anoxic (*e.g.*, the Stockton Deep Water Ship Channel) and the movement of salmonids through these reaches is interrupted until DO levels return to sustainable levels for the fish. These interruptions to the salmonids' migrations expose the fish to environmental conditions that have negative impacts to the fish's health. Decreases in the viability of gametes in holding adults, and an increase in the susceptibility of the fish to pathogens can be attributed to these delays. Furthermore, extended delays due to low DO and poor water quality in the Delta may lead to increases in salmonid straying rates to spawning grounds outside the adult's natal stream (T. Heyne, DFG, personal communication, February 11, 2003).

B. Water and Sediment Quality

The water quality of the Delta has been negatively impacted over the last 150 years. Increased water temperatures, decreased dissolved oxygen levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. The California Water Quality Control Board-Central Valley Regional (Regional Board) in its 1998 Clean Water Act §303(d) list characterized the Delta as an impaired waterbody having elevated levels of chlorpyrifos, DDT, diazinon, electrical conductivity, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan and toxaphene), mercury, low dissolved oxygen (DO), organic enrichment, and unknown toxicities (Regional Board 1998, 2001).

In general, water degradation or contamination can lead to either acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically when concentrations are lower, to chronic or sublethal effects that reduce the physical health of the organism to survive over an extended period of time. Mortality may become a secondary effect due to compromised physiology or behavioral changes that lessen the organism's ability to carry out its normal activities. For example, increased levels of heavy metals are detrimental to the health of an organism because they interfere with metabolic functions by inhibiting key enzyme activity in metabolic pathways, decrease neurological function, degrade cardiovascular output, and act as mutagens, teratogens or carcinogens in exposed organisms (Rand 1995; Goyer 1996). For listed species, effects may occur directly to the listed fish or to its prey base, which reduces the forage base available to the listed species.

Sediments can either act as a sink or as a source of contamination depending on hydrological conditions and the type of habitat the sediment occurs in. Sediment provides habitat for many aquatic organisms and is a major repository for many of the more persistent chemicals that are introduced into the surface waters. In the aquatic environment, most anthropogenic chemicals and waste materials including toxic organic and inorganic chemicals eventually accumulate in sediment (Ingersoll 1995).

Direct exposure to contaminated sediments may cause deleterious effects to listed salmonids (*e.g.*, lesions, decreased respiratory function, narcosis, tumors, etc.). This may occur if a fish swims through a plume of the resuspended sediments or rests on contaminated substrate and absorbs the toxic compounds through one of several routes: dermal contact, ingestion, or uptake across the gills. Elevated contaminant levels may be found in localized "hot spots" where discharge occurs or where river currents deposit sediment loads. Sediment contaminant levels can thus be significantly higher than the overlying water column concentrations (EPA 1994). However, the more likely route of exposure to salmonids is through the food chain, when the fish feed on organisms that are contaminated with toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself. Therefore the degree of exposure to the salmonids depends on their trophic level and the amount of contaminated forage base they consume. Response of salmonids to contaminated sediments is similar to water bourne exposures.

C. Water Operations

Operations of the CVP and SWP pumps in the south Delta have significantly altered water flow patterns in the Delta. When exports are high, water is drawn into the southern portions of the Delta through the Delta Cross Channel, Georgiana Slough and Three Mile Slough from the mainstem of the Sacramento River. Likewise, water flow in the lower San Joaquin River can even be reversed and drawn towards the pumping facilities through the interconnected waterways of the South Delta. Fish are drawn with these altered flow patterns towards the pumping facility. These alterations in water flow have resulted in fish from both the Sacramento River and the San Joaquin River systems being drawn into the South Delta as a result of the water diversions. Lower survival rates are expected due to the longer migration routes, where fish are exposed to increased predation, higher water temperatures, more unscreened water diversions, degraded water quality, reduced availability of food resources, and entrainment into the CVP/SWP export facilities near Clifton Court Forebay in the south Delta (FWS 1990, 1992). Currently, the CVP/SWP pumping facilities are operated to avoid pumping large exports of water during critical migratory or life stage phases of listed fish. Real time monitoring of fish movements, and the development of more efficient fish screens have led to a decrease in the numbers of fish lost to the projects, but entrainment still accounts for significant losses to the listed fish populations. Additionally, Herren and Kawasaki (2001) reported that the Delta region had 2,209 other diversions based upon their field observations. Of these diversions, 90% measured between 12 and 24 inches and only 0.7% had screens on the intakes designed to protect fish from entrainment.

D. Invasive Species

Invasive species greatly impact the growth and survival of juvenile salmonids in the Delta. Non-native predators such as striped bass, largemouth bass, and other sunfish species present an additional risk to the survival of juvenile salmonids migrating through the Delta that was not historically present prior to their introduction. These introduced species are often better suited to the changes that have occurred in the Delta habitat than are the native salmonids. The presence of the Asian clam (*Potamocorbula amurensis)* has led to alterations in the levels of phyto- and zooplankton found in water column samples taken in the Delta. This species of clam efficiently filters out and feeds upon a significant number of these planktonic organisms, thus reducing the populations of potential forage species for juvenile salmonids. Likewise, introductions of invasive plant species such as the water hyacinth and *Egeria densa* have diminished access of juvenile salmonids to critical habitat (Peter Moyle, University of California, Davis, personal communication, April 25, 2002). *Egeria densa* forms thick "walls" along the margins of channels in the Delta. This growth prevents the juvenile salmonids from accessing their preferred shallow water habitat along the channel's edge. In addition, the thick cover of *Egeria* provides excellent habitat for ambush predators, such as sunfish and bass, which can then prey on juvenile salmonids swimming along their margins. Water hyacinth (*Eichhornia crassipes*) creates dense floating mats that can impede river flows and alter the aquatic environment beneath the mats. DO levels beneath the mats often drop below sustainable levels for fish due to the increased amount of decaying vegetative matter produced from the overlying mat. Like *Egeria*, water hyacinth is often associated with the margins of the Delta waterways in its initial colonization, but can eventually cover the entire channel if conditions permit. This level of infestation can produce barriers to salmonid migrations within the Delta.

The introduction and spread of *Egeria* and water hyacinth have created the need for aquatic weed control programs that utilize herbicides targeting these species. The EDCP resulted in the treatment of

1,583 acres in the first two years of treatment. Diquat, the active ingredient of Reward®, has been shown to have a 96 hour LC_{50} (*i.e.*, lethal concentration at which 50 % of exposed test organism die) for salmonids at concentrations as low as 11 parts per million (ppm) for juveniles and potentially as low as 0.76 ppm for larval fish. Fluridone, the active ingredient of Sonar® has been shown to have a 96 hour LC_{50} of 7 to 12 ppm in rainbow trout (*O. mykiss*). Both herbicides are expected to have environmental concentrations one to two orders of magnitude lower than acutely toxic levels, but only after complete mixing in the water column. Furthermore, sublethal effects related to the herbicides may occur even at the lower concentrations, and indirect adverse effects from the dieback of the treated aquatic vegetation on water quality may cause take of listed salmonids within the treatment area.

The DBW control program targeting water hyacinth has been in operation from 1982 through 1999 in the Delta. It recently was reinstated, and the proposed project considered in this biological opinion addresses years three through five of a five year program (see *II. Description of the Proposed Action*). DBW has employed herbicides as the preferred method of control for water hyacinth for 17 years. Chemicals previously utilized in DBW's control program included the aquatic herbicides Weedar®64 (2,4-Dichlorophenoxyacetic acid, dimethylamine salt; 2,4-D), Rodeo® (glyphosate, N-(phosphonomethyl) glycine (isopropylamine salt), and Reward® (diquat dibromide); the adjuvants Activator 90® (alkyl polyoxyethylene ether and free fatty acids), Placement® (amine salts of organic acids, aromatic acid, aromatic and aliphatic petroleum distillate), R-11® (alkyl aryl polyethoxylates, compounded silicone and linear alcohol), Agri-dex® (paraffin base petroleum oil and polyoxyethylate polyol fatty acid esters), Bivert® (amine salts of organic acids, aromatic acid, aromatic and aliphatic petroleum distillates), and SurpHtac®(polyozyethylated (6) decyl alcohol, 1-aminomethanamide dihydrogen tetraoxosulfate); and the activator Magnify®(ammonium salts, aklyl polyglucoside, and dimethylpolysilozane). From 1983 - 1999, a total of 17,613 acres were treated with 4,861 applications of primarily 2,4-D (>95% of the total applied herbicides). For the last 6 years of the program, a total of 8,361 gallons of herbicide and 4,914 gallons of adjuvants were used in the Water Hyacinth Control Program (WHCP). An estimated 959 gallons of Weedar®64, 16 gallons of Rodeo®, and 320 gallons of Placement® were applied to Delta waters in the 2001 WHCP season, covering 1002 acres of Delta waters. The DBW estimates that it used a maximum of 900 gallons of herbicide on 500 - 1,000 acres of Delta waterways during the 2002 treatment season.
2,4-D has a 96 hour LC_{50} (*i.e.*, lethal concentration at which 50 % of exposed test organism die) ranging from 1.4 ppm to 358 ppm with a median of 27.3 ppm for rainbow trout, and a median of 14.8 ppm for Chinook salmon. Glyphosate has a 96 hour LC_{50} of 130 to 210 ppm depending on water hardness. As mentioned previously for the EDCP, herbicides applied under the WHCP are expected to have environmental concentrations one to two orders of magnitude lower than acutely toxic concentrations, but only after complete mixing in the water column. Sublethal effects related to the herbicides may occur even at these lower concentrations, and indirect adverse effects from the dieback of the treated aquatic vegetation on water quality may cause harm of listed salmonids within the treatment area by interfering with their ability to forage and seek shelter in aquatic vegetation.

The previous two years of monitoring data for the WHCP have shown infrequent excursions for 2,4-D above the herbicide concentration criteria permitted (20 ppb) for the project under the NPDES permit. These elevated levels, however, remained below the label restrictions for this herbicide (*i.e.*, 100 ppb) and the results of biotoxicity testing were inconclusive for water samples taken from treatment sites. Likewise, the EDCP monitoring data indicated that the water column concentrations were below the labeled and NPDES concentration criteria for fluridone in all sites sampled and in all but one site for diquat residues in 2002. Results for 2001 were similar, but had a higher average concentration due to differences in the volume of water used for calculating treatment amounts (high tide volumes versus mean water level volumes). A few monitoring samples indicated biotoxicity to one or more of the test species exposed to sample water, but were inconclusive about the actual cause of the toxicity. Delta waters frequently contain a wide spectrum of chemical constituents, and without appropriate toxicity identification evaluations (TIEs), the root cause of the toxicity is difficult to pinpoint. DBW has yet to ascertain whether the control programs for either water hyacinth or *Egeria* substantially diminished the standing population of these invasive plants or resulted in the creation of areas with increased native aquatic plant growth.

Based on NOAA Fisheries' analysis in the 2001 and 2002 Biological Opinions and the results of the monitoring data reports, these past applications of herbicides were not likely to jeopardize any of the listed species or create adverse modifications to critical habitat. NOAA Fisheries did determine, however, that the programs would have adverse effects on the listed salmonids that were exposed to the herbicides and required reasonable and prudent measures be incorporated into the programs to reduce the impacts upon these fish and their habitat.

E. Habitat Restoration and Environmental Monitoring

Examples of habitat restoration projects conducted under the auspices of CALFED in the Delta region include large scale restoration projects on the Mokelumne and San Joaquin Rivers, purchase of additional upstream flows, and improvement of water quality throughout the watershed (CALFED 2000b). In general, habitat restoration projects are expected to increase habitat complexity or quality, and increase the growth and survival of rearing salmonids by creating conditions that increase the food supply or improve conditions for feeding and successful migration, and decrease the probability of predation.

FWS' Anadromous Fish Restoration Plan (AFRP) has developed numerous actions in the Delta specifically intended to improve the outmigration and survival of juvenile salmon in the Delta (*e.g.* Delta Cross Channel closures, export curtailments, positive Q west conditions [positive delta outflow]); (FWS 1998). AFRP actions also include non-flow fish management projects such as physical facilities to improve fish passage, channel restoration to improve rearing habitat and migration corridors, and fish screen installation to prevent the entrainment of juvenile fish.

The information gathered by the Interagency Ecological Program (IEP) monitoring program is used to adjust operations of the CVP and SWP. IEP projects explore predator-prey relationships; fish abundance and size distribution; geographic distribution, population studies; impacts from water operations; nursery values; entrainment monitoring; and fish screen criteria development. These projects serve not only to improve environmental conditions in the Delta, but also expand the knowledge base of the Delta's ecosystem. However, routine fish surveys conducted within the Delta almost universally results in the bycatch of listed salmonids, and thereby constitute an added source of mortality.

F. Summary

The general decline of habitat quality in the Sacramento-San Joaquin Delta has diminished the Delta's function both as a migratory corridor for juvenile and adult salmonids, and as rearing habitat for juvenile salmonids. The Delta is designated critical habitat for Sacramento River winter-run Chinook salmon. Adverse impacts likely have been greatest on juvenile salmonids. Direct mortality of juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead resulting from entrainment in the CVP and SWP pumps is well-documented, as is predation by several introduced predator fish species on juvenile salmonids. Juveniles drawn into the South Delta from altered flow patterns experience lower survival rates presumably from these and other sources of mortality such as degraded water quality. In contrast, many habitat restoration projects and flow-related actions (*e.g.*, Delta Cross Channel closures) specifically have been intended to improve conditions for juvenile salmonids. These likely have contributed to increased growth and outmigration success of juveniles, but population-level impacts have been difficult to quantify.

The proposed action exposes segments of the three listed salmonid populations to potentially toxic chemicals and impaired water quality during their migrations through the Delta. The more sensitive juvenile stages transit the Delta waters predominately in the spring and early summer, when the WHCP is starting its application schedule. Previous constraints on the timing and location of the early season herbicide applications have minimized the level of exposure to these stages and the current opinion intends to continue this preventative policy, and thus enhance the survivability of the salmonid stocks passing through affected waters.

V. EFFECTS OF THE ACTION

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction of or adverse modification of critical habitat. This biological opinion assesses the effects of the WHCP on endangered Sacramento winter-run Chinook salmon and its critical habitat, threatened Central Valley spring-run Chinook salmon and threatened Central Valley steelhead. The WHCP is likely to adversely affect listed species and critical habitat through application of herbicides to waters of the Delta and San Joaquin River Basin and the resulting short term alterations in the natural environment. In the *Description of the Proposed Action* section of this Opinion, NOAA Fisheries provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this Opinion, NOAA Fisheries provided an overview of the threatened and endangered species and critical habitat that are likely to be adversely affected by the activity under consultation.

Regulations that implement section 7(b)(2) of the ESA require that biological opinions evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA also requires biological opinions to determine if Federal actions would destroy or adversely modify the value of critical habitat (16 U.S.C. §1536).

NOAA Fisheries generally approaches "jeopardy" analyses in a series of steps. First, NOAA Fisheries evaluates the available evidence to identify direct and indirect physical, chemical, and biotic effects of the proposed action on individual members of listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or a sound). Once NOAA Fisheries has identified the effects of the action, the available evidence is evaluated to identify a species' probable response (including behavioral responses) to those effects to determine if those effects could reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). The available evidence is then used to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

A. Approach to Assessment

1. Information Available for the Assessment

To conduct the assessment, NOAA Fisheries examined evidence from a variety of sources. Background information on the status of these species and critical habitat, and the effects of the proposed action on the species and its environment has been published in a number of documents including peer reviewed scientific journals, primary reference materials, governmental and non-governmental reports, and scientific meetings, as well as supporting information supplied with the action's environmental documents.

2. Assumptions Underlying This Assessment

In the absence of definitive data or conclusive evidence, NOAA Fisheries must make a logical series of assumptions to overcome the limits of the available information. These assumptions are made using sound, scientific reasoning that can be logically derived from the available information. The progression of the reasoning is stated for each assumption, and supporting evidence cited.

B. Assessment

1. Natural History of Water Hyacinth

Water hyacinth is a non-native invasive free-floating aquatic macrophyte belonging to the South American pickerelweed family (*Pontederiacea*). It is considered to be one of the most invasive species worldwide, having been reported in 56 countries worldwide (Holm *et al.* 1977; Gopal and Sharma 1981).

Water hyacinth was first reported in California in a Yolo County slough in 1904 (Prokopovich *et al.* 1985). The plant spread gradually through the Delta and by the late 1970's had covered nearly 1,000 acres and 150 miles of the 700 miles of waterways in the Delta (U.S. Army Corps of Engineers 1985). The spread of water hyacinth in the Delta was probably inhibited by the cool winters and occasional freezes that occur in the Central Valley, which can kill or severely retard growth of the water hyacinth (Holm *et al.* 1977).

Water hyacinth grows in wetlands, marshes, shallow water bodies, slow moving waterways, lakes, reservoirs, and rivers. The plants often form large, thick mats that are monospecific in nature. Mats can reach dimensions that can block waterways and impede navigation, agricultural practices and pursuit of recreational activities. Dense mats can also serve as breeding grounds for mosquitoes, which can increase the possibility of vector born diseases in surrounding areas (Savage *et al.* 1990; Meyers 1992; Rodriguez *et al.* 1993; and Manguin *et al.* 1996). During high wind or river flow conditions, small floats of water hyacinth often break off from the larger mats and colonize new areas. Water hyacinths are tolerant of fluctuations in water levels, seasonal flow velocities, and extremes of nutrient availability, pH, toxicants, and temperatures. However, the plants are susceptible to even low levels of salinity, and perish in these environments.

