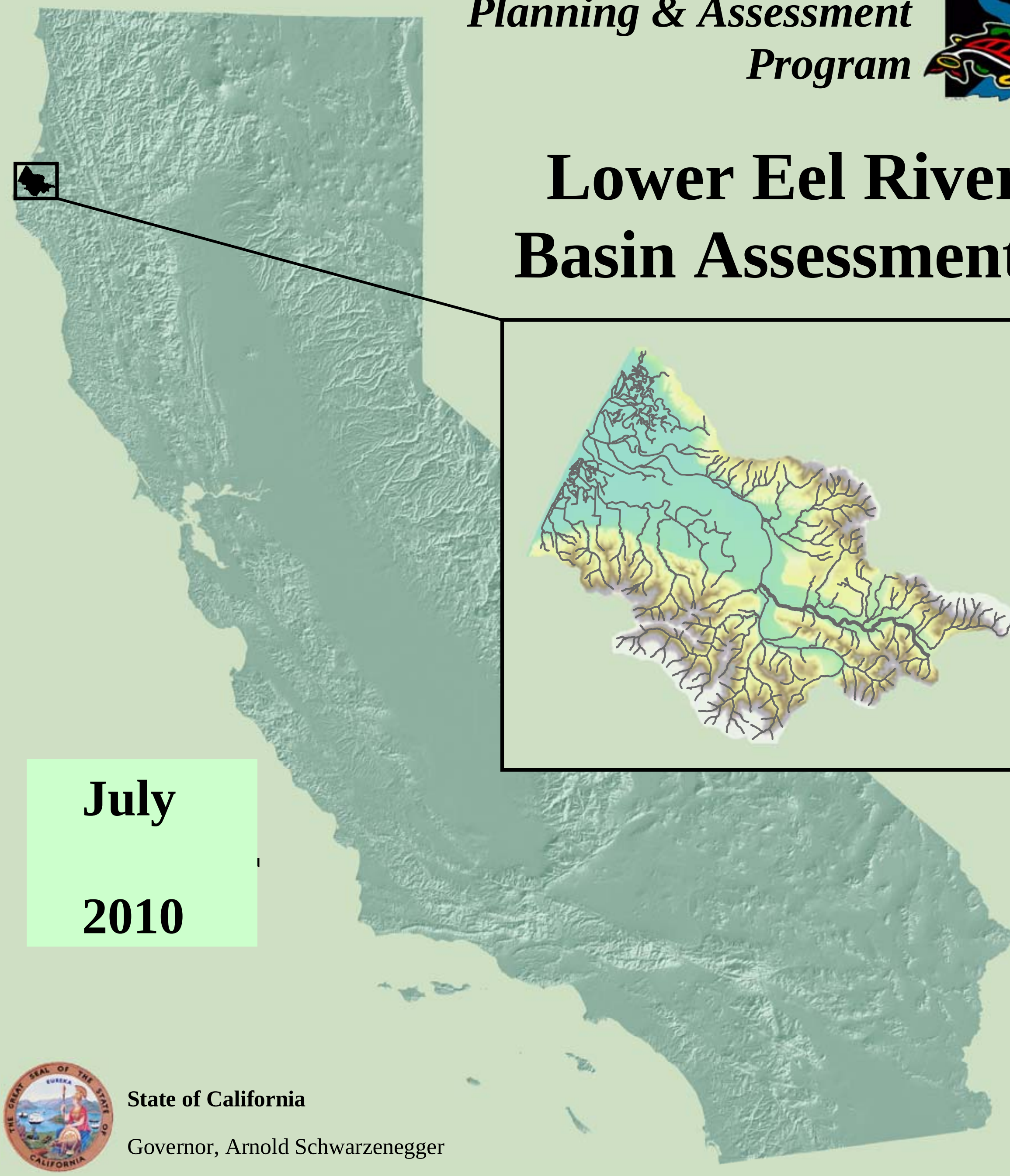
Coastal Watershed Planning & Assessment Program

Lower Eel River Basin Assessment



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2010

State of California

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Pacific States Marine Fisheries Commission

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Lower Eel River Watershed Assessment

Prepared through a cooperative effort by

California Department of Fish and Game
Coastal Watershed Planning and Assessment Program

Pacific States Marine Fisheries Commission

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California Coastal Watershed Planning and Assessment Program

The Lower Eel River Basin Assessment Report is a project of the Coastal Watershed Planning and Assessment Program (CWPAP). The Coastal Watershed Planning and Assessment Program is a California Department of Fish and Game program that conducts fishery-based watershed assessments along the entire California coast. The Lower Eel River Basin was chosen as an area for assessment because of its high fishery value to anadromous salmonids. This report was guided by following the outlines, methods, and protocols detailed in the CWPAP methods manual. The program's work is intended to provide answers to the following assessment questions at the basin, subbasin, and tributary scales in California's coastal watersheds:

- What are the history and trends of the size, distribution, and relative health and diversity of salmonid populations?
- What are the current salmonid habitat conditions; how do these conditions compare to desired conditions?
- What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?
- How has land use affected these natural processes and conditions?
- Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What watershed management and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?
- The assessment program's products are designed to meet these strategic goals:
- Organize and provide existing information and develop limited baseline data to help evaluate the effectiveness of various resource protection programs over time;
- Provide assessment information to help focus watershed improvement programs, and to assist landowners, local watershed groups, and individuals in developing successful projects. This will help guide support programs, such as the CDFG Fishery Restoration Grants Program, toward those watersheds and project types that can efficiently and effectively improve freshwater habitat and lead to improved salmonid populations;
- Provide assessment information to help focus cooperative interagency, nonprofit, and private sector approaches to protect watersheds and streams through watershed stewardship, conservation easements, and other incentive programs;
- Provide assessment information to help landowners and agencies better implement laws that require specific assessments such as the State Forest Practice Act, Clean Water Act, and State Lake and Streambed Alteration Agreements.