The water hyacinth growth cycle starts in spring when overwintering plants (*i.e.*, old stem bases) initiate new growth by producing daughter plants. The minimum growth temperature is 54 ^{0} F, optimal growth temperatures are reached at 77-86 ^{0} F and maximum growth temperature is reached at 92-95 ^{0} F. The daughter plants increase in number during spring and summer until the maximum biomass is reached in September. When the density of the mats has reached its maximum, individual plants begin to increase in size, crowding out smaller plants. This decreases the overall number of plants in the mats, while still maintaining high biomass. Water hyacinth grows faster than any other tested plant (Wolverton and

McDonald 1979) and can double their numbers in as little as 6 days (Mitchell 1976). During late summer and early fall, the plants reach their full bloom. By late fall, the flowers and leaves begin to die back, and by January most of the plants have gone dormant. Water hyacinths are not very tolerant to freezing conditions, and cold climates limit their northern range. Leaves can regrow after moderate freezing, but plants do not survive hard freezes or ice conditions.

2. Problems Associated with Water Hyacinth Infestation

Typically, aquatic vegetation plays an important, beneficial role in the functioning of an aquatic ecosystem. Aquatic vegetation produces oxygen through photosynthesis that leads to an elevation of ambient dissolved oxygen levels in the water column. Macrophytes provide shelter and habitat for invertebrates and juvenile fish whether they are rooted in the substrate or are free floating. Macrophytes also provide substrate for periphyton (algae, fungus, and microflora) to grow on which in turn provides food resources for grazing invertebrates. These invertebrates then provide the basis for the food resources of higher trophic levels, such as fish. Aquatic plants also enhance the cycling of nutrients and minerals. This is done by incorporating them into the plant tissue, which then serves as a nutritional substrate for herbivores or as a nutrient source for bacteria and fungi during their decay. Native aquatic plants are co-evolved with the other flora and fauna in their ecosystems and thus are in equilibrium with the other components of the ecosystem.

Non-native invasive species are those plants or organisms, which have been introduced into an ecosystem in which they have not evolved. These species do not have the checks and balances on their numbers and range that native species have and are likely to adversely affect native species in the invaded ecosystem. Water hyacinth is such a species. The infestation of the Delta with water hyacinth has resulted in several negative impacts on this ecosystem. The increased biomass of water hyacinth has resulted in nighttime depletion of dissolved oxygen through increased levels of plant respiration, particularly during periods of elevated water temperatures. The extensive coverage of water hyacinth mats have excluded numerous species of submerged native plants by shading-out these plants or smothering emergent plants that become surrounded by the mats. Likewise, the extensive mats have created zones of hypoxic or anoxic water conditions due to extensive plant respiration and lack of water-air interface mixing. These conditions have altered the normal assemblages of invertebrate and vertebrate species normally found in ecosystems without the water hyacinth (Baily and Litterick 1993; Toft 2000; CALFED 2000b). Water hyacinths can also lead to abiotic changes in the ecosystem such as accretion of sediment and organic detritus under the mats due to reductions of water flows through the infested sites. Likewise, the ability of the water hyacinth to absorb vast amounts of nutrients and minerals through its extensive root structure can lead to the formation of nutrient sinks in the infested zones. These sinks essentially remove these nutrients from the ecosystem due to the inability of native organisms to feed on the water hyacinth, or survive in the conditions created by the water hyacinth.

3. Physio-chemical Properties of WHCP Herbicides and Adjuvants

The mode-of–action is the overall manner in which a herbicide affects a plant at the tissue or cellular level. Herbicides can be organized into those which are applied to foliage, and those which are applied almost strictly to soil. The foliar groups are further divided into three categories according to movement through the plant:

- Symplastically translocated (source to sink, capable of downward movement in plant),

· Apoplastcially translocated (capable of upward movement in plant),

· Those which do not move appreciably and kill very quickly on contact.

Plants are complex organisms with well-defined structures and numerous biochemical processes that are necessary for life. Some of these vital metabolic pathways include photosynthesis, amino acid and protein synthesis, fat synthesis, pigment synthesis, nucleic acid synthesis, oxidative respiration for energy, and maintenance of cellular membrane integrity. Other essential processes include growth and differentiation, mitosis (cell division) in plant meristems, meiosis (sexual gamete production- pollen and seeds), uptake of ions and molecules, translocation of ions and compounds across cellular membranes, and transpiration. One or more of these essential processes must be disrupted in order for a herbicide to kill a plant (Ross and Childs 1996).

Foliar applied herbicides are either downwardly mobile, contact (non-translocated), or upwardly mobile in their mode-of–action. Downwardly mobile herbicides can be further divided into auxin growth regulators (2,4-D), aromatic amino acid synthesis inhibitors (glyphosate), branched chain amino acid inhibitors, chlorophyll/carotenoid pigment inhibitors (fluridone), or lipid synthesis inhibitors. Contact herbicides destroy by disrupting the cellular membranes of plants. Diquat belongs to this class of herbicides and functions by producing peroxides and free radicals in the cytoplasm upon exposure to light, which then destroy the lipid membranes of the cells almost immediately. Upwardly mobile herbicides move with the transpiration stream in the plant's xylem from the bottom to the top of the plant. This group of herbicides inhibits the photosynthetic pathways of metabolism. Soil applied herbicides inhibit cellular division in the roots, new shoots or both (Ross and Childs 1996).

Weedar® 64 (*i.e.*, a.i. 2,4-D) is an auxin growth regulator. This type of herbicide is applied to the foliage of plants, which almost immediately results in a bending and twisting of the leaves and stems. Delayed symptoms include root formation on dicot stems, misshapened leaves, stems, and flowers and abnormal roots. The amine salt form has been shown to be less toxic to fish than the ester forms of the herbicide, while invertebrates show a higher sensitivity to both the ester and amine forms of the compound than fish. The half-life of Weedar® in aquatic environments can be short, from several days to several weeks (Extoxnet 2001). Rates of breakdown increase with increased levels of nutrients, sediments, and dissolved organic carbon. Maximum concentrations in surface waters are reached in one day, and then dissipate rapidly, especially in moving water (USDA 2002). Microorganisms readily breakdown 2,4-D along two separate metabolic pathways, metabolizing the compound into either pyruvate or 3-oxo-adipate. These intermediate metabolites serve as precursors to other metabolic pathways in the degrading microorganisms (Hill *et al.* 2002). The manufacturer's Material Safety Data Sheet (MSDS, Rhône-Poulenc) indicates that this product is "for use in ponds, lakes, reservoirs, marshes, bayous, drainage ditches, canals, rivers, and streams that are quiescent or slow moving." It further stipulates that "to avoid fish kills from the decaying plant material consuming oxygen, buffer strips of at least 100 feet wide should be left, and that treatment of these strips should be delayed for 4 to 5 weeks or until the dead vegetation has decomposed." This will be the primary compound used for water hyacinth control by the DBW, accounting for more than 97% of chemical usage. Concentrations of 2,4-D in the receiving waters shall not exceed 20 µg/L following application as directed by the current Individual Permit for the WHCP.

Rodeo® (*i.e.*, a.i. glyphosate) is a non-selective, slow acting systemic herbicide. This type of herbicide is sprayed on the foliage due to its rapid degradation by microbes. Symptoms include yellowing of new growth and death of treated plants in days to weeks (Ross and Childs 1996). Glyphosate inhibits an essential enzyme pathway, the shikimic acid pathway. This inhibition prevents plants from synthesizing three key aromatic amino acids, phenylalanine, tyrosine, and tryptophan. These enzymes are essential for the normal growth and survival of most plants. Plants are inefficient at metabolizing glyphosate, therefore the compound readily disseminates throughout the target plant and provides a more effective herbicide (Hartzler 2001). Animals do not synthesize either phenylalanine or tryptophan (essential amino acids), and thus require them in their diets to survive. Glyphosate rapidly degrades in aquatic systems either by photodegradation (28 days) or by microbial degradation into sarcosine or formaldehyde, which then enters the intermediate single carbon metabolism of the bacteria. Glyphosate is also strongly adsorbed to soil particles and suspended particulate matter in the water column, rendering it "biologically unavailable" to most aquatic organisms. Toxicological data indicates that the parent compound, glyphosate, is relatively benign to fish at expected acute field concentrations. Increased toxicity has been shown to occur when the parent compound is mixed with spray adjuvants and the inert portions of the manufacturer's formulation. The manufacturer's MSDS (Monsanto) states that the product may be "applied to emergent weeds in all bodies of fresh and brackish water which may include flowing, non-flowing, and transient waters". Rodeo® does not effectively treat plants which are completely submerged or have the majority of their foliage under water. Restrictions also apply to the application of Rodeo® near potable water intakes. As with 2,4-D, hypoxic conditions may be formed in the water column due to excessive weed decay from previous treatments, thereby causing fish to suffocate from a lack of dissolved oxygen. It is recommended that treating the area in strips may avoid this problem. This will be the least used compound for water hyacinth control by the DBW. Concentrations of glyphosate in the receiving waters shall not exceed 700 µg/L following application as directed by the current Individual Permit for the WHCP.

Reward® (*i.e.*, a.i. diquat dibromide) is a broad spectrum contact herbicide that destroys lipid membranes and disrupts photosynthetic organelles. Diquat is readily absorbed through the plant cuticle and passes into the cytosol of the plant. It then forms superoxide free radicals that are subsequently converted into hydrogen peroxides by the enzyme superoxide dismutase. The hydrogen peroxide and superoxide anion can attack polyunsaturated lipids present in the cellular membranes to produce lipid hydroperoxides which, in turn, can react with unsaturated lipids to form more lipid free radicals, thereby perpetuating the system (Ecobichon in Klassen 1996). Diquat rapidly adsorbs to soil particles and suspended particles in water. It thus quickly becomes relatively biologically unavailable to most aquatic organisms. Diquat's half-life is less than 48 hours in the water column, and may be on the order of 160 days in sediments due to its low bioavailability. Microbial degradation or sunlight may play roles in the degradation of the compound. Plants can absorb diquat from the water and concentrate it in the plant's tissues. Thus, low concentrations are effective for controlling aquatic weeds. Diquat is considered slightly toxic to fish and aquatic invertebrates. It has been reported to be less toxic in hard waters. There is little or no bioconcentration of diquat in fish due to its limited absorption from the gastrointestinal tract (Extoxnet 1993, 1996). One research paper indicated that yellow perch (*Perca flavescens*) exhibited respiratory difficulties when herbicide concentrations were similar to those present during aquatic vegetation control programs (Bimber 1976). The manufacturer's MSDS for Reward® (Zeneca) indicates that the herbicide may be applied to aquatic weeds. In public waters, the herbicide may be applied to still, slow-moving, or other quiescent bodies of water and if warning signs are required by state law they must be posted within the restricted area (1600 feet downstream of the treatment site). Due to the likelihood of hypoxic or anoxic conditions resulting from the decay of dead plant material, the MSDS requires that only one third to one half of the water body be treated at any one time, especially if dense weeds are present, and to wait 24 hours between treatments. Diquat is expected to account for approximately 3% of the total amount of herbicide used in any given spray season if it is used. Concentrations of diquat in the receiving waters shall not exceed 0.5 µg/L following application as directed by the current individual NPDES permit for the WHCP.

The surfactants, R-11 and Agri-Dex, are chemicals that have a pronounced surface activity in aqueous solutions. The surface activity derives from the orientation of the hydrophilic and hydrophobic groups within the surfactant moeity and yields an oriented film at the aqueous interface that decreases surface tension (Diamond and Durkin 1997). Agri-Dex is a blend of polyoxyethylated polyol fatty acid ester, polyol fatty ester, and paraffin base petroleum oil. The surfactant activity derives from the polyoxyethylated polyol fatty acid ester and polyol fatty ester portions of the compound's formulation. The product R-11 is a mixture of octylphenoxypolyethoxyethanol, n-butanol, and compounded silicone (90%) and "constituents ineffective as spray adjuvant" (10%) (Wilbur-Ellis product label). The surfactant activity is provided by the octylphenoxypolyethoxyethanol portion of the formulation. The surfactants enhance the dispersion of the herbicide and its penetration of the hydrophobic waxy cuticle of the plant's leaf surface. This allows for greater delivery of the herbicide into the plant's cytoplasm. The octylphenoxypolyethoxyethanol surfactants also exhibit a level of phytotoxicity, which may further magnify the toxicity of the herbicide it is mixed with.

4. Exposure of Listed Salmonids to WHCP Herbicides

The proposed period for EDCP treatment is from March 1 to November 30. The treatment period would overlap 4 months (50%) of adult winter-run Chinook salmon migration and 5.5 months (61%) of juvenile winter-run Chinook salmon emigration; most of the spring-run adult migration (80%) and juvenile emigration (60%); and 8.5 months (77%) of adult and juvenile steelhead migration in the Delta. During out-migration, the winter-run juveniles are at sub-yearling stage (age 0); spring-run juveniles are at yearling stage (age 1) and steelhead smolts are post-yearlings (age >1). However, herbicide application will be to discrete sections of the Delta, at specific time points in the application season. Thus, the Delta will not be globally impacted at a specific point in time, exposing all listed salmonids in the Delta at that moment to potentially toxic or adverse concentrations of herbicides; neither will any one segment of the Delta be treated continuously for the entire application season, inhibiting movement through it by listed salmonids.

Adult salmonids are not expected to be impacted by the WHCP, as they utilize deep water habitat which is not slated for EDCP chemical control treatments. However, the shallow water “nursery areas” targeted for chemical treatment in the Delta attract juvenile salmonids as these areas provide a rich food supply and protective cover for them. Salmon juveniles move from tidal channels during flood tide to feed in near-shore marshes. They scatter along the edges of the marshes at the highest points reached by the tide, then with the receding tide, retreat into channels that dissect marsh areas and retain water at low tide. Larger juveniles and smolts tend to congregate in surface waters of main and subsidiary slough channels and move into shallow subtidal areas to feed. Although there is some evidence that salmon and steelhead may not occur inside dense infestations of water hyacinth (Baily and Litterick 1993; CALFED 2000b, Grimaldo *et al*. 2000; Toft 2000;), juvenile salmonids occurring along the edges of these areas would be vulnerable to impacts from the WHCP. The exact range of these effects would be hard to determine with any precision as they are dependent upon local conditions and physical environment which change with the application locale. These impacts may include physical disturbance during the herbicide application process and mechanical harvesting, direct exposure to chemical herbicides, various sublethal toxicity effects, and effects on habitat such as reduced DO levels, reduced food supply, and removal of native submergent aquatic vegetation.

5. <u>Toxicity of WHCP Herbicides</u>

Water hyacinth is a floating macrophyte, thus the herbicides are applied by spraying the foliage of the plant above the surface of the water. A conservative estimate of the amount of herbicide entering the water column under normal conditions is approximately 10-20% of the sprayed volume (Anderson 1982).

a. Reward®

Reward® is considered moderately toxic to fish. The 96 hour LC_{50} for rainbow trout ranges from approximately 11.5 mg/L (Gilderhus 1967, Folmar 1976) to 21 mg/L (Worthington and Hance 1991). The 8 hour LC_{50} for diquat dibromide is 12.3 mg/L for rainbow trout and 28.5 mg/L for chinook salmon (Pimental 1971). However, studies by Paul *et al*. (1994) found that diquat was toxic to larval fish as low as 0.74 ppm (96 hour exposure) and would indicate that early life stages may be much more sensitive to diquat than older fish. Folmar’s studies (1976) indicated that rainbow trout did not avoid diquat at concentrations up to 10 mg/L (highest concentration tested), nearly the lethal concentration for this species. Aquatic organisms usually are exposed to multiple lower-level exposures (Campbell *et al*. 2000). *Hyalella azteca*, an amphipod, is one of the most sensitive aquatic organisms tested with a 96-hour LC_{50} of 0.048 mg/L (Wilson and Bond 1969). The use of diquat at recommended treatment levels could delay downstream migration of smolts and possibly affect their survival in seawater (Lorz *et* *al.* 1979). The U.S. Environmental Protection Agency water quality criteria (1973) has established a criterion of 0.5 mg/L (ppm) diquat (instantaneous maximum) as the concentration that is protective of freshwater aquatic life.

b. Weedar®

Weedar® (*i.e.* 2,4-D) is considered slightly toxic to fish in freshwater according to the descriptive guidelines used by Kamrin (1997). The 96 hour LC_{50} for 2, 4-D for rainbow trout (*O. mykiss*) ranges from ~100 mg/L (Johnson and Finley 1980) to more than 1000 mg/L (Doe *et al.* 1988). The formulation of 2,4-D has been shown to affect toxicity, with the acid and amine forms considerably less toxic to different species of salmonids than the ester formulations (Meehan *et al.* 1974). The levels of toxicity of 2,4-D have been shown to be affected by ambient environmental pH, with the toxicity of the compound decreasing with increasing pH. This is due to the degree of dissociation of the acidic herbicide (Doe *et al.* 1988). Water hardness has also been implicated as a factor in affecting 2,4-D toxicity to salmonids. Hard water was shown to reduce the toxicity of the 2,4-D to different species of salmonids (Wan *et al.* 1991). Invertebrates have been shown to have differing sensitivities to 2,4-D (George *et al.* 1982; Sarkar 1991; and Abdelghani *et al.* 1997) and are frequently more sensitive to 2,4-D than fish.

Physiological and morphological alterations have been seen in fish exposed to 2,4-D. Common changes seen in physiological parameters are changes in enzyme activity levels (Neškovi*f et al.*, 1994). Exposure to 2,4-D has also been shown to cause morphological changes in gill epithelium in carp. These changes include lifting of the gill epithelium and clubbing of gill filaments, but are considered non-lethal if the fish is removed to clean water for recovery (Neškovi*f et al.* 1994). In field conditions this would be equivalent to swimming to an untreated area or the herbicide concentration falling off to negligible levels. Carpenter and Eaton (1983) investigated the metabolism of 2,4-D in rainbow trout after injection, and found that almost 99% of the compound is excreted in the urine as unchanged 2,4-D, with a half-life of only 2.4 hours. Less than 1% was found in the bile of treated fish, presumably as a conjugated metabolite. Similar results were shown for metabolic studies in channel catfish (*Ictalurus punctatus*) where 2,4-D was administered orally (Plakas *et al.* 1992). The responses described in the references above all occurred at considerably higher exposure concentrations than are expected to be seen in the WHCP applications in the Delta.

c. Rodeo®

The 96 hour LC_{50} for Rodeo®, calculated as the glyphosate acid for rainbow trout and chinook salmon ranges from 130 mg/L to 140 mg/l in soft water to 210 mg/L to 290 mg/L in hard water for rainbow trout and chinook salmon respectively (Mitchell *et al.* 1987a). Wan *et al.* (1989) also found a correlation between water hardness and toxicity for five species of salmonids (coho, chum, chinook, and pink salmons and rainbow trout). In soft water, chinook salmon and rainbow trout had similar sensitivities to the herbicide, 19 mg/L to 10 mg/L respectively as glyphosate, and 33 mg/L as

Roundup®. However in hard water, the LC_{50} for glyphosate was 197 mg/L and 211 mg/L for rainbow trout and chinook salmon respectively, considerably less toxic than in soft water. Conversely, the Roundup® formulation was more toxic in hard water, 14 mg/l and 17 mg/L for trout and salmon respectively. Folmar *et al.* (1979) found the 96 hour LC_{50} for several different invertebrate and fish species, including rainbow trout. Acute toxicities to rainbow trout were 8.3 mg/L for Roundup® and 140 mg/L for technical glyphosate. The toxicity for the surfactant alone was similar to that of Roundup®, 2.0 mg/L versus 8.3 mg/L for Roundup®.

Folmar *et al.* (1979) also investigated the effects of glyphosate on the reproductive success and behavior of rainbow trout. No significant effects were detected between the control fish and those exposed to the glyphosate in either their gonadal somatic index or fecundity when exposed to 2 mg/L of glyphosate for 12 hours followed by a 30 day recovery period in freshwater. The data found in Folmar *et al.* (1979) indicates that eggs of rainbow trout are less sensitive to the toxicity of Roundup® than some other life stages. Toxicity increased at the yolk-sac stage and early swim up stages, but decreased in the fingerling stage, as fish grew larger. The values for the 96 hour LC_{50} exposures are as follows: eyed eggs – 16 mg/L; sac-fry – 3.4 mg/L; swim-up fry – 2.4 mg/L; fingerling (1.0 g) - 1.3 mg/L; and fingerling (2.0 g) – 8.3 mg/L. Rainbow trout also did not avoid concentrations of the isopropylamine salt of glyphosate up to 10 mg/L (Folmar 1976; Folmar *et al.* 1979). Morgan *et al.* (1991) found similar reactions of rainbow trout fry exposed to Vision®, a glyphosate formulation with either 10% or 15% surfactant. The nominal concentration that elicited a threshold avoidance reaction from the test fish was 54 ppm for Vision®-15 and 150 ppm for Vision®-10, roughly two times the LC_{50} for the fish. Threshold effects for alterations in the fish's behavior where observed at 13.5 ppm for Vision®-15, and 37.5 ppm for Vision®-10 following 24 hours of exposure. These changes were characterized by erratic, gyrating swimming at 24 hours, with the fish eventually becoming moribund at 48 hours.

Physiological studies conducted by Mitchell *et al.* (1987b) on coho salmon showed no adverse effects of exposure of up to 2.3 mg/L of Roundup® in the seawater adaptation of the fish. There were no significant differences in the biochemical and morphological parameters measured in this study between control and treated fish (hematocrit, condition factor, length or weight, or ionoregulatory gill enzymes). Similar findings were made by Janz *et al.* (1991) using the glyphosate herbicide Vision®. Their studies reported that four hour exposures to sublethal concentrations of Vision® did not appear physiologically stressful to juvenile coho salmon, as indicated by secondary stress responses (*i.e.*, increased oxygen consumption, plasma glucose and lactate levels, hematocrit and leukocrit). Rainbow trout exposed for two months at concentrations up to 100mg/L of Vision® exhibited no significant effects in foraging behavior, growth, liver tumors, or gill lesions (Morgan and Kiceniuk 1992). However one study did show immunotoxicity to sublethal levels of glyphosate. At concentrations of 2.8 mg/L, El-Gendy *et al.* (1998) showed that exposure for 96 hours could significantly alter lymphocyte proliferation, humoral and cell mediated immunity and protein synthesis in tilapia for up to four weeks after exposure.

Juvenile salmonids could be exposed to elevated concentrations of diquat, 2,4-D, or glyphosate from the WHCP if they occur very near the herbicide application point during the application process. Concentrations would remain high until the chemical is diluted from mixing in Delta waters. Mixing is expected to occur fairly rapidly (*i.e.*, minutes to hours). Once complete mixing occurs, then assuming the worst case scenario, and using the highest predicted environmental concentration (*i.e.*, 0.37 ppm) and the most sensitive LC_{50} (*i.e.*, 0.74 ppm), the instantaneous diquat concentration is still two times lower than the most sensitive LC_{50} values which are for larval fish. The instantaneous concentration is almost 77 times lower than the published LC_{50} values for chinook salmon and 31 times lower than those for rainbow trout. Likewise, 2,4-D after complete mixing is expected to have an instantaneous maximum concentration of 3.1 ppm. The most sensitive LC_{50} for salmonids (*i.e.*, 100 ppm) is approximately 32 times higher than the expected maximum concentration of 2,4-D after mixing. Assuming the highest instantaneous concentration for glyphosate (*i.e.*, 3.10 ppm) and the lowest salmonid LC_{50} for Rodeo® (130 mg/L to 210 mg/L; soft water, hard water), the ambient environmental concentration of Rodeo® after complete mixing is still approximately 42 to 68 times lower than the 96 hour LC_{50} for Rodeo® exposure to salmonids.

The herbicides applied in the WHCP are expected to be adsorbed to particulate matter suspended in the water and onto sediments on the bottom of the Delta waterways. Bacterial degradation will remove the chemicals from the system and metabolize them to simple carbon compounds. Under field conditions, diquat chemically binds to sediment (Ritter *et al.* 2000). Paul *et al.* (1994) found that sediment removed 60 percent of diquat after four days in a shallow container which continued to be mixed by aeration. Several other field studies with variable results indicate the difficulty in ascertaining the time and rate of diquat dissipation (Yeo 1967), but apparently it can remain bioavailable for several days (Paul *et al.*1994). 2,4-D is also readily degraded in aquatic systems; its decomposition enhanced with increased levels of nutrients, sediment loads, and dissolved organic carbon levels. Under field conditions, Weedar® is expected to have a half-life of several days to several weeks (Extoxnet 2001). Glyphosate will have a similar environmental fate, its half-life in the aquatic environment is only on the order of a few days to weeks (Extoxnet 2001). The environmental fate characteristics of Reward®, Weedar®, and Rodeo® and the application rates used in the WHCP indicate that the long-term concentration levels of the herbicides achieved in Delta waters should be significantly below the acute toxicity levels of listed salmonids. However, recent medical studies in humans have shown correlations with the usage of herbicides, particularly phenoxy acetic acid herbicides (*e.g.*, 2,4- D) to increases in spontaneous abortions (Arbuckle, Lin and Mery 2001) in Ontario farm populations, presence of phenoxy residues in Ontario farmers' sperm (Arbuckle *et al.* 1999), parkinsonism from glyphosate exposure (Barbosa *et al.* 2001), short term decreases in immunological indices in farmers exposed to phenoxy herbicides (Faustini *et al.* 1996), and an increased risk of non-Hodgkin lymphoma from herbicide and pesticide exposures (Lynge 1998, Hardell and Eriksson 1999, McDuffie *et al.* 2001). The epidemiological data for humans exposed to herbicides would indicate that there is sufficient concern to warrant restricted usage of the compounds in aquatic environmental settings until more extensive physiological research is conducted.

d. Surfactants

Surfactants are frequently toxic in their own right. The surfactant R-11 has a 96 hour LC_{50} of 3.8 ppm for rainbow trout, making it considerably more toxic than the glyphosate it is commonly mixed with (Diamond and Durkin 1997). Curran *et al.* (2003) found that R-11 was significantly more toxic to smaller rainbow trout (0.39 g) than it was to larger fish (15.46 g) when the LC_{50} of each size was compared (5.19 ppm v. 6.57 ppm) and that EPA test criterion size (<3g) indicates that differences in fish size may cause differences in the 96-h LC_{50} as great as 200%. Experimental data indicates that the surfactant Agri-Dex is approximately 300x less toxic than R-11 (3.8 ppm v. >1000 ppm) when their 96-h LC_{50} values are compared (Diamond and Durkin 1997). Furthermore, the surfactant R-11 has been implicated as causing endocrine disruption in fish and amphibians as one of its constituents is a nonylphenol polyethoxylate (NPE). Nonylphenols are weakly estrogenic, and have been shown to cause endocrine disruption under laboratory conditions at low doses (20 ppb) (UK Marine SACS Project 2003). Chronic toxicity values (No Observed Effects Concentrations or NOECs) for NPEs and their metabolites have been shown to occur as low as 6 ppb in fish and 3.9 ppb for aquatic invertebrates (Environment Canada 2003). In comparison to the project's herbicides, the surfactant R-11 is more toxic and has a range of effects that present themselves in the low parts per billion concentration range.

In any case, sublethal effects and effects on habitat resulting from the WHCP that may ultimately increase the likelihood of mortality of salmon and steelhead are of concern, and are the category of effects that are most likely to occur during this program. Sublethal effects are characterized as those that occur at concentrations that are below those that lead directly to death. Sublethal effects may impact the fish's behavior, biochemical and/or physiological functions, and create histological alterations of the fish's anatomy. In addition, changes in the sensitivities of fish to other contaminants (*i.e.*, chemical synergism), particularly pesticides and other aromatic hydrocarbons, may increase the mortality of exposed fish. Degradation of habitat is expected to occur due to decreases in DO level due to water hyacinth decomposition, decreases in native vegetative cover, decreases in the invertebrate standing population which reduces the forage base available to juvenile salmonids, and changes in ambient water temperature due to changes in the amount of vegetative cover.

6. <u>Sublethal Effects</u>

In contrast to the acute lethality endpoints associated with the WHCP, nonlethal or sublethal endpoints may be more appropriate to the levels of exposure likely to be seen in the herbicide application protocol employed in the WHCP. Sublethal or nonlethal endpoints do not require that mortality be absent; rather, they indicate that death is not the primary toxic endpoint being examined. Rand (1995) states that the most common sublethal endpoints in aquatic organisms are behavioral (*e.g.*, swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological (*e.g.*, growth, reproduction, and development), biochemical (*e.g.*, blood enzyme and ion levels), and histological changes (*e.g.*, degenerative necrosis of the liver, kidneys, and gill lamellae; Lorz *et al.* 1979). Some sublethal effects may indirectly result in mortality. Changes in certain behaviors, such as swimming or olfactory responses, may diminish the ability of the salmonids to find food or escape from predators and may ultimately result in death. Some sublethal effects may have little or no long-term consequences to the fish because they are rapidly reversible or diminish and cease with time. Individual fish may exhibit different responses to the same concentration of toxicant. The individual condition of the fish can significantly influence the outcome of the toxicant exposure. Fish with greater energy stores will be better able to survive a temporary decline in foraging ability, or have sufficient metabolic stores to swim to areas with better environmental conditions. Fish that are already stressed are more susceptible to the deleterious effects of contaminants, and may succumb to toxicant levels that are considered sublethal to a healthy fish.

a. *Narcosis*

Fish, when exposed to elevated concentrations of polar and nonpolar organic compounds such as the herbicides used in the WHCP, can become narcotized. Narcosis is a generalized nonselective toxicity response that is the result of a general disruption of cell membrane function. The process of narcosis is poorly understood, but is thought to involve either a "critical volume" change in cellular membranes due to the toxicant dissolving into the lipid membrane and altering its function, or by the "protein binding" process in which hydrophobic portions of receptor proteins in the lipid membrane are bound by the toxicant molecules, thus changing the receptor protein's function (Rand 1995). Exposure to elevated concentrations of the herbicides would occur in the immediate area of herbicide application, prior to dilution in the surrounding water column. A fish with narcosis would be more susceptible to predation as a result of a loss of equilibrium, a reduction in swimming ability or a lack of predator avoidance behavior. Furthermore, a fish with narcosis would also have difficulty maintaining its position in the water column, and could potentially be carried by water currents into areas of sub-optimal water quality where conditions may be lethal to salmonids (*e.g.*, hypoxic regions within water hyacinth mats).

b. *Rheotropism*

Rheotropism refers to fish behavior in a current of water, either directly as a response to water flowing over the body surface or indirectly as a response to the visual, tactile or inertial stimuli resulting from the displacement of fish in space (Dodson and Mayfield 1979). Fish respond physically and behaviorally to foreign stimuli (see Appendix A). Rainbow trout yearlings exposed to 0.5 ppm and 1.5 ppm of diquat for 24 hours exhibited no significant variation in the frequency of positive rheotaxis and a significant decrease in swimming speeds caused by short-term exposure to diquat (Dodson and Mayfield 1979). Subtoxic effects of diquat on yellow perch (*Perca flavescens*) include a level of respiratory stress indicated by the cough response and reduced swimming speeds in exposure to 1.0 to 5.0 ppm diquat over 48 hours to 72 hours (Bimber *et al.* 1976). Fish exposed to diquat over longer periods of time may move passively downstream and into decreasing concentrations of diquat, exhibiting a passive avoidance response. The level of chemical absorption is dependent upon the fish species as well as individual fish characteristics. Hiltebran *et al.* (1972) exposed bluegills (*Lepomis macrochirus*) to diquat and demonstrated that as the length of exposure time increased, proportionally less diquat appeared to have been absorbed. It was unknown if this result was due to the metabolism, or elimination, of diquat. A "leveling off" of diquat residues in fish tissue was observed in increasing diquat concentrations rather than with increasing exposure time (Dodson and Mayfield 1979).

c. *Chemical Interactions*

Rand (1995) states that in "assessing chemically induced effects (responses), it is important to consider that in the natural aquatic environment organisms may be exposed not to a single chemical but rather to a myriad or mixture of different substances at the same or nearly the same time. Exposures to mixtures may result in toxicological interactions." A toxicological interaction is one in which exposure to two or more chemical residues results in a biological response quantitatively or qualitatively different from that expected from the action of each chemical alone. Exposure to two or more chemicals simultaneously may produce a response that is simply additive of the individual responses or one that is greater (synergistic) or less (antagonistic) than expected from the addition of their individual responses. Application of herbicides from the WHCP project may contribute to elevated toxicological responses caused by unknown sources of chemical compounds within the project area. Over 30 different herbicides are applied annually on agricultural lands in the Delta, and an additional 5 million pounds are applied upstream in the Sacramento River, San Joaquin River, and French Camp Slough (Kuivila *et al.* 1999). Chemicals used by the WHCP may build up on sediments at treatment sites. High additive concentrations of the various herbicides utilized in the Central Valley can potentially impair primary production in a defined geographic area (Kuivila *et al.* 1999) if contaminated waters come together in a confined area. Waters that flow through treated locations can carry herbicides to adjacent areas while concentrations in the water are still high enough to cause adverse impacts to aquatic organisms, if present, and possibly irrigation, municipal waste supplies and recreation.

Exposure of fish to the aromatic hydrocarbons typical of many families of herbicides and pesticides may result in the biotransformation of these compounds by various enzyme systems in the fish. Most organic contaminants are lipophilic, a property that makes these compounds readily absorbed across the lipid membranes of the gill, skin, and gastrointestinal tract. Following absorption, compounds that are susceptible to biotransformation are converted to more water soluble metabolites that are easier to excrete than the parent compound. Compounds that are resistant to metabolism are often sequestered in the lipid-rich tissues of the body. Although biotransformation is often considered a positive event in the detoxification of the contaminant, the parent compound of some contaminants are actually less toxic than the metabolites formed. These reactive intermediate metabolites can cause significant problems in other metabolic pathways, including alterations in the synthesis of DNA and RNA, redox cycling of reactive compounds, and induction of enzymatic systems that could lead to altered metabolism of environmentally encountered contaminants (Di Giulo *et al.* in Rand 1995). Within the Delta, mixtures of contaminants, particularly organophosphate pesticides (OP's) are common. Induction of the biotransforming enzymatic pathways, particularly the p450 monooxygenases by herbicides, may actually increase the sensitivity of a fish to other environmental contaminants. Organophosphate insecticides often are activated by the monooxygenase system (Murty 1986, Dr. M.J. Lydy. Southern Illinois University, Carbondale, personal communication, 2003). Thus, the higher the activity of the monooxygenase system, the more reactive metabolite formed from the metabolism of these OP's.