General Assessment Approach

The general steps in our large-scale assessments include:

- Determine logical assessment scales;
- Discover and organize existing data and information according to discipline;
- Identify data gaps needed to develop the assessment;
- Amass and analyze information;
- Conduct Integrated Analysis (IA);
- Conduct Limiting Factors Analysis (LFA);
- Conduct refugia rating analysis;
- Develop conclusions and recommendations;
- Facilitate implementation of improvements and monitoring of conditions.

Scale of Assessment and Results

The assessment team used the California Watershed Map (CalWater version 2.2.1) to delineate the Lower Eel River Assessment Basin (Figure 1). The area was further partitioned into four subbasins for the purpose of analysis: the Estuary, Salt River, Middle, and Upper subbasins. In general, the CalWater 2.2.1 Planning Watersheds (PWs) contained within each of these assessment subbasins have common physical, biological, and/or cultural attributes. However, there is enough variance among the areas' attributes that they were delineated as separate subbasins. Demarcation in this logical manner provides a large, yet common scale for conducting assessments. It also allows for the reporting of findings as well as making recommendations for watershed improvement activities that are generally applicable across this relatively homogeneous area.

Assessment Products

This report and its appendices are intended to be useful to landowners, watershed groups, agencies, and individuals to help guide restoration, land use, and management decisions. Assessment products are as follows:

- Collection of Lower Eel River Basin historical and sociological information;
- Description of historic and current vegetation cover and change, land use, geology and fluvial geomorphology, water quality, and instream habitat conditions;
- Evaluation of watershed conditions affecting salmonids;
- An interdisciplinary analysis of the suitability of stream reaches and the watershed for salmonid production and refugia areas;
- Tributary and watershed recommendations for management, refugia protection, and restoration activities to address limiting factors and improve conditions for salmonid productivity;
- Monitoring recommendations to improve the adaptive management efforts;
- Ecological Management Decision Support system (EMDS) models to help analyze data;
- Databases of information used and collected;
- A data catalogue and bibliography;
- Web based access to the Program's products: http://coastalwatersheds.ca.gov, http://www.calfish.org, http://imaps.dfg.ca.gov, http://bios.dfg.ca.gov, and ArcIMS site.

Salmonids, Habitat, & Land Use Relationships

There are several factors necessary for the successful completion of an anadromous salmonid's life history. In their freshwater phases, adequate flow, good water quality, free passage, good stream habitat conditions, and proper riparian function are essential for survival. Stream condition includes several factors: adequate stream flow, suitable water quality, appropriate stream temperature, and complex, diverse habitat. Adequate instream flow during low flow periods is essential to provide juvenile salmonids free forage range, cover from predation, and utilization of localized temperature refugia from seeps, springs, and cool tributaries. Important aspects of water quality for anadromous salmonids include water temperature, water chemistry, turbidity, and sediment load. Habitat diversity for salmonids is provided by a combination of deep pools, riffles, and flatwater habitat types.A functional riparian zone helps to control the amount of sunlight reaching the stream, and provides vegetative litter and invertebrate fall. These contribute to the production of food for the aquatic community, including salmonids. Tree roots and other vegetative cover provide stream bank cohesion and buffer impacts from adjacent uplands. Near-stream vegetation eventually provides large woody debris and complexity to the stream (Flosi et al. 1998).

Geology, climate, watershed hydrologic responses, and erosion events interact to shape freshwater salmonid habitats. "In the absence of major disturbance, these processes produce small but virtually continuous changes in variability and diversity against which the manager must judge the modifications produced by nature and human activity. Major disruption of these interactions can drastically alter habitat conditions" (Swanston 1991). Major watershed disruptions can be caused by catastrophic events, such as major floods or earthquakes. They can also be created over time by multiple small natural and/or human disturbances.

Natural disturbance and recovery processes, at scales from small to very large, have been at work on North Coast watersheds since their formation millions of years ago. Recent major natural disturbance events include large flood events such as occurred in 1955 and 1964 (Lisle 1981a), and locally, 1974 (U.S. EPA 2001). Major human disturbances associated with post-European expansion such as dam construction, agricultural and residential land development, and timber harvesting practices used particularly before the implementation of the 1973 Z'Berg-Nejedly Forest Practice Act have occurred over the past 150 years (Ice 2000).

Salmonid habitat was also degraded during parts of the last century by well-intentioned but misguided restoration actions such as the removal of large woody debris from streams (Ice 1990). More recently, efforts at watershed restoration have been initiated at the local and state levels by such major programs as CDFGs Fishery Restoration Grants Program (FGRP). For example, several California counties, with FGRP funding, have addressed fish passage problems associated with their roads' stream crossings, opening many miles of historic habitat to salmonids. For additional information on stream and watershed recovery opportunities and project types, see the publication by the Federal Interagency Stream Restoration Working Group (FISRWG 1998).

Thus, a main component of large-scale assessment is to identify curable problems that limit production of anadromous salmonids in North Coast streams and watersheds, and prioritize them for treatment. That process begins with the identification of limiting factors, which can be anything that constrains, impedes, or limits the growth and survival of a population. Limiting factors analysis (LFA) provides a means to evaluate the status of key factors that affect anadromous salmonid life history. This information is useful to understand the underlying causes of stream habitat deficiencies and help determine if watershed processes are being overly influenced by landuse activities, and if so, what can be done to reduce their impacts.

Lower Eel River Basin

The present name for the Eel River reflects the abundance of so called lamprey eels (*Lampetra tridentata*) that Euro-American settlers observed being collected by the native peoples in the area. However, it is with these native people that the Eel River shares its original name of Wiyot. "…Eel River is called by the Indians, Weott [sic] - plenty- from the immense quantities of Salmon obtained by them every fall in that stream…" (Humboldt Times, September 23, 1854). Indeed, upon settling in the area, Euro-Americans established an extremely lucrative commercial salmon fishery, targeting the "vast number of salmon which, so they say, used to impede traveling over the fords" (Ferndale Enterprise May 4 1987). The incredible success of the commercial fishery and canning operations eventually led to the creation of hatcheries to replace depleted stocks, and an inevitable ban to commercial fishing in 1926.