In summation, all fish exposed to the chemical constituents in the herbicides and surfactants will be expected to exhibit some level of adverse effects. Acute direct exposures to higher concentrations of the active ingredients can result in death. On the other hand, exposures to lower concentrations of the active ingredients in the herbicides will result in a spectrum of responses ranging from avoidance reactions and mild physiological disturbances to long term morbidity and shortened life span. Exposure of listed fish to these herbicides can significantly increase their vulnerability to predation from both piscine and avian predators. Symptoms of behavioral and physiological perturbations resulting from exposure often make affected fish stand out to predators from their unexposed cohorts. Longer term impacts will include a decrease in the physiological health of exposed fish after they leave the application area. These adverse effects are expected to be magnified by the conditions present in the Delta during the project's application schedule. The degraded habitat that is currently representative of the Delta exposes listed salmonids to a myriad of chemical constituents, many of which are known to have toxic effects on salmonids. The multiple exposures of the fish to different compounds in the water, in addition to the exposure of the fish to the active compounds in the WHCP's proposed herbicides, is likely to exacerbate the rate of morbidity and mortality in exposed fish. The indications of these adverse effects may not present themselves for days to months following the exposure, and may be very subtle in nature, but will produce fish with a lowered chance of survival and hence a lowered chance for contributing to the recovery of the fish's population.

7. Effects on Habitat

a. Physical Disturbance

Operation of the program's water craft in the project area may result in effects due to wake turbulence, sediment resuspension, physical impact with propellers, and discharge of pollutants from the motor's exhaust and lubrication systems. These impacts may be exacerbated because the water hyacinth infested areas tend to be shallow and the dense vegetation mats enhance sediment accumulation through trapping suspended particulates on their leaves. Wake induced turbulence in these areas disturbs the sediments captured by these plants and resuspends it into the adjacent water column. The interaction of propellers with the vegetation shreds the plants into smaller fragments, some of which may retain their propagative viability if sufficient root structure remains.

b. Dissolved Oxygen Levels

Juvenile salmonids may be directly affected through the reduction in DO levels resulting from the decomposition of plants killed by the herbicide application. This effect may be amplified by increased water temperatures resulting from decreased shading due to the elimination of the water hyacinth mat. Low DO levels (< 3 mg/L) can result in fish kills if fish are unable to move out of the zone of hypoxic or anoxic waters. Low dissolved oxygen levels are particularly harmful to salmonids, which have a high metabolic requirement for dissolved oxygen (Bjornn and Reiser 1991). Studies have shown that dissolved oxygen levels below 5 mg/L have a significant negative effect on growth, food conversion efficiency, and swimming performance. High water temperatures, which result in reduced oxygen solubility, can compound the stress on fish caused by marginal DO concentrations (Bjornn and Reiser 1991). Stress from low DO can make juvenile salmonids more susceptible to predation and disease, and less likely to smolt due to insufficient energy reserves. Adult salmonids may experience delayed migration through Delta waters if DO is below concentrations needed for survival (Hallock *et al*. 1970). Delay in upstream migration can have a negative impact on the maturation of gonadal tissue, particularly if ambient water temperatures in the Delta are also elevated. Salmonids exposed to elevated temperatures during gonadal maturation have reduced fertility and lower numbers of viable eggs (CALFED 2000a). Fish exposed to DO levels below 5 mg/L for extended periods usually are compromised in their growth and survival (Piper *et al*. 1982). NOAA Fisheries expects that fish and mobile invertebrates generally will avoid areas with extensive infestations of water hyacinth due to the decreased ambient levels of DO in the water column.

The increased biomass of the floating water hyacinth mat will increase the respiratory burden on DO during the night and limit light penetration to submerged portions of the plants during the day, thus reducing photosynthesis and resultant oxygen production. Increased detrital deposition below the water hyacinth due to reduced water flow, and plant matter falling from the overlying mats will increase biological oxygen demand (BOD) in the affected areas of the infestation. The applications of herbicides are expected to initially decrease DO levels even further in areas treated for the plant. This would result from the decomposition of the dead vegetable matter and an increase in BOD. This effect is expected to be transitory as the decaying vegetation is dispersed by tidal and river currents from the treatment area. Areas of higher tidal and river current exposure will be flushed faster than areas of low water body exchange, such as dead end sloughs and restricted peripheral channels. Additional parameters affecting the DO levels are the rate of decay for the treated vegetation which is dependent on ambient water temperature and microbial activity. Higher water temperatures should theoretically result in higher microbial activity, thus resulting in a faster decline in the DO levels. However, the duration of the depressed DO levels should be shorter than in a cooler temperature profile due to the vegetative biomass being metabolized at a faster rate. Conversely, a cooler ambient temperature would result in a prolonged DO depression, although perhaps not to the hypoxic levels reached in a warmer water profile.

c. Invertebrate Populations

Invertebrates could be exposed to elevated concentrations of diquat, 2,4-D, or glyphosate from the WHCP if they occur within the immediate area of the initial application of herbicide concentrate to the water column. The volume of water available for dilution of the applied herbicide and the rate of water exchange will determine the extent of the elevated herbicide residues in the water column. The annual monitoring reports have indicated occasional elevated toxicity to *daphnia spp*. from monitored sites following herbicide applications, although direct correlations to the herbicide concentration has not been definitively made. Regions of low dissolved oxygen caused by drifting mats of decaying vegetation or smothering of benthic substrate may cause a localized decrease in populations and diversity of invertebrates. Many invertebrates have limited ability to migrate out of the treatment area, and thus are more susceptible to the effects of elevated herbicide concentrations or low dissolved oxygen levels. Following treatment, new populations of invertebrates are expected re-establish themselves through larval recolonization of the area as soon as habitat conditions are suitable for their growth. However, juvenile salmonids, at least temporarily, may be required to enlarge their foraging area to obtain sufficient food. This may increase their exposure to predators, decreasing their likelihood of survival. Also, the rate of survival for juvenile salmonids would be a balance between the amount of metabolic energy expended in swimming during foraging behavior versus the amount of caloric intake achieved from the prey captured during foraging. Caloric intake needs to exceed the metabolic cost of swimming in order for the juvenile fish to have sufficient energy reserves for growth and other metabolic needs.

d. Native Vegetation

There are potential impacts to native submerged and emergent vegetation from the WHCP. Long-term exposure to applied herbicides could significantly alter existing local plant community composition adjacent to these treatment sites due to the rates of recolonization and species abundance for pioneering plants. When applied at label rates, the program's herbicides are toxic to other aquatic plants they may come into contact with for an extended period of time.

Native submergent and emergent vegetation may be harmed or killed by the application of herbicides during the WHCP depending on the level of exposure. However, as with losses of invertebrates, NOAA Fisheries believes that a reduction in native vegetation would be temporary, as adjacent plants should recolonize the treated area. Removal of the thick mats of water hyacinth will allow light penetration to submergent plants in areas previously shaded by these mats. Likewise, the water hyacinth will not be able to smother and abrade native emergent plants. Treated areas also will allow the native plants the opportunity to re-colonize without competing with water hyacinth for space and nutrient resources. During periods of juvenile salmonid migration, treated areas may not provide the necessary vegetative cover or food resources needed by the fish. Treatment could possibly magnify this impact, increasing the areas devoid of aquatic vegetation or having compromised water quality. NOAA Fisheries believes that these localized effects will reduce the probability of survival of juveniles emigrating through or rearing in the treatment area. Adjacent untreated acreage could be available to provide shelter and foraging for the juvenile salmonids as they move out of the treated area. However, expenditures of metabolic reserves will have to be utilized for swimming to these new areas, making these reserves unavailable for other physiological needs like growth or smoltification. This shift in the utilization of metabolic energy stores has the potential to decrease the survival probability and physical health of juvenile salmonids.

e. Beneficial Effects

Reductions in the percentage of water hyacinth infested waterways is likely to increase the habitat area available for use by salmonids. It may also result in increased flows through these waterways, increased sunlight penetration, and re-establishment of native aquatic vegetation, and recolonization of native invertebrate species. These changes may result in positive effects on the suitability of the Delta waterways for salmonid rearing and migration.

VI. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area considered in this biological opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultations pursuant to section 7 of the ESA.

Cumulative effects include ongoing point and non-point storm water and irrigation discharges related to agricultural and urban activities. These discharges contain numerous pesticides and herbicides that may adversely affect salmonid reproductive success and survival rates. Agricultural practices in the Delta may reduce riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. Unscreened agricultural diversions throughout the Delta entrain all life stages of listed fish. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the Delta.

The Delta region, which includes portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus and Yolo counties, is expected to increase its population by nearly 3 million people by the year 2020 (California Commercial, Industrial and Residential Real Estate Services Directory 2002). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns.

Increased urbanization is expected to result in increased wave action and prop wash in Delta waterways due to increased boating activity. This potentially will degrade riparian and wetland habitat by eroding channel banks, thereby causing an increase in siltation and turbidity. Wakes and prop wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This in turn would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids. Increased boat operation in the Delta will likely also result in more contamination from the operation of engines on powered craft entering the water bodies of the Delta.

VII. INTEGRATION AND SYNTHESIS

The degree to which Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead may be impacted by the WHCP is a function of their presence within the action area. The proposed period of implementation of the WHCP is from March 1 through November 30, which will overlap with more than half of the migration periods for all three listed ESUs. The period of greatest overlap with the presence of listed juvenile salmonids in the Delta is during the higher flow periods of spring (*e.g.*, from March 1 through June 1) and fall (*e.g.*, October 1 through November 30).

Based on the foregoing analysis, NOAA Fisheries anticipates that applications of Reward®, Weedar®, or Rodeo® to the waters of the Delta and its tributaries during the WHCP treatment seasons in an effort to control water hyacinth will not result in acute lethal effects to listed salmonids, unless fish are present in the immediate area during or immediately after the herbicide is applied. Nonetheless, there is a potential for loss of a certain fraction of the migrating population that is exposed to the toxicants. Although fish should not be present in the cores of water hyacinth mats, they may be present along the periphery of the mats, utilizing them for cover from overhead predators. Thus, fish may be exposed to lethal or sublethal concentrations of herbicides that are applied to the margins of the mat or to herbicides present in the water column directly below the mat or flowing out of the area of application.

The most important impacts of the WHCP are expected to occur to juvenile salmonids, and include sublethal effects and effects to habitat. As stated in Rand (1995), sublethal effects to listed salmonids can be expected to take the form of behavioral, physiological, biochemical, or histological changes in the exposed fish. These changes may not be immediately lethal, but can cause fish to exhibit impaired behaviors (*e.g.*, narcosis) or eventually develop a lesser level of physical health, thus reducing their chances of survival as compared to unexposed fish. Possible consequences include loss of equilibrium, reduced swimming ability, and impaired predator avoidance behavior, which could lead to increased predation risk or reduced foraging ability. Chemical synergism between the WHCP herbicides and other contaminants in the Delta could occur and exacerbate these effects.

The WHCP is expected to result in several temporary degraded habitat conditions. These are expected to include physical disturbance, elevation of water temperature caused by reduced shading, reduction of dissolved oxygen levels resulting from decaying water hyacinth, reduction in the invertebrate forage base for juvenile salmonids, and reduction of native vegetation which juvenile salmonids may utilize for cover. Even though juvenile salmonids should be able to leave or avoid areas of degraded habitat, they may need to expend valuable metabolic energy to do so. This could result in depleted energy stores that could have been used for other physiological needs, such as growth or smoltification.

As stated previously in the project description, the WHCP proposes to treat 367 possible sites for water hyacinth infestation (see Table 1). These sites range between one to two miles in length. Treatment sites are located throughout the Delta, including portions of the Sacramento River, Steamboat Slough, and Sutter Slough, as well as most of the San Joaquin River watershed between the first dam on each tributary and its confluence downstream with the mainstem of the San Joaquin River and then north along the mainstem to the Delta. The geographical coverage of the WHCP overlaps with the known migration corridors for all three listed salmonids as well as the fall/late fall run of Chinook salmon in the Central Valley. However, DBW has a limited number of spray boats (i.e., in 2002, four full time and three part time crews and boats were used) that can be active on any given weekday. Therefore, only a fraction of the 367 sites can be treated in any given day, and not all sites treated may be within areas expected to support salmonids. Each crew is capable of treating at a maximum 50 acres per a day if conditions are optimal and they work overtime. However, due to environmental and logistical constraints, the treatment acreage is frequently less. In addition to the low number and area of coverage of daily sites for the treatment program, only the waters near the periphery of the water hyacinth mat will have elevated herbicide concentrations capable of having toxicological effects on the fish. Even though the interior of the mat will have similar elevated concentrations of herbicides following treatment, it is unlikely that any salmonids will be present within the interior due to its low ambient DO levels. Therefore the total area of Delta waters likely to have negative effects on fish during the period of elevated concentrations is far smaller than 50 acres on any given treatment day. As a result, NOAA Fisheries reasons that very few listed salmonids will be present within areas of toxicological effect. The duration of elevated herbicidal concentrations in the peripheral waters will depend on the rate of mixing that occurs and the subsequent dilution of the herbicide applied to the mat as well as other physical conditions such as adsorption to suspended matter in the water column and water hardness. The dilution of applied herbicides will occur over a period of minutes to hours, dependent on current velocity, tidal stage and local water quality. These parameters will invariably change on both a spatial and temporal scale in the described action area. Therefore, NOAA Fisheries expects that areas with elevated herbicide concentrations will be both small and transient in nature, resulting in low levels of exposure to salmonids migrating through the action area and transitory impacts on critical habitat. Degraded habitat conditions eventually will be attenuated as DO levels increase and invertebrates recolonize treated areas. In addition, the removal of water hyacinth eventually may improve habitat conditions for juvenile salmonids if water flow improves and native vegetation colonizes the treated areas, creating shaded habitat.

While there will be negative impacts to a proportion of the listed salmonid populations that are within the immediate vicinity of a herbicidal application at the moment of application or immediately following it, the exact proportion of each ESU affected by the application is difficult to determine since the density of migrating fish and the timing of migration can vary annually and within seasons based on a myriad of factors. However, as discussed above, only a small segment of each listed salmonid race is expected to be actually exposed to concentrations sufficiently elevated to have a negative impact on the individual fish. Effects of primary concern are sublethal, as few or no fish are likely to be directly killed during herbicide application. Sublethal effects such as behavioral changes (*e.g.*, swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological changes (*e.g.*, growth, reproduction, and development), biochemical changes (*e.g.*, blood enzyme and ion levels), and histological changes (*e.g.*, degenerative necrosis of the liver, kidneys, and gill lamellae) are expected in the fish that are exposed to areas of elevated herbicide and surfactant concentrations. However, based on the low likelihood of fish exposure to these levels and the small numbers of salmonids likely affected, this level of impact is not expected to detectably reduce the numbers, reproduction, or distribution of the cohorts affected during each year of treatment.

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the current status of the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, the environmental baseline, the effects of the proposed WHCP for years 2003 through 2005, and the cumulative effects, it is NOAA Fisheries' biological opinion that the WHCP, as proposed, is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead, or result in the destruction or adverse modification of the designated critical habitat for Sacramento River winter-run Chinook salmon.

Notwithstanding this conclusion, NOAA Fisheries anticipates that some activities associated with this project may result in the incidental take of these species. Therefore, an incidental take statement is included with this Biological Opinion for these actions.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act 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 NOAA Fisheries as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary and must be undertaken by the USDA-ARS so that they become binding conditions of any grant or permit issued to the DBW, as appropriate, for the exemption in section 7(o)(2) to apply. The USDA-ARS has a continuing duty to regulate the activity covered in this Incidental Take Statement. If the USDA-ARS: (1) fails to assume and implement the terms and conditions of the Incidental Take Statement, and/or (2) fails to require the DBW to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the USDA-ARS and the DBW must report the progress of the action and its impact on the species to NOAA Fisheries as specified in this Incidental Take Statement (50 CFR § 402.14 (i)(3)).

This Incidental Take Statement is applicable to the operations of the WHCP as described in the initiation package received by NOAA Fisheries on November 19, 2002, which was authored by the DBW and submitted by the USDA-ARS. All applications of permitted herbicides as described in the project description for the program will have incidental take coverage as stipulated under the terms of section 7(b)(4) and section 7(o)(2) of the ESA during the operational season approved by NOAA Fisheries (*i.e.*, April 1 through October 15) for the years 2003 through 2005, providing that the terms and conditions of this biological opinion are implemented. The incidental take coverage for this biological opinion will terminate following the close of the 2005 application season (October 15, 2005). After this time, incidental take of listed salmonids by the WHCP will not be exempt from the take prohibitions of section 9 of the ESA under the authority of this biological opinion.

A. Amount or Extent of Take

NOAA Fisheries anticipates that the proposed WHCP will result in the incidental take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead due to direct and indirect impacts caused by the application of chemical herbicides to waters of the Delta. Any incidental take resulting from the project will most likely be limited to emigrating fry and juveniles present in the Delta action area during the operational season of the WHCP. The incidental take is expected to be in the form of death, injury, harassment, and harm.

The numbers of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead directly taken will be difficult to quantify because dead and injured individuals will be difficult to detect and recover. However, take is expected to include:

1. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead juveniles harmed or killed from exposure to lethal or sublethal concentrations of diquat, 2,4-D, glyphosate and their application mixtures applied to waters of the Delta during implementation of the WHCP (*i.e.*, applicant's proposed implementation period from March 1 through November 30) for the years 2003 through 2005. Sublethal exposure may cause behavioral changes (*e.g.,* narcosis) or declines in physical health that may result in decreased growth or increased likelihood of predation.

2. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead juveniles harmed, harassed, or killed from altered habitat conditions caused by the application of diquat, 2,4-D, glyphosate and their application mixtures to the waters of the Delta during implementation of the WHCP (*i.e.*, applicant's proposed implementation period from March 1 through November 30) for the years 2003 through 2005. Such conditions may include reduced DO levels, reduced food supply, physical disturbance, and consequent avoidance of habitat and increased energy expenditure and likelihood of predation.

B. Effect of the Take

In the accompanying biological opinion, NOAA Fisheries determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

C. Reasonable and Prudent Measures

Pursuant to section 7(b)(4) of the ESA, the following reasonable and prudent measures are necessary and appropriate to minimize take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead.

1. Measures shall be taken to reduce impacts to juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead from chemical control treatment and/or monitoring activities.

2. Measures shall be taken to reduce the impact of DBW's WHCP boating operations on Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead.

3. Measures shall be taken to monitor the DBW's WHCP operations and the ambient Delta hydrologic conditions.

D. Terms and Conditions

In order to be exempt from the prohibitions of Section 9 of the Act, the USDA-ARS must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. **Measures shall be taken to reduce impacts to juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead from chemical control treatment and/or monitoring activities.**

    a. Chemical controls for the WHCP in the Delta shall not be applied before April 1 of each control season in any portion of the action area. Applications of herbicides may be conducted in areas of the Delta as follows:

        i. The following sites may be treated after April 1 of each application season. Treated sections should start at the inner margin of the infested water body and move progressively outwards towards the main channels, as practical:

        - The San Joaquin River upstream of the confluence with the Merced River (Hills Ferry) and associated sloughs and canals in Merced and Fresno counties south of the confluence of the Merced and San Joaquin Rivers.

        - Delta east side sloughs that have minimal current and unsuitable salmonid habitat:

          Fourteenmile Slough east of Shima Tract
          Pixley Slough
          Rio Blanco Tract
          White and Disappointment Slough, east of Honker Cut
          Sycamore Slough
          Hog Slough
          Beaver Slough
          Lost Slough
          Snodgrass Slough above the Delta Cross Channel
          Stone/ Beach Lakes Area

        ii. Areas available to herbicide application as of April 15 are portions of the South Delta that are within the region bounded by the placement of the four South Delta Temporary Barriers. These include portions of Old River, Middle River, Paradise Cut, Salmon Slough, Tom Paine Slough, Sugar Slough, Grant Line, Fabian, and Bell Canals.

iii. The remainder of the action area may be treated after June 1, or when IEP data indicates that the pulse of migrating salmon has moved through the Delta. If IEP data shows that fish are still present in these reaches, spraying activities may be suspended upon the discretion of NOAA Fisheries personnel. Between July 1 and October 15, there are no application restrictions for areas to be sprayed within the defined action area.

iv. The WHCP may operate from July 1 through October 15 without restriction to locations treated throughout the project area; chemical controls for the EDCP shall not be applied after October 15 of each treatment season.

b. Any winter-run Chinook salmon, spring-run Chinook salmon, and steelhead trout mortalities found at or in the vicinity of a treatment site (*i.e.*, within 400 meters) shall be collected, fork length measured and the body placed in a whirl-pak bag. The bag will be labeled with the time, date, location of capture, and a description of the near-shore habitat type and water conditions and frozen. NOAA Fisheries, Sacramento office shall be notified as soon as possible of any mortalities at 916-930-3600 and a representative of NOAA Fisheries will collect the specimen.

c. DBW staff and their assigned agents must follow all Federal and State laws applicable to the use of the herbicides and any adjuvants and apply them in a manner consistent with the product labeling, the current NPDES permit or the NPDES General Permit if granted, the Description of the Proposed Action, and determinations from the California Department of Pesticide Regulation.

d. The use of the adjuvant R-11 shall be reduced to minimize its toxic effects on aquatic organisms where practicable. The less toxic adjuvant, Agri-Dex, shall be used in its place.

e. Fish passage shall not be blocked within treatment areas. Protocols shall be followed to ensure that WHCP operations do not inhibit passage of fish in each area scheduled for treatment or exceed limitations on contiguous treated acreage.

f. The DBW will provide a copy of each week's Notice of Intent (NOI) to Jeffrey Stuart, Fishery Biologist, Protected Resources Division, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814, by the Friday prior to the treatment week. This notification will include the sites scheduled for treatment and a contact person for those sites.

g. Jeffrey Stuart will be the appointed NOAA Fisheries representative on the Water Hyacinth Task Force (Task Force), and provide technical assistance to the Task Force along with carrying out the duties of a Task Force member. As part of the WHCP Task Force, the NOAA Fisheries representative will be active in guiding decisions on prioritizing treatment sites in regards to the presence of salmonids.

2. Measures shall be taken to reduce the impact of DBW's WHCP boating operations on designated critical habitat of Sacramento River winter-run Chinook salmon, and habitat for Central Valley spring-run Chinook salmon and Central Valley steelhead.

a. USDA-ARS and DBW shall comply with the receiving water limitations of the Individual Permit (or the General Permit, if granted) issued for the WHCP in regards to oils, greases, waxes, floating material, or suspended material derived from the operation of program vessels or application activities.

b. The USDA-ARS and DBW shall ensure that any mixing of chemicals, or disinfecting and cleaning of any equipment shall be done in strict accordance with the operational protocols of the WHCP and that all equipment is in working order prior to engaging in application activities, including the operation of the program's vessels.

c. Operation of program vessels in shallow water habitats shall be done in a manner that causes the least amount of disturbance to the habitat. Operational procedures for vessels in these habitats should minimize boat wakes and prop wash.

d. Operation of program vessels shall avoid or minimize to the greatest practicable extent dislodging portions of existing water hyacinth mats that can drift into other areas. This will avoid or minimize new infestations of the weed due to drifting fragments.

3. Measures shall be taken to monitor DBW's WHCP's control operations and Delta hydrologic conditions.

a. The USDA-ARS shall ensure that the DBW follows a comprehensive monitoring plan designed to collect project operational information. The monitoring plan shall adhere to the requirements of the Individual Permit, or if granted, the General Permit and have at a minimum those water quality criteria stated in Attachment B of the permit, *i.e.* data on water temperatures, dissolved oxygen, pH, turbidity, water hardness, electrical conductivity and chemical concentrations in the application areas as well as other criteria stated in the attachment. Chemical concentrations (including both herbicides and adjuvants) shall have at a minimum, a pre- and post-application water sample taken at the furthest down current site of the application zone. Previous water sampling protocols provided only a minimal accounting of chemical dispersion profiles.

In order to provide a more complete profile of initial dispersion rates, water samples shall be drawn at the following depths below the water surface: 0.5, 1, 2, 4 feet, and one foot above the bottom, within five minutes of cessation of the application of the herbicide(s). Additional tests, if required by other federal and state agencies, shall be conducted and the information made available to NOAA Fisheries. The results of this monitoring program will be used to determine if the DBW is affecting Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead trout to an extent not previously considered.

b. The USDA-ARS, in coordination with the DBW, shall provide bimonthly (*i.e.*, every other month) monitoring reports of the hydrologic conditions and the amounts of chemical discharges to Jeffrey Stuart, NOAA Fisheries, Sacramento Field Office. These reports shall also include information on the following parameters:

    i. Pre-treatment and post-treatment measurements on chemical residues, pH and turbidity levels as well as water temperatures and dissolved oxygen concentrations at selected sites in the Delta. These sites shall be reflective of the different water types found in the range of application sites and will be determined by DBW as part of their NPDES permit conditions.

    ii. Receiving water temperatures and dissolved oxygen levels and resultant changes in those conditions resulting from WHCP operations during each month.

    iii. Amounts, types, and dates of application of herbicides and adjuvants applied at each site.

    iv. Visual assessment of pre- and post-treatment conditions of treated sites to determine the efficacy of treatment and any effects of chemical drift on downstream habitats immediately adjacent to the treated sites.

    v. Operational status of equipment and vessels, including repairs and spraying equipment calibrations as needed.

c. The USDA-ARS, in coordination with the DBW, shall summarize the above bimonthly reports into an annual report of the DBW project operations, monitoring measurements and Delta hydrological conditions for the previous treatment year for submission to NOAA Fisheries by January 31 of each year. The annual report of DBW operations shall also include:

i. A description of the total number of winter-run and spring-run chinook salmon or steelhead observed taken, the manner of take, and the dates and locations of take, the condition of the winter-run chinook salmon, spring-run chinook salmon, or steelhead trout taken, the disposition of fish taken in the event of mortality and a brief narrative of the circumstances surrounding the take of the fish. This report shall be sent to the address given below.

ii. Listed salmonids or other fish species that are observed to be behaving in an erratic manner shall be reported (see Appendix A).

d. All bimonthly reports and the annual report shall be submitted by mail or Fax to:

NOAA Fisheries-Sacramento Field Office
Attn: Supervisor
650 Capitol Mall, Suite 8-300
Sacramento, California 95814
Fax: (916)930-3629

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on a listed species or critical habitat or regarding the development of pertinent information.

1. The USDA-ARS and DBW should support anadromous salmonid monitoring programs throughout the Sacramento-San Joaquin Delta to improve the understanding of migration and habitat utilization by salmonids in the Delta region.

2. The USDA-ARS and DBW should support and promote aquatic and riparian habitat restoration within the Delta region, and encourage practices that avoid or minimize negative impacts to salmon and steelhead as described in Appendix A of Attachment 14 to the Pacific Coast Salmon Plan as they pertain to agricultural practices in the project area through education, extension programs, and research.

3. The USDA-ARS and DBW should encourage alternative non-chemical controls of water hyacinth and other non-native invasive vegetation in the Sacramento/San Joaquin Delta and its tributaries, in conjunction with a re-vegetation program with native plants in the Delta.

4. The USDA-ARS and DBW should increase public awareness of the potential threats to proper ecosystem function by exotic species introductions such as water hyacinth.

5. The USDA-ARS and DBW should pro-actively promote state legislation that takes steps to curb the importation and marketing of water hyacinth, and prevent future exotic species introductions into the state.

In order for NOAA Fisheries to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, NOAA Fisheries requests notification of the implementation of any conservation recommendations.

XI. REINITIATION OF CONSULTATION

This concludes formal consultation on the actions outlined in the November 16, 2002 request for consultation received from the USDA-ARS. This biological opinion is valid for the project described for the years 2003 through 2005. As provided for 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 taking specified in any incidental take statement 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 previously considered; (3) the agency action is subsequently modified in a manner that causes an affect to the listed species that was not considered in the biological opinion; or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

XII. Literature Cited

Abdelghani, A.A., Tchounwou, P.B., A.C. Anderson, H. Sujono, L.R. Heyer, and A. Monkiedje. 1997. Toxicity of single and chemical mixtures of Roundup, Garlon-3A, 2,4-D and Syndets Surfactant to channel catfish (*Ictalurus punctatus*), bluegill Sunfish (*Lepomis macrochirus*), and crawfish (*procambarus spp.*). *Environ. Toxicol. Water Qual.* 12: 237-243.

Allen , M.A. and T.J. Hassler. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest), chinook salmon. U.S. Fish and Wildlife Service Report 82 (11.49). April 1986.

Anderson, L. W.J. 1982. Experimental application of 2,4-D Dichlorophenoxy acetic acid (2,4-D) for the control of water hyacinth in the delta. United States Dept. of Agriculture, Agricultural Research Service. Davis, California. 17pp.

Arbuckle, T.E., Z. Lin, and L.S. Mery. 2001. An Exploratory analysis of the effect of pesticide exposure on the risk of spontaneous abortion in an Ontario farm population. *Environ. Health Perspect.* Aug 109(8): 851-857.

Arbuckle, T.E., S.M. Schrader, D. Cole, J.C. Hall, C.M. Bancej, L.A. Turner, and P. Claman. 1999. 2,4-Dichlorophenoxyacetic acid residues in semen of Ontario farmers. *Reprod. Toxicol.* Nov-Dec 13(6): 421-429.

Bailey, R.G. and M.R. Litterick, (1993). The Macroinvertebrate fauna of water hyacinth fringes in the Sudd swamps (River Nile, southern Sudan). *Hydrobiologia* 250:97-103.

Barbosa, E.R., M.D. Leiros da Costa, L.A. Bacheschi, M. Scaff, and C.C. Leite. 2001. Parkinsonism after glycine-derivative exposure. *Mov. Disord.* 16(3):565-568.

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

Bimber, K.L. 1976. Respiratory stress in yellow perch induced by subtoxic concentrations of diquat. *Ohio J. Science*. 76(2):87-90.

Bjornn, T.C. and D.W. Reiser, 1991. Habitat requirements of salmonids in streams. *In*: W. Meehan: Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitat. American Fisheries Society Special Publication 19. Bethesda, Maryland. Pp 83-138.

Brett, J.R. 1952. Temperature tolerance of young Pacific salmon, genus *Oncorhynchus*. *J. Fish. Res. Bd. Can.* 9: 265-323.

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

CALFED Bay Delta Program. 2000a. Comprehensive Monitoring, Assessment and Research Program. Final Programmatic EIS/EIR Technical Appendix. Appendices found at http://calfed.ca.gov/programs/cmarp/.

CALFED Bay Delta Program. 2000b. Ecosystem Restoration Program (ERP) Vol. 1, Sacramento California. Prepared for the CALFED Bay Delta Program.

California Commercial, Industrial and Residential Real Estate Services Directory, found at http://www.ured.com/citysubweb.html.

California Department of Fish and Game (DFG). 1998. A status review of the spring-run Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River Drainage. State of California, The Resources Agency. 49 pp.

California Regional Water Quality Control Board-Central Valley Region. 1998. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins. http://www.swrcb.ca.gov/~rwqcb5/home.html

California Regional Water Quality Control Board-Central Valley Region. 2001. *Draft Staff Report on Recommended Changes to California's Clean Water Act Section 303(d) List*. Found at http://www.swrcb.ca.gov/rwqcb5/tmdl/.

Calkins, R.D., W.F. Durand, and W.H. Rich. 1940. Report of the board of consultants on the fish problem of the upper Sacramento River. Stanford University., 34 pp. (Available from Environmental and technical Services division, NMFS, 525 N.E. Oregon St. Suite500, Portland, OR. 97232.)

Campbell, K.R., S.M. Bartell, and J.L Shaw. 2000. Characterizing aquatic ecological risks from pesticides using a diquat dibromide case study. II. Approaches using quotients and distributions. Environmental Toxicology and Chemistry 19(3):760 - 774.

Carpenter, L.A. and D.L. Eaton. 1983. The disposition of 2, 4-Dichlorophenoxy acetic acid in rainbow trout. *Arch. of Environ. Contamin. Toxicol.* 12:169-173.

Conomos, T. J., R.E. Smith and and J. W. Gartner, (1985). Environmental settings of San Francisco Bay. *Hydrobiologia* 129: 1-12.

Curran, C.A., J.M. Grassley, and C.E. Grue. 2003. Toxicity of R-11® Surfactant to Juvenile Rainbow Trout: Does Size Matter? Program and Abstracts: 12th Annual Meeting of the Pacific Northwest Chapter of the Society of Environmental Toxicology and Chemistry (PNW-SETAC).

Diamond, G.L. and P.R. Durkin. 1997. Effects of Surfactants on the Toxicity of Glyphosate, with Specific Reference to Rodeo. Prepared by Syracuse Environmental Research Associates for the Animal and Plant Health Inspection Service (APHIS). Report Number SERA TR 97-206-1b.

Di Giulo, R.T., W.H. Benson, B..M. Sanders, and P.A. Van Veld. 1995. Biochemical Mechanisms: Metabolism, Adaptation, and Toxicity Rand, G.M. (editor): Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment, Second Edition. Taylor and Francis, 1995. pp 523-560.

Dodson, J.J. and C.I. Mayfield. 1979. Modification of the rheotropic response of rainbow trout (Salmo gairdneri) by sublethal doses of the aquatic herbicides diquat and simazine. Environ. Pollut. 18:147-157.

Doe, K.G., W.R. Ernst, W.R. Parker, G.R. Julien, and P.A. Hennigar. 1988. Influence of pH on the acute sublethality of fenitrothion, 2,4-D, and aminocarb and some ph-altered sublethal effects of aminocarb on rainbow trout (*Salmo gairdneri*). *Can J. Fish. Aquat. Sci.* 45: 287-293.

Dunford, W. E. 1975. Space and food utilization by salmonids in marsh habitats in the Fraser River Estuary. M.Sc. Thesis. University of British Colombia, Vancouver, B.C. 81 pp.

Ecobichon, D.J. 1996. Toxic effects of Pesticides *In*: Casarett & Doull's Toxicology: The Basic Science of Poisons, Fifth Edition. Curtiss D. Klassen, editor. McGraw Hill. New York. Pp. 643-690.

El-Gendy, K.S., N.M. Aly, and A.H. El-Sebae. 1998. Effects of edifenphos and glyphosate on the immune response and protein biosynthesis of boltifish (*Tilapia nilotica*). *J. Environ. Sci. health,* B 33(2): 135-149.