The Eel River is California's third largest river system with a watershed area of approximately 3,680 square miles, and as such is one of its most important anadromous salmonid habitats. The Lower Eel River Basin is located approximately 200 miles north of San Francisco and encompasses approximately 172 square miles. This report's assessment area includes both the Lower Eel River, from its mouth to RM 21, and the Lower Van Duzen River, from its mouth to RM 9. For the purpose of assessment, this catchment has been divided into four subbasins: Estuary, Salt River, Middle, and Upper (Figure 1).

The Estuary Subbasin is approximately 24 square miles in area and includes approximately 7 miles of the mainstem from the mouth to Fernbridge, and about 40 miles of tidally driven sloughs. This subbasin makes up approximately 14% of the total assessment area.

The Salt River, which once functioned as a significant part of the Eel River estuary, has been assessed by the CWPAP team in a separate report (Downie and Lucey, 2005). Because the Salt River is such an integral part of the Eel River estuary, it is difficult to assess the watershed without it. Therefore, the Salt River is included as a subbasin of the Lower Eel watershed assessment. At 49 square miles, the Salt River Subbasin makes up approximately 29% of the Lower Eel Basin. In total, the Salt River Subbasin includes approximately 42 miles of tidally driven sloughs and freshwater tributaries.

The Middle Subbasin makes up approximately 14% of the total assessment area with an area of 24 square miles. In total, this subbasin contains approximately 40 miles of stream, as well as approximately 6 miles of the mainstem Eel, from Fernbridge to the mouth of the Van Duzen River. The Middle Subbasin includes the city of Fortuna, which is the assessment area's largest population center.

The Upper Subbasin is the largest in the assessment area at 75 square miles, comprising 43% of the total. This subbasin includes all Eel River tributaries along 7.5 miles of the mainstem Eel River from Barber Creek to Dean Creek. It additionally includes tributaries to the Van Duzen River from its mouth to Cummings Creek (approximately 9 miles). The Upper Subbasin includes approximately 133 miles of permanent and intermittent stream.

The Lower Eel River Basin can be described as highly dynamic. The Basin experiences high levels of sedimentation due to natural hillslope processes, erodible soils and high levels of precipitation (Reynolds et al. 1981). Additionally, the area is situated in a tectonically complex area resulting in part from compression generated by convergence and subduction between the Gorda and North American Plates, which is further enhanced by accelerated uplift from the

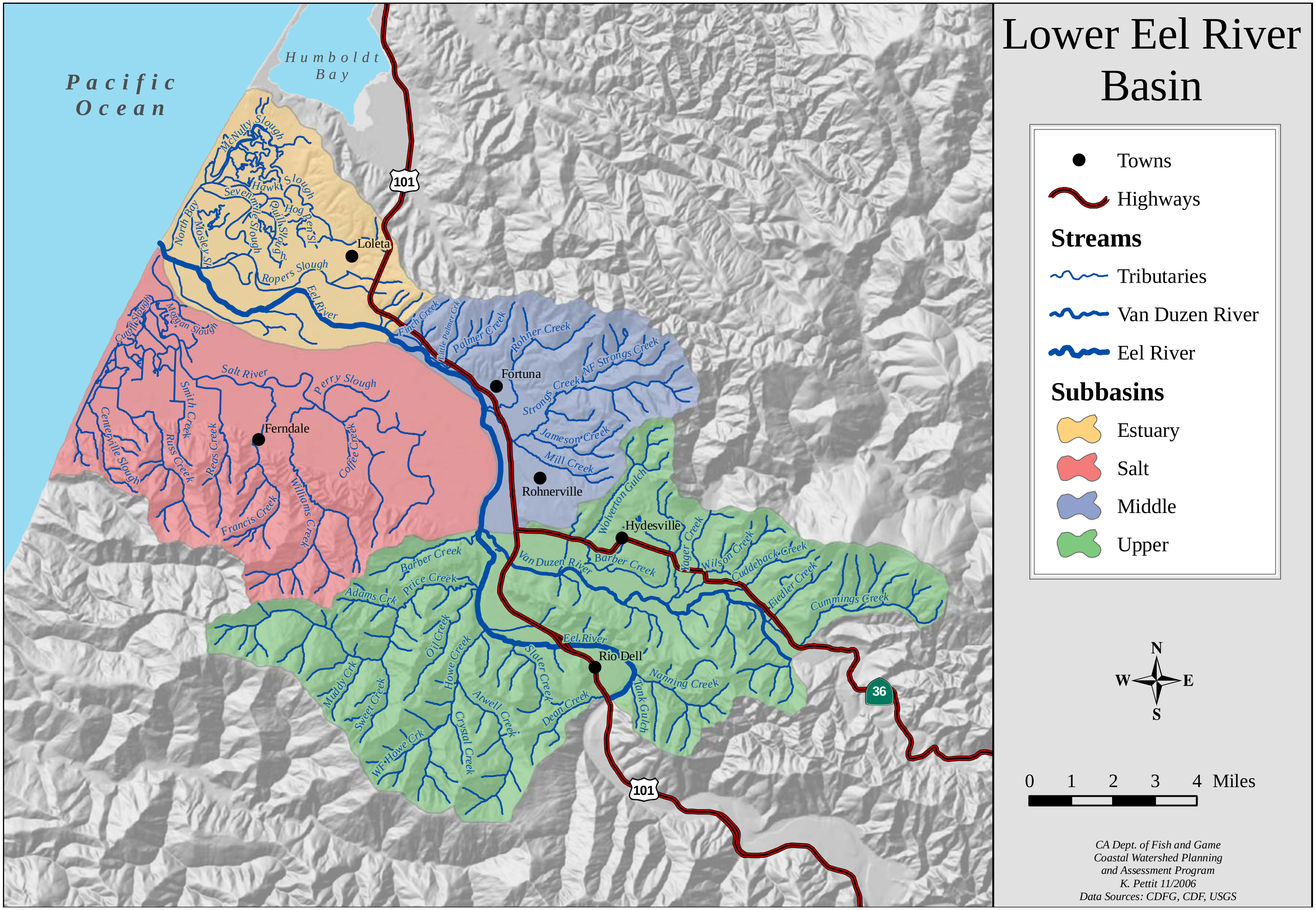

Figure 1: Lower Eel River Basin with subbasins, and streams.

encroaching Mendocino Triple Junction. These natural processes, in combination with land use, have greatly altered the size, shape and watershed processes of the Basin. Land use has had a major effect on the Eel's watershed processes. Historically, the Basin's fertile delta soils attracted settlers to the area. Land clearing and conversion for the purposes of agriculture began as early as the 1850s. With the success of grazing, came the creation of innovative creameries. As trees were felled to make room for these pasture lands, a productive and profitable timber harvesting industry began to develop. The Eel River also supported several salmon canneries and packing plants with its highly successful commercial salmon fishery. Export of the Basin's products was available via commercial ships at the Eel River estuary's Port Kenyon on the Salt River, and through Humboldt Bay, located 5 miles to the north. The area's rich natural resources enticed settlers to the area and effectuated the eventual name of the Basin's population center, Fortuna.

Today, the Eel River as a whole has the highest recorded average suspended sediment yield than any other U.S. river its size (Brown and Ritter 1971). Landslides and erosion introduce large quantities of sediment to streams, and are exacerbated by the region's climate, geology, topography and land use. In 2002, the Environmental Protection Agency listed the lower portion of the Eel River as an impaired water body due to sediment and temperature. The Lower Eel Basin is the depositional zone for the entire 3684 square mile basin. In this capacity, it is characteristic of the status of watershed processes throughout the catchment. These processes determine the stream conditions encountered by fish and wildlife at all levels.

Assessment Sample Base

Studies of the fishes and habitat throughout the Lower Eel River Basin are somewhat limited. This assessment was based on the following data:

- The CDFG has conducted 24 habitat inventories on 21 streams within the Lower Eel Basin between the years of 1991 and 2004. Long-running CDFG data for spawning surveys of Cummings Creek, and several other spawning observations were also available for tributaries in the Lower Eel Basin;
- A search of the CDFG libraries located in the Humboldt County Fisheries Management Unit Office in Eureka and the North Coast California Coho Salmon Investigation Office in Arcata produced various historical, anecdotal, and scientific records of fish sampling throughout the Lower Eel River Basin;
- The CDFG and Humboldt State University have surveyed the Eel River estuary on several occasions, with comprehensive studies occurring in 1951, 1977, and 1995;
- The Pacific Lumber Company (PALCO) has conducted several biological surveys on Cummings Creek of the Upper Subbasin beginning in 1998 and extending into the 2000s. They also performed biological surveys on Nanning Creek in the summer of 2001;
- The Fortuna high school's Fortuna Creeks Project has collected water quality data for streams in the Middle Subbasin since 1997;
- The Humboldt County Resource Conservation District has conducted a number of studies within the Eel River Delta including: biological conditions, vegetation surveys, habitat types and associated fishes and invertebrates, animal waste assessment project, channel elevation surveys, and water quality collections.

Lower Eel River Basin Management Issues

Initial analyses of available data by watershed experts developed this working list of general issues and/or concerns:

The morphology of the Lower Eel River Basin has been changed due to erosion and aggradation:

- The Lower Eel River Basin has undergone considerable sedimentation and deposition, which has resulted in:
  - An overall decrease in tidal prism and shallowing of the estuary and riverbed (Williams 1988);
  - Loss of estuarine habitat area and diversity;
  - Loss of spawning area for salmonids due to excess siltation of gravel beds (Reynolds et al., Stream Inventory Reports, CDFG spawning surveys);

  - o Intermittent and periodically dry reaches in tributaries and lower mainstem Van Duzen River during low summer and autumn flows (Williams 1988), (Reynolds et al. 1981) (CDFG field surveys);
  - o Highly channelized streams (Reynolds et al. 1981);
  - o Reduction of riparian vegetation on stream banks;
- The Lower Eel Basin is very seismically active, resulting in extensive surface erosion, uplift and landslides (Reynolds et al. 1981, PALCO Van Duzen Watershed Analysis, 2002);
- Large seasonal storms result in flooding and stream channel modification.

Historic and current land use has altered watershed processes and conditions:

- Agricultural lands now dominate what was historically forested riparian, and wetland habitat throughout the Lower Eel River Basin (Williams 1988, Monroe et al. 1974, Roberts 1992);
- There has been an overall change in species of grass for the purposes of grazing, which has reduced the root strength of prairie vegetation, increasing slumping in upper reaches of the system, like the North Fork Eel River (Reynolds et al. 1981);
- Livestock have unrestricted access in some streams of the Lower Eel Basin causing stream bank erosion and riparian vegetation damage (ERWIG, P. Halstead pers. comm.);
- Filling, draining and diking of streams has been required to allow for residential development in the Middle Subbasin (Roberts 1992);
- Most of the streams of the Middle Subbasin run through urban areas and as such, are subject to input of polluted storm runoff and garbage (Halstead pers. comm., Yazzolino pers. comm.);
- Basin-wide disturbance activities, including timber harvesting practices, gravel mining, road construction, residential development, land subdivision activities and grazing have caused an increase in sedimentation in the entire Eel River Basin (Williams 1988, Monroe et al. 1974, CDFG 1997 [Eel River Action Plan]);
- Dredging and filling, gravel and sand mining, dams and water diversions have contributed to the Eel River estuary's dynamic position of its main channel (Puckett 1977);
- Water quality is degraded through runoff from dairy operations, urban wastewater,and urban storm water (Roberts 1992, Monroe et al. 1974, Yazzolino pers. comm.);
- Streambank erosion above and below Fernbridge has caused loss of pasture and could be a threat to the bridge and the Humboldt Creamery's Wastewater Treatment Plant.