Environment Canada. 2003. Priority Substances Assessment Program, Existing Substances Evaluation. Assessment Report - Nonylphenol and its Ethoxylates. Available at: http://www.ec.gc.ca/substances/ese/eng/psap/final/npe.cfm

Extoxnet.1993. Extension Toxicology Network, Toxicology Briefs. A Pesticide Information Profile of the Cooperative Extension Offices of Cornell University, Oregon State University, University of Idaho, University of California, Davis and the Institute for Environmental Toxicology at the University of Michigan. Found at http://pmep.cce.cornell.edu/profiles/extoxnet/dienchlor-glyphosate/diquat-ext.html

Extoxnet.1996. Extension Toxicology Network, Toxicology Briefs. A Pesticide Information Profile of the Cooperative Extension Offices of Cornell University, Oregon State University, University of Idaho, University of California, Davis and the Institute for Environmental Toxicology at the University of Michigan. Found at http://ace.orst.edu/info/extoxnet/pips/diquatdi.html.

Extoxnet.2001. Extension Toxicology Network, Toxicology Briefs. A Pesticide Information Profile of the Cooperative Extension Offices of Cornell University, Oregon State University, University of Idaho, University of California, Davis and the Institute for Environmental Toxicology at the University of Michigan. Found at http://pmep.cce.cornell.edu/profiles/extoxnet.24d-captan/24d-ex.html.

Faustini, A. L. Settimi, R. Pacifici, V. Fano, P. Zuccaro, and F. Forastiere. 1996. Immunological changes among farmers exposed to phenoxy herbicides: preliminary observations. *Occup. Environ. Med.* Sept. 53(9): 583-585.

Fisher, F.W. 1994. Past and present status of Central Valley chinook salmon. *Conservation Biology*. 8(3):870-873.

Folmar, L.C. 1976. Overt avoidance of rainbow trout fry to nine herbicides. *Bull. Environ. Contam. and Toxicol.* 15(5): 509-514.

Folmar, L.C., H.O. Sanders and A.M. Julin. 1979. Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates. *Arch. Environ. Contamin. Toxicol.* 8:279-278.

George, J.P., H.G. Hingorani, and K.S. Rao. 1982. Herbicide toxicity to fish food organisms. *Environmental Pollution. (Series. A)* 28: 183-188.

Gilderhus, P.A. 1967. Effects of Diquat on bluegills and their food organisms. *Prog. Fish Cult.* 29(2): 67-74.

Gopal, B. and K.P. Sharma, 1981. Water-Hyacinth (*Eichhornia crassippes*): the most troublesome weed in the world. Hindasia publishers, Delhi, India.

Goyer, R.A. 1996. Toxic Effects of Metals *In:* Casarett & Doull's Toxicology: the Basic Science of Poisons, Fifth Edition. Curtis D. Klassen, editor. McGraw Hill. New York. Pp. 691-736.

Grimaldo, L., R. Miller, C. Peregrin, Z. Hymanson, and J. Toft. 2000 How does Brazilian waterweed (*Egeria densa*) influence the fish assemblage in the Sacramento-San Joaquin Delta (Ca): Potential conflicts with ecosystem restoration. in Aquatic Invaders: Entry, Impact, and Control. American Fisheries Society Annual Meeting, August 20 - 24, 2000, St. Louis, Mo. Missouri Chapter of the American Fisheries Society and Missouri Department of Conservation

Hallock, R.J., R.F. Elwell, and D.H. Fry, Jr. 1970. Migrations of adult king salmon *Oncorhynchus tshawytscha* in the San Joaquin Delta as demonstrated by the use of sonic tags. California Department of Fish and Game, fish Bulletin 151.

Hardell, L. and M. Eriksson. 1999. A case-control study of non-Hodgkin lymphoma and exposure to pesticides. *Cancer* March 15 85(6): 1353-1360.

Hartzler, R. 2001. Glyphosate –A Review. Iowa State University, Extension Agronomy. Found at http://www.weeds.edu/mgmt/2001/glyphosate%20review.html.

Healey, M.C. 1980. Utilization of the Nanaimo River estuary by juvenile chinook salmon *Oncorhynchus tshawytscha. Fish. Bull*. 77:653-668.

Healey, M.C. 1982. Juvenile pacific salmon in estuaries: the life support system. Pp.315-341. *In*: V.S. Kennedy (ed.). Estuarine Comparisons. Academic Press, New York, NY.

Healey, M. 1991. Life history of chinook salmon. *In*: C. Groot and L. Margolis: Pacific Salmon Life Histories. University of British Columbia Press. Pp 213-393.

Herren, J.R. and S.S. Kawasaki. 2001. Inventory of Water Diversions in Four Geographic Areas in California's Central Valley. *In*: R.L. Brown, ed. Fish Bulletin 179: Contributions to the Biology of Central Valley Salmonids. Vol. 2. Sacramento, CA, California Department of Fish and Game. Pp: 343-355.

Hill, B., E. Young, D.J. Oh, 2002. 2,4-Dichlorophenoxyacetic Acid Degradation Pathway Map. University of Minnesota. Found at http://umbbd.ahc.umn.edu/2,4-d/2,4-d_map.html.

Hiltibran, R.C., D.L. Underwood and J.S. Fickle. 1972. Fate of Diquat in the Aquatic Environment. University of Illinois, Water Resources Center. Water Research Report No. 52. Final Report - Project No. A-035-Ill.

Holm, L.G., D.L. Plucket, J.V. Pancho, and J.P. Herberger, 1977. The World's worst weeds; Distribution and biology. Honolulu, University Press of Hawaii.

Ingersoll, C.G. (1995) Sediment Tests *in* Rand, G.M. (editor): Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment, Second Edition. Taylor and Francis, 1995. pp 231-255.

Interagency Ecological Program (IEP) Steelhead Project Work Team. 1999. Monitoring, assessment, and research on Central Valley steelhead; Status of knowledge, review existing programs, and assessment needs. *In*: Comprehensive Monitoring, Assessment and Research Program Plan, Tech. App. VII-11.

Janz, D.M., A.P. Farrell, J.D. Morgan, and G.A. Vigers. 1991. Acute stress responses of juvenile coho salmon (*Oncorhynchus kisutch)* to sublethal concentrations of Garlon 4®, garlon 3A® and Vision® herbicides. *Environ. Tox. and Chem.* 10: 81-90.

Johnson, W.W. and M.T. Finely. 1980. Handbook of Acute toxicity of Chemicals to Fish and Aquatic Invertebrates, Resource Publications 137. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 10-38.

Kamrin, M.A., ed. 1997. Pesticide Profiles: Toxicity, Environmental Impact, and Fate. Institute for Environmental Toxicology, Michigan State University, East Lansing, MI. Lewis Publishers, Boca Raton, NY.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1981. Influences of freshwater inflow on chinook salmon (*Oncorhynchus tshawytscha)* in the Sacramento-San Joaquin estuary, pp. 88-102. *In*: R.D. Cross and D.L. Williams (eds.). Proceedings of the National Symposium on Freshwater Inflow to Estuaries. USFWS Biol. Serv. Prog. FWS/OBS-91/04(2).

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento- San Joaquin estuary, California, pp. 393-411. *In*: V.S. Kennedy (ed.). Estuarine Comparisons. Academic Press, New York, NY.

Kuivila, K.M., H.D.Barnett, and J.L. Edmunds. 1999. Herbicide concentrations in the Sacramento-San Joaquin Delta, California. in U.S.Geological Survey Toxic Substances Hydrology Program - Proceedings of the Technical Meeting. Charleston, South Carolina, March 8-12, 1999, Vol. 2, Contamination of Hydrologic Systems and Related Ecosystems, 1999, U.S.Geological Survey Water-Resources Investigations Report 99-4018B1999, pp. 69-79.

Levings, C.D. 1982. Short term use of low-tide refugia in a sand flat by juvenile chinook, (*Oncorhynchus tshawytscha)*, Fraser River estuary. *Can Tech. Rpt. Fish. and Aquat. Sci.* 1111. 7 pp.

Levings, C.D., C.D. McAllister, and B.D. Chang. 1986. Differential use of the Campbell River estuary, British Colombia, by wild and hatchery-reared juvenile chinook salmon (*Oncorhynchus tshawytscha*). *Can. J. Fish. Aquat. Sci.* 43:1386-1397.

Levy, D.A. and T.G. Northcote. 1981. The distribution and abundance of juvenile salmon in marsh habitats of the Fraser River estuary. Westward Research Center, University of British Columbia, Vancouver, Canada. Technical Report No. 25. 117pp.

Lorz, H.W., S.W. Glenn, R.H. Williams, and C.M. Kunkel. 1979. Effects of selected herbicides on smolting of coho salmon. U.S. Environ. Prot. Agency, Ecol. Res. Ser. EPA-600/3-79-071. Corvallis, Oregon. 101 pp.

Lynge, E. 1998. Cancer incidence in Danish phenoxy herbicide workers, 1947-1993. *Environ. Health. Perspect.* Apr 106 Suppl. 2:683-686.

Manguin, S., D.R. Roberts, R.G. Andre, E. Rejmankova, and S. Hakre, (1996). Characterization of *Anopheles darlingi* (Diptera: Culicidae) Larval Habitats in Belize, Central America*. J. Med. Entomol*. 33(2): 205-211.

McDonald, J. 1960. The behavior of Pacific salmon fry during the downstream migration to freshwater and saltwater nursery areas. *J. Fish. Res. Board Can.* 17(5): 655-676.

McDuffie, H.H., P. Pahwa, J.R. McLaughlin, J.J. Spinelli, S. Fincham, J.A. Dosman, D. Robson, L.F. Skinnider, and N.W. Choi. 2001. Non-Hodgkin's lymphoma and specific pesticide exposures in men: cross-Canada study of pesticides and health. *Cancer Epidemiol. Biomarkers Prev*. Nov 10(11): 1155-1163.

McEwan, D.R. and T. Jackson. 1996. Steelhead Restoration and Management Plan for California. Calif. Dept. of Fish and Game, February, 1996. 234 pp.

Meehan, W.R., L.A. Norris, and H.S. Sears. 1974. Toxicity of various formulations of 2,4-D to salmonids in Southeast Alaska. *J Fish. Res. Board Can.* 31: 480-485.

Meyers, R.P. (1992). Residential Encroachment on Wetlands. *Proc. Calif. Mosq. Vector Control Assoc.* 60: 17-20.

Mitchell, D.G., P.M. Chapman, and T.J. Long. 1987a. Acute toxicity of Roundup® and Rodeo® herbicides to rainbow trout, chinook, and coho salmon. *Bull. Environ. Contam. Toxicol.* 39: 1028-1035.

Mitchell, D.G., P.M. Chapman, and T.J. Long. 1987b. Seawater challenge testing of coho salmon smolts following exposure to Roundup® herbicide. *Environ. Toxicol. And Chem.* 6:875-878.

Mitchell, D.S. 1976. The growth and management of *Eichhornia crassipes* and *Salviniai* spp. in their native environment and in alien situations. *In*: Varsheny, C.K. and J. Rzoska, editors, Aquatic Weeds in Southeast Asia. The Hague: Dr. W. Junk b.v., Publishers.

Morgan, J.D., G.A. Vigers, A.P. Farrell, D.M. Janz, and J.F. Manville. 1991. Acute avoidance reactions and behavioral responses of juvenile rainbow trout (*Oncorhynchus mykiss*) to Garlon 4® and Garlon 3A® and Vision® herbicides. *Environ. Tox and Chem.* 10: 73-79.

Morgan, M.J. and J.W. Kiceniuk. 1992. Response of rainbow trout to a two month exposure to Vision®, a glyphosate herbicide. *Bull. Environ. Contamin. Toxicol.* 48:772-780.

Moyle, P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern of California. Wildlife and Fisheries Biology Department, U. C. Davis. Prepared for the Resources Agency, California Department of Fish and Game, Rancho Cordova. 222 p.

Murty, A.S. 1986. Toxicity of Pesticides to Fish. Boca Raton, FL. CRC Press.

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. Dept. of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35, 443 pp.

National Marine Fisheries Service (NMFS). 1997. Proposed recovery plan for the Sacramento River winter-run chinook salmon. NMFS, Southwest Region, Long Beach, California. 288 pp. plus appendices.

Neškoviƒ, N.K., V. Karan, I. Elezoviƒ, V. Poleksiƒ and M. Budimir. 1994. Toxic effects of 2,4-D herbicide on fish. *J. Environ.Sci. Health* B29(2): 265-279.

Pacific Fisheries Management Council 2002. Review of 2002 Ocean Salmon Fisheries. Found at: http://www.pcouncil.org/salmon/salsafe02/salsafe02.html.

Paul, E.A., H.A. Simonin, J. Symula, and R.W. Bauer. 1994. The toxicity of diquat, endothall, and flouridone to early life stages of fish. *J. Freshwater Ecology*. 9(3): 229-239.

Pimental, D. 1971. Ecological effects of pesticides on nontarget species. Executive office of the President's office of Science and technology, U.S. Government printing Office, Washington D.C.

Piper, R.G., McElwain, I.B., Orme, L.E., McCraren, J.P. Fowler, L.G., and J.R. Leonard. 1982. Fish Hatchery Management. U.S. Dept. of Int., U.S. Fish and Wildlife Serv. 517 pp.

Plakas, S.M., L. Khoo, and M.G. Barron. 1992. 2,4-Dichlorophenoxyaceitic acid disposition after oral administration in channel catfish. *J. Agric. Food Chem.* 40: 1236-1239.

Prokpovich, N., A. Storm, and C. Tennis, 1985. Toxic Trace metals in water hyacinth in the Sacramento-San Joaquin delta, California. *Tech Notes. Bull. Assoc. Eng. Geol*. 352-358.

Rand, G.M. (editor): Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment, Second Edition. Taylor and Francis, 1995.

Rectenwald, H. 1989. California Department of Fish and Game memorandum to Dick Daniel, Environmental Services Division, concerning the status of the winter-run chinook salmon prior to the construction of Shasta dam. August 16, 1989. 2 pp. + appendices.

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

Ritter, A.M., J.L. Shaw, W.M. Williams, and K.Z. Travis. 2000. Characterizing aquatic ecological risks from pesticides using a diquat dibromide case study. I. Probabilistic exposure estimates. Environmental Toxicology and Chemistry 19(3):749-759.

Rodriguez, A.D., R.H Rodriguez, R.A. Meza, , J.E. Hernandez, , E Rejmankova, H.M Savage, D.R Roberts, K.O. Pope, and L. Legters (1993). Dynamics of Population densities and Vegetation Associations of *Anopheles albimanus* larvae in a Coastal Area of Southern Chiapas, Mexico. *J. Am. Mosq. Control Assoc.* 9(1):46-57.

Ross, M.A. and D.J. Childs, 196. Herbicide –mode- of Action. Cooperative Extension Service, Purdue University. Found at: www.agcom.purdue.edu./AgCom/Pubs/WS-23.html.

Sarkar, S.K. 1991. Effects of the herbicide 2,4-D on the bottom fauna of fish ponds. *The Prog. Fish Cult*. 53: 161-165.

Savage, H.M., E.Remankova,, J.I. Arredondo-Jimenezc, D.R. Roberts, and M.H. Rodriguez, (1990). Limnological and Botanical Characterization of Larval Habitats for Two Primary Malarial Vectors, *Anopheles albimanus* and *Anopheles pseudopunctipennis*, in Coastal Areas of Chiapas State, Mexico. *J. Am. Mosq. Control Assoc.* 6(4):612-620.

Shapovalov, L. and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdnerii*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. *Calif. Dept. Fish and Game, Fish. Bull.* No.98. 373 pp.

Skinner, J.E.1962. Fish and wildlife resources of the San Francisco Bay area. California Dept. Fish and Game Water Project Branch, Report. 1, Sacramento. 226 pp.

Sommer, T.R., M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer. 2001. Floodplain rearing of juvenile chinook salmon: evidence of enhanced growth and survival. *Can. J. Aquat. Sci.* 58: 325-333.

Toft, J.D. 2000. Community effects of the non-indigenous aquatic plant water hyacinth (*Eichhornia crassipes*) in the Sacramento/San Joaquin Delta, California. University of Washington.

UK Marine SACS Project (United Kingdom Marine Special Areas of Conservation Project). 2003. Report on Surfactants. Available at: http://www.ukmarinesac.org.uk/activites/water-quality/wq8_46.htm

U.S. Fish and Wildlife Service. 1990. An analysis of fish and wildlife impact of Shasta Dam water temperature control alternatives. Fish and Wildlife Coordination Act Report. U.S. Fish Wildl. Serv. Reg. 1. December 1990.

U.S. Fish and Wildlife Service. 1998. Central Valley Project Improvement Act Tributary Production Enhancement Report. Draft report to Congress on the feasibility, cost, desirability of implementing measures pursuant to subsections 3406 (e) (30 and (e)(6) of the Central Valley Project Improvement Act. USFWS, Central Valley Fish and Wildlife Restoration program Office, Sacramento, California.

U.S. Fish and Wildlife Service. 1992. Measures to improve the protection of chinook salmon in the Sacramento-San Joaquin River Delta. Expert testimony of the U.S. Fish and Wildlife Service on chinook salmon - Technical information for the State Water Resources Control Board, Water Rights Phase of the Bay/Delta Estuary Proceedings, July 6, 1992. WRINT-USFWS-7. 61 pp.

U.S. Army Corps of Engineers, 1985. State Design Memorandum Water Hyacinth Sacramento-San Joaquin Delta, California. U. S. Army Corps of Engineers.