Alterations to watershed processes have affected the basin both socially and economically:

- The Salt River of the Eel River estuary is no longer navigable by sea-going ships;
- Seasonal drainage problems are becoming more frequent in residential and business areas, which can prove costly for private land owners and public entities (Downie and Lucey 2005);
- In order to address drainage issues, the city of Fortuna would need to spend approximately $10 million, which is well beyond the available budget (approximately $300,000). State and federal funding that the city does receive is already earmarked for mandated sewage and drinking water regulations (W. Yazzolino, pers. comm.);
- Fortuna and Loleta have lost substantial tourism dollars because they can no longer advertise as major fishing venues due to low flows and reduced salmon numbers (W. Yazzolino, pers. comm.);
- Increased development has introduced construction wastes to the watershed through storm drains. The city of Fortuna is not monitoring water quality changes with regards to storm runoff, though it is beginning to address these issues associated with development through the creation of regulatory programs.

Fish and wildlife have been adversely impacted by current watershed conditions in the Basin:

- Stream channelization, water control practices, barriers to fish migration in the form of levees and dikes, and sedimentation have resulted in a decreased ability of the Basin to support anadromous fisheries (Monroe et al. 1974);
- Spawning areas are affected by sediments trending toward increasing fines, and decreasing geometric mean particle size, and compaction of spawning gravel (PALCO Van Duzen Watershed Analysis 2002, Monroe et al. 1974);

- Stream aggradation has resulted in loss of rearing habitat in the estuary, as well as increased water temperatures resulting in decreased dissolved oxygen (Monroe et al. 1974);
- Aquatic macroinvertebrates are affected by increased sedimentation in streams and loss of estuary habitat (Monroe et al. 1974, Williams 1988);
- Riparian vegetation has been reduced throughout the study area, resulting in a decrease in shade canopy and recruitment of large wood to streams, rivers, and the estuary (Reynolds et al. 1981);
- Upstream migration of fish is restricted during early autumn dry periods, particularly in the Eel River just above the Van Duzen confluence. This has led to stranding mortality in early fall Chinook salmon;
- Fish passage is additionally affected by culverts, tide gates, channel narrowing, increased stream flows, and reduced floodplains.

Responses to Assessment Questions

This assessment uses six guiding assessment questions (page 1) to organize its issues, findings, conclusions and recommendations. The following discussion of the assessment questions and recommendations for improvement activities specific to subbasins, streams, stream reaches, and in some cases potential project sites, are included in each subbasin section of this report. The CDFG appendix contains more specific assessment methods, findings, conclusions, and recommendations for stream and watershed improvements.

What are the history and trends of the size, distribution, and relative health and diversity of fish populations in the Lower Eel River Basin?

<u>Findings and Conclusions:</u>

- Historical accounts of the recreational fishery in the Eel River estuary describe excellent salmon and steelhead fishing over the entire delta, with anglers gaining access to catch “from boat to shore” (Haley 1970). Large commercial harvest of salmon and steelhead were taken from the estuary from 1860 to 1926. The commercial fishery has been eliminated and the recreational fishery has been significantly reduced and is now catch and release only (zero bag limit);
- The NMFS has listed northern California runs of coho (1997), Chinook (1999), and steelhead (2000) as threatened under the federal Endangered Species Act. The California Fish and Game Commission also listed coho as threatened in 2005;
- Salmon populations are considerably smaller and less well distributed compared to historic range. Coho salmon have been documented in 13 tributaries across the basin and Chinook salmon in six tributaries. Steelhead trout have been documented in 21 tributaries and cutthroat trout in eight tributaries. In addition, all four species of salmonids use the mainstem Eel River and estuary as critical migration routes and use the estuary as rearing habitat;
- These remaining populations are critical to recovery of salmon and steelhead along the entire North Coast;
- The most comprehensive studies of the estuary were year-long investigations preformed in 1951, 1977, and 1995. These studies indicate the presence of juvenile Chinook salmon from spring to fall (March through November), coho salmon from spring through summer, and year-round presence of steelhead. Adult Chinook salmon and steelhead hold in the estuary until sufficient flows allow upstream migration in the fall;
- Three tributaries in the Middle Subbasin have been inventoried in 1993 and 2004 by CDFG. These data have confirmed, in addition to other fish studies, the presence of coho salmon, steelhead, and coastal cutthroat, among other species. Some historical and anecdotal accounts (dating back to the early 1950s) list the presence of these salmonid species in several Middle Subbasin tributaries;

- Stream inventories conducted by CDFG on fourteen tributaries in the basin between 1991 and 2002, as well as other fish sampling data, have documented the presence of Chinook salmon, coho salmon, and steelhead. Historical recorded data show that these salmonid species were being collected in fish rescue operations in the late 1940s;
- Coastal cutthroat trout were present in a 1984 survey of Centerville Slough, a tributary to the Salt River, indicating presence in the Eel River estuary. Cutthroat trout have also been observed during surveys of the Middle Subbasin between 1984 and 1995, but have not been confirmed present in the Upper Subbasin. The Eel River is the current southern extent of coastal cutthroat trout (Miller and Lea 1972);
- Tidewater goby, a species listed as endangered under the federal Endangered Species Act (ESA), were collected by the United States Fish and Wildlife Service in an unnamed slough of the Eel River estuary near Cannibal Island in August 2004;
- Sacramento pikeminnow, which were introduced into Lake Pillsbury in 1979, have been observed in many surveys of the Lower Eel River Basin from the estuary to RM 21 at Scotia. Pikeminnow predate on juvenile salmonids, particularly outmigrating salmonids (Moyle 2002);
- The Salt River Subbasin once supported populations of coho salmon, Chinook salmon, steelhead, and coastal cutthroat. Recent surveys have found small numbers of these salmonids in a more limited distribution than in the past.

What are the current salmonid habitat conditions in the Lower Eel River Basin? How do these conditions compare to desired conditions?

<u>Findings and Conclusions:</u>

<u>Flow and Water Quality</u>

- Stream and tidal flow has been altered by tide gates and levees constructed along streams and slough channels;
- Water quality is being impacted by cattle waste in estuary sloughs and in streams of the Middle and Upper Subbasins;
- Low summer flows may be stressful to salmonids and dry or intermittent reaches on the Van Duzen River prevent connection with the Eel River and impede passage to spawning grounds;
- In 1992, the EPA listed the Lower Eel River as impaired due to elevated sedimentation/siltation and temperature. The NCRWQCB has continued to identify the basin as impaired in subsequent listing cycles, the latest in 2006;
- Turbidity levels are high during winter rains, which correspond to salmon spawning season.

<u>Erosion/Sediment</u>

- Excessive sedimentation within the watershed has resulted in an overall loss of rearing and feeding habitat for salmonids within the estuary;
- The Van Duzen River is usually isolated from the Eel River by subsurface flows in late summer and early fall due in part to increased bedload materials at the confluence;
- Livestock have unrestricted access to many of the Lower Eel River tributaries and estuary sloughs, resulting in stream bank erosion;
- Soils in surveyed reaches of streams in the Lower Eel Basin are prone to erosion, and slides have been observed to contribute fines to the streams.

<u>Riparian Condition/Water Temperature</u>

- Much of the Lower Eel Basin has been cleared of riparian vegetation to create pasture land for cattle;

- Though water temperatures in CDFG surveyed reaches of streams in the Lower Eel Basin were suitable for salmonids, water temperature data are limited, and therefore inconclusive;
- Water temperatures of the mainstem collected by the Humboldt County Resource Conservation District (1998) in the summers of 1996 and 1997 within the basin, found unsuitable conditions for salmonids (maximum temps ranged from 73ºF–77ºF);
- Water temperatures collected by the Fortuna Creeks Project over a six-year sample period demonstrate stressful (above 68ºF) and occasionally lethal (above 75ºF) conditions, particularly on Rohner Creek;
- The majority of the surveyed tributary reaches in the Lower Eel Basin (70%) met the target value of 80% canopy coverage, but lack larger conifer overstory.

<u>Instream Habitat</u>

- Quality pool structure is generally lacking in streams throughout the basin; no surveyed streams met standards for pool shelter. Eight of the seventeen reaches surveyed obtained ratings considered fully unsuitable;
- On average, pool depths were considered poor for salmonids in all CDFG surveyed streams in the basin;
- Large woody debris is generally lacking in many areas of the basin.

<u>Gravel/Substrate</u>

- Due to increased sedimentation, stream beds have been described as heavily silted in many CDFG habitat inventories throughout the basin;
- Only 7% of pool tails in the Lower Eel Basin have cobble embeddedness in category one, which meets spawning gravel targets for salmonids;
- Areas of suitable spawning gravel are very limited throughout the Basin.

<u>Refugia Areas</u>

- The Middle and Upper subbasins provide medium potential refugia;
- The Salt River Subbasin provides lower quality stream refugia;
- The Estuary Subbasin and lower 3.4 miles of the Salt River provides critical estuarine rearing habitat for juvenile salmonids and other valuable fishery resources.

<u>Other</u>

- When flows are sufficiently high, the Eel River floods into treatment ponds of the Fortuna Wastewater Treatment Plant;
- A culvert on Mill Creek, tributary to Strongs Creek, in the Middle Subbasin does not meet CDFG and NOAA Fisheries fish passage guidelines. Other creeks with possible fish passage problems include Palmer Creek, Dean Creek, Price Creek, Adams Creek, and Barber Creek on mainstem Eel (RM 10).

What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?

<u>Findings and Conclusions:</u>

- The Lower Eel Basin receives highly variable precipitation throughout the year. High levels of winter precipitation can lead to widespread flooding throughout the basin. The drainage capacity of the Eel River has been drastically altered due to excessive sedimentation, which can exacerbate flood events;
- The floods of 1955 and 1964 catastrophically impacted the basin by depositing large amounts of sediment

in the channel;

- Friable soils, steep upstream terrain, and high levels of rainfall result in numerous landslides. Saturated soils are highly vulnerable to sliding during the many earthquakes that characterize the basin;
- The basin is located in a tectonically complex area, resulting in part from compression generated by convergence between the Gorda and North American Plates, underplating and accretionary tectonics along the Cascadia Subduction Zone and further enhanced by accelerated uplift from the encroaching Mendocino Triple Junction;
- Estuarine conditions extend from the mouth to Fernbridge (RM 7); tidal influence, evidenced by water movement, continues beyond this point, possibly to the mouth of the Van Duzen River;
- The basin's vegetation has been historically and is currently composed of primarily coniferous forest, predominantly of the Redwood Alliance. However, on all surveyed tributaries in the Upper Subbasin, deciduous canopy was more prevalent than coniferous. Reclaimed pasturelands are now also prevalent in the basin.

How has land use affected these natural processes and conditions?

<u>Findings and Conclusions:</u>

- Tideland reclamation and the construction of dikes and levees for agricultural purposes have changed the natural function of the estuary considerably. Slough and creek channels that once meandered throughout the delta are now confined by levees, sufficiently slowing flow to a point that many have become filled with sediment. Remnant slough channels are visible throughout the delta. It is generally accepted that the estuary and tidal prism has been reduced by over half of their original size;
- Riparian vegetation in the basin was cleared, and salt marsh vegetation was converted in order to create pastures for cattle. This change in species of grass has reduced the strength of prairie vegetation, causing soils to be more susceptible to slumping;
- Wastes from the dairy industry, as well as urban storm runoff have affected the water quality;
- Sedimentation and in-filling as a result of urbanization, land subdivision activities, gravel mining, and timber harvesting practices have resulted in an overall reduction in channel area, and consequently in available salmonid habitat;
- Because of the geologic characteristics within the Lower Eel, the basin is affected by highly variable runoff rates. Disturbance of the basin's already unstable soils by landuse activities has disturbed runoff rates.