U.S. Department of Agriculture, Forest Service.2002. 2,4-D Pesticide Fact Sheet. Found at http://www.fs.fed.us/foresthealth/pesticide/24d.html.

U.S. Environmental Protection Agency: Methods for measuring the toxicity and bioaccumulation of sediment associated contaminants with freshwater invertebrates. EPA 600/R-94/024. Duluth, MN: Washington D.C.: U.S. EPA 1994.

Vogel, D.A. and K.R. Marine.1991. Guide to upper Sacramento River chinook salmon life history. Report of CH2M Hill to U.S. Bureau of Reclamation, Central Valley Project, Redding, California.

Wan, M.T., R.G. Watts, and D.J. Moul. 1989. Effects of different dilution water types on acute toxicity to juvenile Pacific salmonids and rainbow trout of glyphosate and its formulated products. *Bull. Environ. Contam. Toxicol.* 43:378-385.

Wan, M.T., R.G. Watts, and D.J. Moul. 1991. Acute toxicity to juvenile Pacific Northwest Salmonids of Bascid Blue NB755 and its mixture with formulated products of 2,4-D, Glyphosate, and triclopyr. *Bull. Environ. Contam. Toxicol.* 47: 471-478.

Washington State Department of Ecology. 2001. Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management. The Water Quality Program. February 2001. Publication Number 00-01-040. Found at http://www.ecy.wa.gov/biblio/wq.html.

Washington State Department of Ecology. 2002. Final Supplemental Environmental Impact Statement for Diquat Dibromide. The Water Quality Program. September 2002. Publication Number 02-10-052. Found at http://www.ecy.wa.gov/biblio/wq.html.

Wilson, D.C. and C.E. Bond, 1969. The Effects of the Herbicide Diquat and Dichlobenil (Casoron ®) on Pond Invertebrates Part 1. Acute Toxicity. *Trans. Amer. Fish. Soc*. 98(3): 438-443.

Wolverton, B.C. and R.C. McDonald. 1976. Water Hyacinth (*Eichhornia crassipes*) productivity and harvesting studies. *Econ. Botany* 33:1-10.

Worthingcton, C.R. and R.J. Hance (editors) 1991. The Pesticide Manual- A World Compendium, 9th Edition. Great Britain: British Crop Protection Council. 1141 pp.

Yeo, R.R. 1967. Dissipation of Diquat and Paraquat and Effects on Aquatic Weeds and Fish. *Weeds* 15:42.

Yoshiyama, R.M., F.W. Fisher, and P.B. Moyle. 1998. Historical abundance and decline of chinook salmon in the Central valley region of California. *North American. J. Fisheries Management*. 18:487-521.

Table 1: Water Hyacinth Control Program Treatment Sites 2003-2005

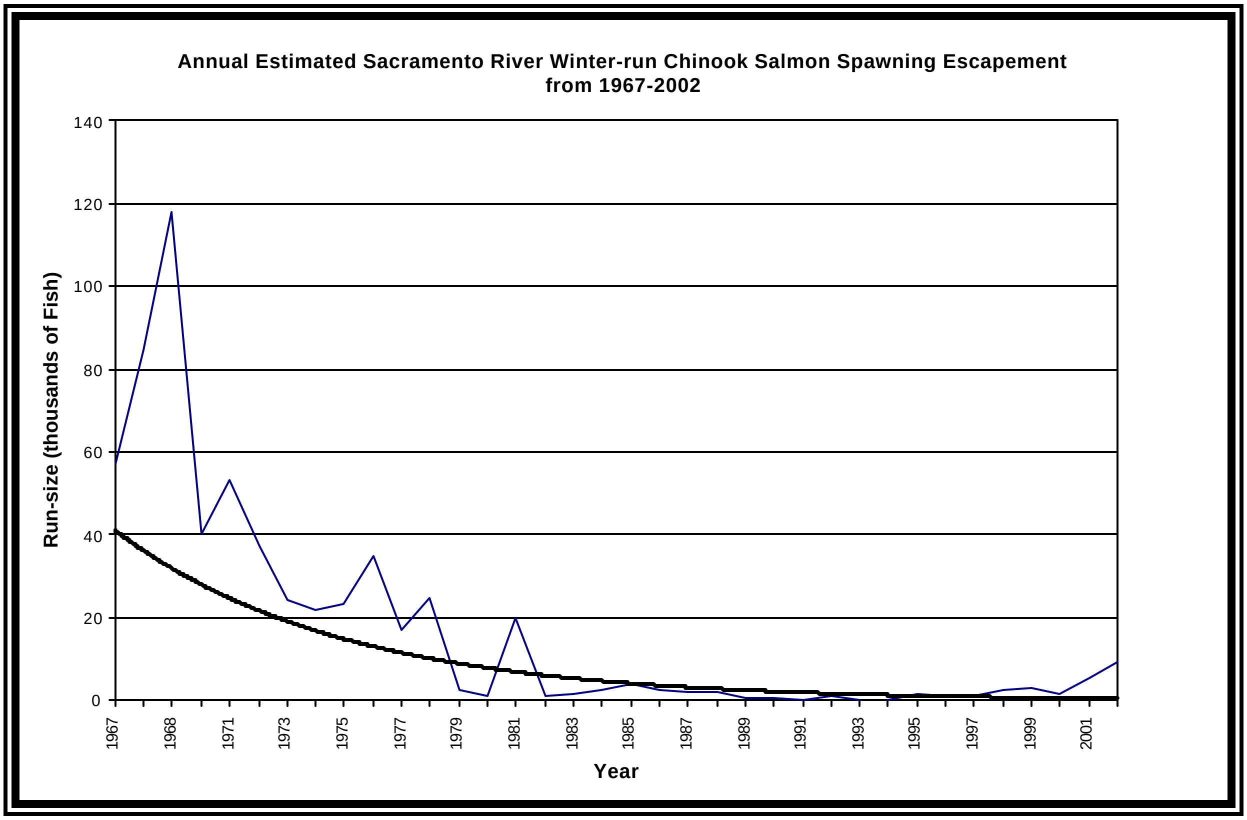
County	Location	Site Number(s)	Water Type
San Joaquin	San Joaquin River	1,2,3,4,5,	Tidal
San Joaquin	French Camp Slouogh, Walker Slough	6	Tidal
San Joaquin	San Joaquin River	7	Tidal
San Joaquin	Mormon Slough, San Joaquin River Deep Water Ship Channel	8	Tidal
San Joaquin	Burns Cutoff	9	Tidal
San Joaquin	Buckley Cove, San Joaquin River Deep Water Ship Channel	10	Tidal
San Joaquin	Black Slough, Black Slough Landing, 14 Mile Slough, San Joaquin River	11	Tidal
San Joaquin	Turner Cut	12	Tidal
San Joaquin	Heypress Reach, Hog Island Cut, San Joaquin River Deep Water Ship Channel, 21 Mile Slough	13	Tidal
San Joaquin	San Joaquin River	14	Tidal
San Joaquin	Empire Tract Slough	15	Tidal
San Joaquin	Mandeville Cut, Mandeville Reach, San Joaquin River Deep Water Ship Channel, 3-River Reach, Venice Cut, Venice Reach	16	Tidal
San Joaquin	Potato Slough	17	Tidal
San Joaquin	Mokelumne River	18	Tidal
Contra Costa	San Joaquin River	19	Tidal
Sacramento	San Joaquin River, 7-Mile Cut	20	Tidal
Contra Costa	San Joaquin River	21	Tidal
Sacramento	Sacramento River, 3-Mile Slough	22	Tidal
Sacramento	Lake Natoma	none	Slow Moving
Contra Costa, Sacramento	False River, San Joaquin River	23	Tidal
Contra Costa, Sacramento	San Joaquin River	24	Tidal
San Joaquin	14 Mile Slough	25	Tidal
San Joaquin	14 Mile Slough	26,28,29	Tidal
San Joaquin	5 Mile Slough	27	Tidal
San Joaquin	Mosher Slough	30	Tidal
San Joaquin	Bear Creek, Disappointment Slough, Pixley Slough	31	Tidal
San Joaquin	Disappointment Slough	32,33	Tidal
San Joaquin	Bishop Cut	34	Tidal
San Joaquin	Telephone Cut	35	Tidal
San Joaquin	White Slough	36,37,39	Tidal
San Joaquin	Bishop Cut	38	Tidal
San Joaquin	Little Potato Slough	40,41	Tidal
San Joaquin	Little Connection Slough	42	Tidal
San Joaquin	Potato Slough	43,44	Tidal
San Joaquin	Middle River	45,46,47,48,49,52,53,56,58,59,66,67,68	Tidal
San Joaquin	North Canal, Victoria Canal	50,51	Tidal
San Joaquin	North Victoria Canal, Woodard Canal	54,55	Tidal
San Joaquin	Railroad Cut	57	Tidal
San Joaquin	Empire Cut	60	Tidal

County	Location	Site Number(s)	Water Type
San Joaquin	Whiskey Slough	61,62,63	Tidal
San Joaquin	Trapper Slough	64	Tidal
San Joaquin	Latham Slough	65	Tidal
San Joaquin	Connection Slough, Middle River	69	Tidal
San Joaquin	Old River	70,71	Tidal
San Joaquin	Old River, Paradise Cut	72	Tidal
San Joaquin	Old River, Paradise Cut, Salmon Slough	73	Tidal
San Joaquin	Sugar Cut, Tom Paine Slough	74	Tidal
San Joaquin	Old River	75,76,77,78,79,83,84,85,8 7,89,90,91,92,98,99	Tidal
San Joaquin	Fabian & Bell Canal, Grant Line Canal	80,81,82	Tidal
Contra Costa	Italian Slough	88	Tidal
Contra Costa	Indian Slough	93	Tidal
Contra Costa	Warner Dredge Cut	94,95,96	Tidal
Contra Costa	Rock Slough	97	Tidal
San Joaquin	Connection Slough, Old River	100	Tidal
San Joaquin	Old River	101	Tidal
Contra Costa	Sheep Slough	102	Tidal
Contra Costa, San Joaquin	Old River	103,104	Tidal
Contra Costa	False River,	105	Tidal
Contra Costa	Fisherman's Cut	106	Tidal
Contra Costa	Piper Slough	107	Tidal
Contra Costa	Roosevelt Cut, Sand Mound Slough	108	Tidal
Contra Costa	Sand Mound Slough	109	Tidal
Contra Costa	Taylor Slough	110,111	Tidal
Contra Costa	Dutch Slough, Emerson Slough	112	Tidal
Contra Costa	Dutch Slough	113, 114	Tidal
Contra Costa	Big Break	115,116,117,118	Tidal
Contra Costa, Sacramento	San Joaquin River	119,120,121	Tidal
Sacramento	Sherman Lake	**132**	Tidal
Contra Costa	Frank's Tract	**173, 174, 175**	Tidal
Solano	Sacramento River, Decker Isalnd	176	Tidal
San Joaquin	South Mokelumne River	200, 201, 202, 204, 206, 208	Tidal
San Joaquin	Sycamore Slough	203	Tidal
San Joaquin	Hog Slough	205	Tidal
San Joaquin	Beaver Slough	207	Tidal
Sacramento, San Joaquin	North Mokelumne River	209, 210,211,2113	Tidal
Sacramento, San Joaquin	Snodgrass Slough, Delta Cross Channel	**212**	To Be Determined
Sacramento	Snodgrass Slough	214, 215, 216,217, 218, 219	Tidal
Sacramento	Stone Lakes	220, 221, 222, 223, 224, 225, 226, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239	Tidal

County	Location	Site Number(s)	Water Type
Sacramento, Solano	Sacramento River	**240**	To Be Determined
Sacramento	Sacramento River	**241, 242, 243, 244, 245**	To Be Determined
Sacramento, Yolo	Sacramento River	**246, 247, 248, 249, 250**	To Be Determined
Sacramento, Solano	Steamboat Slough	**251, 252, 253**	To Be Determined
Sacramento	Steamboat Slough	**254, 255**	To Be Determined
Sacramento, Solano	Sutter Slough	**256, 257**	To Be Determined
Sacramento	Sutter Slough	**258,259**	To Be Determined
Soalno, Sacramento	Cache Slough	**260**	To Be Determined
Solano	Cache Slough	**261, 272, 277, 278, 280**	To Be Determined
Solano	Miner Slough	**262, 263,264, 265, 266**	To Be Determined
Solano	Prospect Lsough	**267**	To Be Determined
Solano, Yolo	Sacramento Deep Water Ship Channel	**268**	To Be Determined
Solano	Tox Drain, Liberty	**270**	To Be Determined
Solano, Yolo	Tox Drain, Liberty	**271**	To Be Determined
Solano	Shag Slough	**273, 274**	To Be Determined
Solano, Yolo	Shag Slough	**275, 276**	To Be Determined
Solano	Hass Slough, Duck Slough	**279**	To Be Determined
Solano	Lindsey Slough	**281, 282, 283, 284**	To Be Determined
Sacramento	Georgiana Slough	**285, 286, 287, 288, 289**	To Be Determined
San Joaquin	San Joaquin River	300, 302, 303, 304, 305, 306, 307, 308, 309	Fast or Slow Moving
San Joaquin	Wethall Slough	301	Fast or Slow Moving
Stanislaus	San Joaquin River	310, 313, 314, 316, 318, 319, 320, 321, 322, 323	Fast or Slow Moving
Stanislaus	Brush Lake	316	Fast or Slow Moving
Stanislaus	Finnegan Cut, San Joaquin River	311, 312	Fast or Slow Moving
Stanislaus	Laird Slough	315	Fast or Slow Moving
Stanislaus	Del Puerto Creek, San Joaquin River	317	Fast or Slow Moving
Stanislaus	Lake Ramona	320	Fast or Slow Moving
Merced, Stanislaus	San Joaquin River	324, 325	Fast or Slow Moving

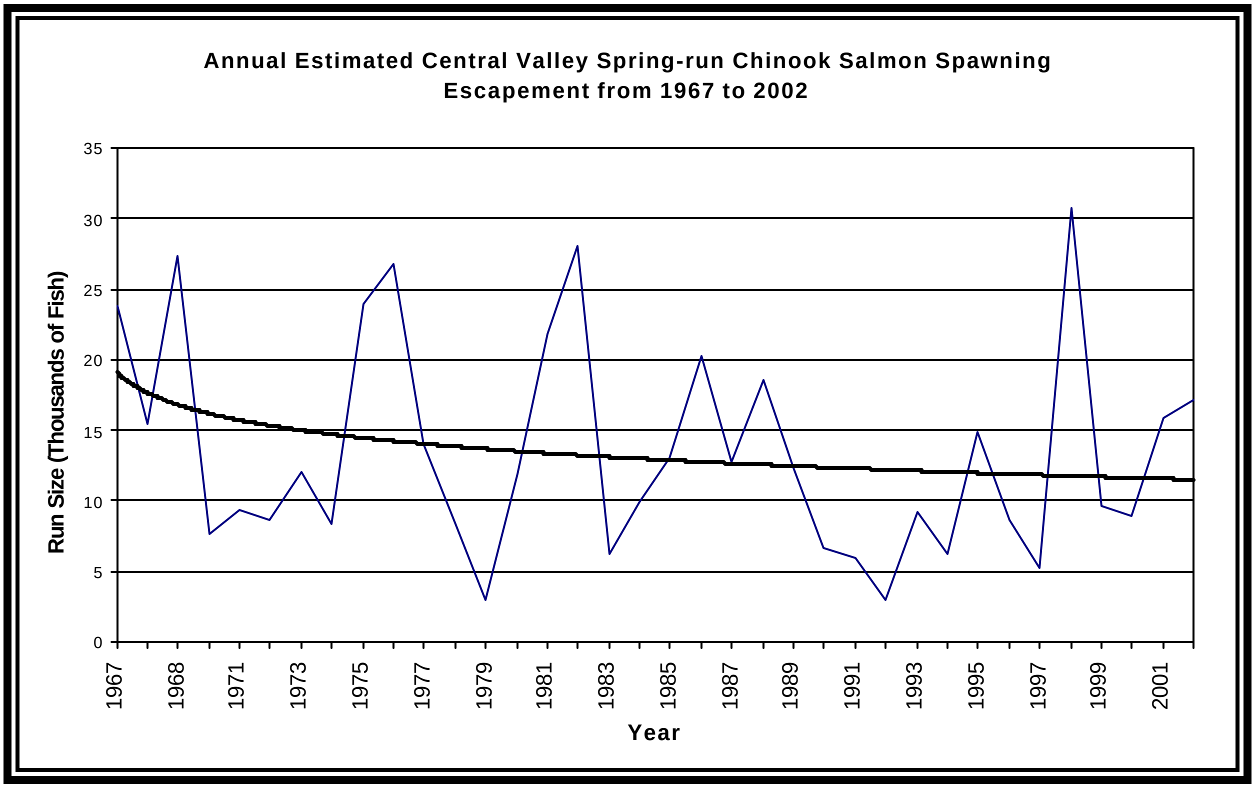
County	Location	Site Number(s)	Water Type
Merced	San Joaquin River	401, 403, 414, 415, 417, 418, 419, 421,422, 423, 424, 425, 426, 427	Fast or Slow Moving
Merced	Snag Slough, San Joaquin River	402	Fast or Slow Moving
Merced	Salt Slough	405, 406, 407, 408, 409, 410, 412, 413	Fast or Slow Moving
Merced	Poso Slough	414A	Fast or Slow Moving
Merced	Mud Slough	411	Fast or Slow Moving
Merced	Bear Creek, Bravel Slough	416	Fast or Slow Moving
Merced	San Joaquin River	**420**	To Be Determined
Merced	Merced River	500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 517, 518, 519, 520, 521, 522, 523, 524, 526, 527, 530, 532	Fast or Slow Moving
Merced	Ingalsbe Slough, Hope Town Slough	516	Fast or Slow Moving
Merced	Ingalsbe Slough	525	Fast or Slow Moving
Merced	Merced River, North Canal	528, 529	Fast or Slow Moving
Merced	Main Canal	531, 533, 537	Fast or Slow Moving
Merced	Main Canal, Canal Creek	534, 535	Fast or Slow Moving
Merced	Main Canal, Parkinson Creek	536	Fast or Slow Moving
Stanislaus	Stanislaus River	600	Fast or Slow Moving
Stanislaus	Toulumne River	700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718	Fast or Slow Moving
Fresno	San Joaquin River	900, 901, 902, 903, 904, 905, 909, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929	Fast or Slow Moving
Fresno, Madera	Firebaugh	**906, 907, 908**	To Be Determined
Fresno	San Joaquin River, Mendota Pool	910	Fast or Slow Moving
Fresno	Fresno Slough	910A, 910B	Fast or Slow Moving