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

<u>Findings and Conclusions:</u>

- Based on available information for the Lower Eel Basin, the CWPAP team believes that salmonid populations are limited by:
  - Low summer flows;
  - High summer water temperatures;
  - High levels of fine sediments in streams;
  - Shortage of areas with suitable spawning gravel in tributaries;
  - Decreased channel capacity;
  - Loss of estuarine habitat;
  - Competition with Sacramento pikeminnow.

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Recommendations:

Flow and Water Quality Improvement Activities

- Increase the tidal prism to help maintain existing channels and help remove excessive fine sediment accumulations;
- Conduct an inventory of tide gates and levees in the watershed;
- Where necessary, identify barriers to fish migration in the form of large debris accumulations, culverts, etc. and modify them;
- Protect summer stream flows from summer diversions;
- Livestock management fencing should be placed in areas where cattle have unrestricted access to streams.

Erosion and Sediment Delivery Reduction Activities

- The impact of property subdivision on streams of Lower Eel Basin should be minimized through the use of better land management practices. Opportunities to acquire conservation easements should be examined;
- Conduct an upslope erosion inventory on streams in the Middle and Upper subbasins in order to identify and map stream bank and road-related sediment sources. Sites should be prioritized and improved in order to decrease sediment contributions within the basin;
- Encourage the use of cattle exclusion fencing along streams where livestock have unrestricted access;
- In streams where spawning area is limited, projects should be designed to trap and sort spawning gravels in order to expand and enhance redd distribution.

Riparian and Habitat Improvement Activities

- Identify and prioritize locations within the delta where vegetation can be returned to salt tolerant species, thus increasing salt marsh around slough channels and providing a buffer to adjacent lands during inundation;
- Develop a grading ordinance to protect riparian vegetation. Ripparian buffer should be allowed to grow/re-grow along estuarine channels;
- Programs to increase riparian vegetation should be implemented in streams where shade canopy is below target values of 80% coverage. Additionally, those streams that are vegetated with exotic species should be considered for native plant restoration;
- In order to protect riparian vegetation, and decrease stream bank erosion due to unrestricted access of cattle to streams, use of livestock management fencing should be prescribed;
- In creeks where fish spawning and rearing habitat is limited, pool enhancement and instream structures should be added to increase complexity;
- In streams where spawning area is limited, projects should be designed to trap and sort spawning gravels in order to expand and enhance redd distribution;
- Log debris accumulations in streams that retain high levels of fine sediment should be assessed, and carefully removed where appropriate.

Education, Research, and Monitoring Activities

- Improve educational outreach to community;
- Encourage and partner with Fortuna Creeks Project's urban stream clean-up, habitat restoration and monitoring;
- Support the HCRCD in its efforts to monitor and improve habitat and water quality in the basin;
- Because water quality data are limited, monitoring of summer water temperatures should be preformed over at least a three to five year period;
- Water quality data, including temperature and dissolved oxygen, should be consistently collected throughout the year, for several years, in order to accurately characterize conditions in the streams. Salinities should be collected in the estuary and upstream to determine the extent of brackish conditions;
- Conduct habitat and fish inventories on urban streams of the Middle Subbasin, including Palmer, Jameson, and Rohner Creeks and unnamed tributaries to Strongs Creek;
- Partner with local academic institutions and private agencies as a means to encourage the study of the fish and habitat.

Subbasin Issue Summaries

Estuary Subbasin

The Estuary Subbasin is made up of the Eel River alluvial floodplain, excluding the Salt River drainage, from the Eel River's mouth to approximately 7 miles upstream at Fernbridge. This subbasin only encompasses part of the Eel River estuary - it does not include the Salt River, which is discussed as a separate subbasin.

The Estuary Subbasin is 24 square miles in size and contains approximately 40 miles of meandering sloughs and three miles of intermittent freshwater tributaries. The estuary is a sand bar built estuary that typically remains open to tidal exchange year-round. Tides are mixed diurnal, with two lows and two highs of unequal size generally occurring within a 24-hour period. Elevations are generally very low, but reach approximately 700 feet in areas near Table Bluff on the northwest margin of the subbasin. The town of Loleta is located at the base of rolling hills at an elevation of approximately 50 feet above sea level.

Findings and Issues

Fishery and Other Natural Resources:

- The lower Eel River from the mouth to the confluence with the Van Duzen River was once one of the most popular areas in the basin to fish for salmon;
- Major declines in salmonid abundance and changes in the fishing regulations have contributed to large reduction in angling effort and the salmonid catch in the estuary;
- The majority of fish found in the estuary are considered marine or anadromous species that utilize the estuary for spawning and/or juvenile rearing habitat. Many of these fish are also considered estuarine dependant because they require an estuarine ecosystem to complete a critical life history phase. Juvenile salmonids have been observed in the estuary on a year-round basis;
- While the overall amount of habitat available has been greatly reduced and the ecosystem altered, nonetheless, the Eel River estuary provides critical rearing habitat for juvenile anadromous salmonids and several other valuable fishery resources;
- The Eel River estuary is of great value as habitat for resident and migratory wildlife;

- Much of the historic tidal wetland habitat held in the public trust in the north sloughs area is managed for water fowl hunting opportunities.

Natural Processes of the Estuary:

- Tidal inflows make major contributions to the estuary ecosystem;
- Tidal influence extends to upstream of Fernbridge;
- Tidal flows help maintain cool water temperature in the estuary;
- The Eel River delta is naturally susceptible to flooding and winter floods in this low relief, alluvial delta are not unusual;
- The Salt River is an important component of the Eel River estuary.