Figure 1: Sources NMFS 1997, PFMC 2002



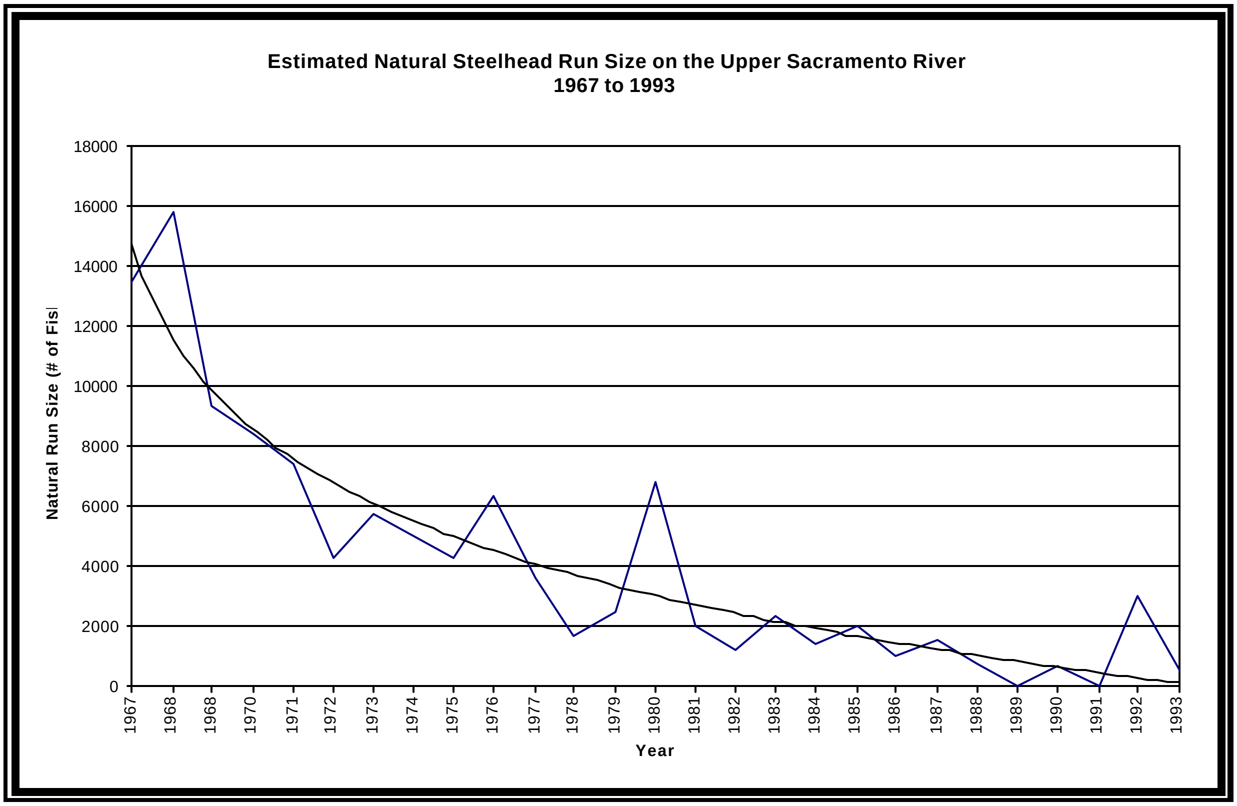
Trend line for Figure 1 is an exponential function: $Y = 46.606\ e^{-0.1269x}$ $R^2 = 0.5449$

Figure 2: Source PFMC 2002, Yoshiyama 1998.



Trend line for Figure 2 is an exponential function: Y = -2.1276 Ln (x) + 19.146, $R^2 = 0.0597$

Figure 3: Source McEwan and Jackson, 1996



Note: Steelhead escapement surveys at RBDD ended in 1993

Trend line for Figure 3 is a logarithmic function: Y= -4419 Ln(x) + 14690 $R^2 = 0.8574$

Appendix A.

<u>Physical Effects and Avoidance Behavior in Fish due to Chemical Contamination</u>

"The death of some organisms, such as mysids and larval fish, is easily detected because of a change in appearance from transparent or translucent to opaque. General observations of appearance and behavior, such as erratic swimming, loss of reflex, discoloration, excessive mucus production, hyperventilation, opaque eyes, curved spine, hemorrhaging, molting, and cannibalism, should also be noted in the daily record" (Section 10.1.3, Weber, 1993).

Overt Signs of Fish Distress

I. Respiratory stress - hyperventilation.
II. Disorientation in swim pattern, induced by narcosis.*
III. Mucus secretions from gills, mouth distension or 'cough' reflex.

Behavioral Response

I. Actively move from area of contamination.
II. Reduced swimming rate.
III. Passively be carried away from the area (some chemical impact to fish).
IV. Lethal concentration causes fish mortality. Fish rise to water surface, ventral-side up, with distended belly, no respiration, rigor mortis.

*Narcosis: a general, nonspecific, reversible mode of toxic action that can be produced in most living organisms by the presence of sufficient amounts of many organic chemicals. Effects result from the general disruption of cellular activity. The mechanism producing this effect is unknown, with the main theories being binding to proteins in cell membranes and 'swelling' of the lipid portion of cell membranes resulting from the presence of organic chemicals. Hydrophobicity dominated the expression of toxicity in narcotic chemicals.

References:

Rand, G.M.(ed.) 1995. Fundamentals of aquatic toxicology: effects, environment fate, and risk assessment. 2nd edition. Taylor & Francis, publ. 1125 pp.

Weber, C.I. 1993. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. EPA/600/4-90/027F

Enclosure 2.

Magnuson-Stevens Fishery Conservation and Management Act (MSA)

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended (U.C. 180 *et seq.*), requires that Essential Fish Habitat (EFH) be identified and described in federal fishery management plans (FMPs). Federal action agencies must consult with the National Marine Fisheries Service (NOAA Fisheries) on any activity which they fund, permit, or carry out that may adversely affect EFH. NOAA Fisheries is required to provide EFH conservation and enhancement recommendations to the federal action agencies.

EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purposes of interpreting the definition of EFH, “waters” includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities; “necessary’ means habitat required to support a sustainable fishery and a healthy ecosystem; and “spawning, breeding, feeding, or growth to maturity” covers all habitat types used by a species throughout its life cycle. The proposed project site is within the region identified as Essential Fish Habitat (EFH) for Pacific salmon in Amendment 14 of the Pacific Salmon Fishery Management Plan and for starry flounder (*Platicthys stellatus*) and English sole (*Pleuronectes vetulus*) in Amendment 11 to the Pacific Coast Groundfish Fishery Management Plan.

The Pacific Fishery Management Council (PFMC) has identified and described EFH, Adverse Impacts and Recommended Conservation Measures for salmon in Amendment 14 to the Pacific Coast Salmon Plan (Salmon Plan) (PFMC 1999). Freshwater EFH for Pacific salmon in the Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers *et al.* (1998), and includes the following hydrologic units that pertain to the project area: San Joaquin Delta (*i.e.*, number 18040003), lower Sacramento River (number 18020109), Lower American River (number 18020111) and the middle San Joaquin River-lower Merced River-lower Stanislaus River (number 18040003). Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Salmon Plan that occur in the San Joaquin Delta.

Factors limiting salmon populations in the Delta include periodic reversed flows due to high water exports (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversion, predation by introduced species, and reduction in the quality and quantity of rearing habitat due to channelization, pollution, rip-rapping etc.(Kondolf *et al.*, 1996a, 1996b; Dettman *et al.* 1987; California Advisory Committee on Salmon and Steelhead Trout [CACSST] 1988).

LIFE HISTORY AND HABITAT REQUIREMENTS

Pacific Salmon:

General life history information for Central Valley Chinook salmon is summarized below. Information on Sacramento River winter-run and Central Valley spring-run Chinook salmon life histories is summarized in the preceding Biological Opinion for the proposed project (Enclosure 1). Further detailed information on Chinook salmon ESUs are available in the NOAA Fisheries status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers *et al.* 1998), and the NOAA Fisheries proposed rule for listing several ESUs of Chinook salmon (NOAA Fisheries 1998).

Adult Central Valley fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers from July through April and spawn from October through December (U.S. Fish and Wildlife Service [FWS] 1998). Chinook salmon spawning generally occurs in clean loose gravel in swift, relatively shallow riffles or along the edges of fast runs (NOAA Fisheries 1997).

Egg incubation occurs from October through March (Reynolds *et al.* 1993). Shortly after emergence from their gravel nests, most fry disperse downstream towards the Delta and estuary (Kjelson *et al.* 1982). The remainder of fry hide in the gravel or station in calm, shallow waters with bank cover such as tree roots, logs, and submerged or overhead vegetation. These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, aquatic and riparian vegetation, logs, and undercut banks provide habitat for food organisms, shade, and protect juveniles and smolts from predation. These smolts generally spend a very short time in the Delta and estuary before entry into the ocean. Whether entering the Delta or estuary as fry or juvenile, Central valley Chinook salmon depend on passage through the Sacramento-San Joaquin Delta for access to the ocean.

Starry Flounder:

The starry flounder is a flatfish found throughout the eastern Pacific Ocean, from the Santa Ynez River in California to the Bering and Chukchi Seas in Alaska, and eastwards to Bathurst inlet in Arctic Canada. Adults are found in marine waters to a depth of 375 meters. Spawning takes place during the fall and winter months in marine to polyhaline waters. The adults spawn in shallow coastal waters near river mouths and sloughs, and the juveniles are found almost exclusively in estuaries. The juveniles often migrate up freshwater rivers, but are estuarine dependent. Eggs are broadcast spawned, and the buoyant eggs drift with wind and tidal currents. Juveniles gradually settle to the bottom after undergoing metamorphosis from a pelagic larvae to a demersal juvenile by the end of April. Juveniles feed mainly on small crustaceans, barnacle larvae, cladocerans, clams and dipteran larvae. Juveniles are extremely dependent on the condition of the estuary for their health. Polluted estuaries and wetlands decrease the survival rate for juvenile starry flounder. Juvenile starry flounder also have a tendency to accumulate many of the contaminants in the environment.

English Sole:

The English sole is a flatfish found from Mexico to Alaska. It is the most abundant flatfish in Puget Sound, Washington and is abundant in the San Francisco Bay estuary system. Adults are found in near-shore environments. English sole generally spawn during late fall to early spring at depths of 50 to 70 meters over soft mud bottoms. Eggs are initially buoyant, then begin to sink just prior to hatching. Incubation may last only a couple of days to a week depending on temperature. Newly hatched larvae are bilaterally symmetrical and float near the surface. Wind and tidal currents carry the larvae into bays and estuaries where the larvae undergo metamorphosis into the demersal juvenile. The young depend heavily on the intertidal areas, estuaries and shallow near shore waters for food and shelter. Juvenile English sole feed on small crustaceans such as copepods, amphipods, and on polychaete worms. Polluted estuaries and wetlands decrease the survival rate for juvenile English soles. The juveniles also have a tendency to accumulate many of the contaminants found in their environment and this exposure manifests itself as tumors, sores, and reproductive failures.

II. PROPOSED ACTION

The proposed action is described in Part II *Description of the Proposed Action* of the preceding Biological Opinion for endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, Central Valley steelhead and critical habitat for winter-run Chinook salmon (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on Sacramento River winter-run and Central Valley spring-run Chinook salmon habitat are described at length in Section V (*Effects of the Action*) of the preceding biological opinion, and generally are expected to apply to central Valley fall-run Chinook salmon habitat, starry flounder, and English sole EFH. The effects on starry flounder EFH are expected to be greater because larval starry flounder occur in the action area during the periods of herbicide applications.

IV. CONCLUSION

Based on the best available information, NOAA Fisheries believes that the proposed Water Hyacinth Control Program may adversely affect EFH for Central Valley fall-/late fall-run Chinook salmon, Sacramento River winter-run Chinook salmon, and Central Valley spring-run Chinook salmon managed under the Salmon plan. Likewise, the Water Hyacinth Control Program may adversely affect starry flounder or English sole EFH in the action area.

V. EFH CONSERVATION RECOMMENDATIONS

The habitat requirements for Central Valley fall-/late fall-run Chinook salmon within the action area are similar to those of the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead addressed in the preceding Biological Opinion (Enclosure 1). Therefore NOAA Fisheries recommends that the terms and conditions 1a-b, 1d-e, and 2a-d from the biological opinion be adopted as EFH Conservation Recommendations for EFH in the action area. The previous recommendations for the salmon EFH will serve as conservation recommendations for the groundfish EFH. Additional conservation measures, as addressed in Appendix A of Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999) where applicable to the authority of the USDA-ARS and the DBW. Starry flounder and English sole EFH may be protected by following the conservation recommendations for Pacific salmon EFH in addition to the following recommendations:

1. Minimize the application of herbicides in waters that serve as rearing habitat for juvenile flatfish in the Delta,

2. Minimize the disturbance of benthic substrate in areas of shallow water used by flatfish for foraging; and

3. Avoid degradation of native emergent and submerged vegetation in marshes and submerged tidal flats in areas utilized by juvenile flatfish for rearing and foraging.

VI. STATUTORY REQUIREMENTS

Section 305 (b) 4(B) of the MSA requires that the federal lead agency provide NOAA Fisheries with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the lead agency for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR § 600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreement with NOAA Fisheries over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

Literature Cited:

California Advisory Committee on Salmon and Steelhead Trout (CACSST). 1998. Restoring the balance. California Dept. of Fish and Game, Inland Fisheries Division, 84pp.

Dettman, D.H., D.W. Kelley, and W.T. Mitchell. 1987. The influence of flow on Central Valley salmon. Prepared by the California Dept. of Water Resources. Revised July 1987, 66pp.

Healey, M.C. 1991. Life history of Chinook salmon. *In* C. Groot and L. Margolis: Pacific Salmon Life Histories. University of British Columbia Press. pp. 213-393.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile Chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California, pp. 393-411. *In*: V.S. Kennedy (ed.). Estuarine comparisons. Academic Press, New York, NY.

Kondolf, G.M., J C. Vick and T.M. Ramirez. 1996a. Salmon spawning habitat rehabilitation in the Merced, Tuolumne, and Stanislaus Rivers, California: An evaluation of project planning and performance. University of California Water Resources Center Report No. 90, ISBN 1-887192-04-2, 147pp.

Kondolf, G.M., J.C. Vick and T.M. Ramirez. 1996b. Salmon spawning habitat on the Merced River, California: An evaluation of project planning and performance. Trans. Amer. Fish. Soc. 125:899-912.

Lister, D.B. and H.S. Genoe. 1970. Stream habitat utilization by cohabiting underyearlings of (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Big Qualicum River, British Columbia. J. Fish. Res. Board Can. 27:1215-1224.

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. Dept. Of Commerce, NOAA Tech Memo. NMFS-NWFSC-35, 443p.

National Marine Fisheries Service (NMFS). 1997. Proposed recovery plan for the Sacramento River winter-run Chinook salmon. NMFS, Southwest Region, Long Beach, California. 288 p. plus appendices.

National Marine Fisheries Service (NMFS). 1998. Endangered and threatened species: Proposed endangered status for two Chinook salmon ESUs and proposed threatened status for five Chinook salmon ESUs; proposed redefinition, threatened status, and revision of critical habitat for one Chinook salmon ESU; proposed designation of Chinook salmon critical habitat in California, Oregon, Washington, Idaho. Federal Register 63 (45): 11482-11520. March 9, 1998.

Pacific Fishery Management Council (PFMC). 1999. Description and identification of essential fish habitat, adverse impacts and recommended conservation measures for salmon. Amendment 14 to the Pacific Coast Salmon Plan, Appendix A. PFMC, Portland, OR.

Reynolds, F.L., T.J. Mills, R. Benthin and A. Low. 1993. Restoring Central Valley streams: A plan for action. California Dept. of Fish and Game, Sacramento, CA. 129pp.

U.S. Fish and Wildlife Service. 1998. Central Valley Project Improvement Act Tributary Production Enhancement Report. Draft report to Congress on the feasibility, cost, and desirability of implementing measures pursuant to subsections 3406(e)(3) and (e)(6) of the Central Valley Project Improvement Act. USFWS, Central Valley Fish and Wildlife Restoration Program Office, Sacramento, CA.