Land Use Impacts on the Estuary:

- Since the estuary is located at the bottom of the Eel River Basin, it is susceptible to watershed cumulative effects. Therefore, the condition of the estuarine environment is influenced by conditions of the Eel River Basin as a whole;
- Beginning in the late 1800s, the physical structure and natural processes have been altered by conversion of riparian forests and wetlands to farming and pasture lands;
- Estuarine channels were once cleared of LWD to promote navigation by boats. A relative paucity of woody debris in the estuary may limit shelter habitat needed by juvenile salmonids during large winter runoff flows and also limits cover to escape from predators;
- The Eel River estuary receives sediment loads, turbidity, and other aspects of water quality and quantity from the entire basin;
- Large scale erosion and associated sediment inputs to streams of the Eel River Basin and Salt River Basin have contributed to excessive sediment accumulations in the Eel River estuary, including the main estuarine channel;
- As a combined result of a reduction in tidal prism and excessive amounts of sediments delivered to the estuary, the overall amount of habitat area and its complexity have been altered/reduced, adversely impacting the fishery resources. Moreover, channels have filled in and become more prone to overflow their banks;
- Channel and bank modifications within the Eel River estuary have also altered estuarine morphology, hydrologic and fluvial processes. The reduction in salt marsh habitat area and loss of channel connectivity and complexity has altered the natural ecosystem process involved with nutrient cycling, food production, and resulted in a loss of habitat area and diversity;
- The loss of approximately 90 percent of original wetland habitat and tidal prism is from land reclamation and the affects of levees and tide gates. The network of levees and tide gates in the Eel River estuary has reduced channel connectivity and blocked the ebb and flood of the ocean tides;
- Levees also reduce capacity of flooded delta lands to drain and prolong the effects of flooding;
- Dairy and cattle waste products have potential to degrade water quality in the estuary;
- Cattle have access to many estuarine channels and contribute to bank erosion and degrade water quality;
- Efforts have been made to reduce dairy wastes from entering the network of estuary channels, but monitoring studies have not been implemented to gauge effectiveness of the dairy waste management;
- Water temperature in the upper estuary is above desired levels.

Management:

- There is no comprehensive management plan for the Eel River estuary;

- In the estuary there are competing interests by multiple users for a limited amount of public lands.

Recommendations

Flow and Water Quality Improvement Activities:

- Insure the supply of freshwater inflows are provided for maintaining estuarine habitat diversity and to drive ecosystem processes that fish, wildlife, and vegetative communities depend on for part or all of the life history cycles;
- Use levee set backs, reconfiguration, or levee removal strategies to develop a wider flood plain that restores natural sinuosity, improves connectivity with sloughs and adjacent wetlands in North Slough channels or other areas constricted by levees;
- Increase tidal prism by modifying tide gates to restore tidal and riverine flow and connectivity between the main channel and slough channels and adjacent wetlands;
- Continue to prevent or reduce cattle waste and agricultural and dairy by-products from entering stream and slough channels;
- Take measures to insure that water treatment facilities in Fortuna, Loleta, Ferndale and other nearby areas do not contaminate estuarine waters.

Erosion and Sediment Delivery Reduction Activities:

- Land managers should work to maintain and/or establish adequate streamside protection zones to encourage growth of riparian vegetation to help stabilize stream banks;
- Increase slough channel scour potential by restoring tidal prism in historic tidal wetland areas;
- Continue efforts such as road improvements, good maintenance, and decommissioning and other erosion control practices associated with all land use activities throughout the Eel River basin to reduce sediment delivery to the estuary;
- Armour eroding banks near Fernbridge or other such areas with bioengineered techniques that secure large wood pieces into banks and integrate live trees into the stabilization project.

Riparian and Instream Habitat Improvement Activities:

- Where feasible, restore or improve width of riparian vegetation stands with native vegetation (Sitka spruce, cottonwood, redwood, alder willow) along the banks of lower Eel River and slough channels;
- Work to restore natural functioning tidal and drainage patterns within the McNulty Slough portion of the Ocean Ranch Wildlife Area and other north slough area channels and wetlands. The project should address water temperature, water flow regimes and other parameters needed to promote seasonal and/or year round use by fishery resources;
- Candidate sites for levee removal include both sides of McNulty Slough and its tributaries, and the land west of McNulty slough. The northwestern delta should be expanded rapidly outward from earlier project sites;
- Consider conservation easements or land acquisitions that would promote the removal or modification of tide gates and levees in order to restore tidal prism and tidal wetlands;
- Develop policy or regulations that prohibit or reduce wood removal from within the estuarine channel banks (0.25 mile upstream from the Fernbridge to river mouth) and out to 50 feet from the high tide shore line of the North Bay. Such regulations should protect wood pieces on stream banks needed to reduce potential from further bank and beach erosion, provide instream shelter during high flows for fish, and protect bank restoration projects;

- Develop plans to eradicate or control the spread of invasive Spartina densiflora. An optimal strategy for low to medium sized budgets is to remove Spartina in areas where it grows in low density subpopulations.

Education, Research, and Monitoring Activities:

- Develop an inclusive estuarine (Salt and Eel River estuary) ecosystem management and monitoring plan that works with natural processes restore tidal connectivity to wetlands and increases tidal prism;
- Investigate potential impacts form sea level rise, increased storm intensity and other impacts to the estuary related to climate change;
- Add to baseline data regarding habitat utilization by all estuarine species;
- Study and assess the status of estuarine conditions needed to complete specific life history requirements for salmonids and other estuarine dependant fish and invertebrate species;
- Continue and expand water quality monitoring (including temperature and D.O).of nutrient levels that may be elevated from runoff from cattle pastures, sewage treatment facilities or other sources;
- Monitor the progress of natural succession (biotic and abiotic) and fish and wildlife resource utilization within the Ocean Ranch wildlife area. This should include the estuarine area and the fresh water impoundment;
- Determine the percentage of adult Chinook returning to the Eel River that show extended estuary rearing patterns by using scale analysis or other means;
- Investigate operations of tide gates on McNulty Slough, Hawk Slough, Centerville Slough and others to determine effects and/or loss of properly functioning saltwater/freshwater ecotone;
- Investigate dynamics of breaching the seaward levee at the south end of McNulty Slough to increase tidal prism and develop connectivity between wetlands and other sites to restore wetland connectivity.

Salt River Subbasin

The Salt River Subbasin is the southern portion of the Eel River estuary. In its 49 square miles, it contains 42 miles of sloughs and freshwater tributaries. This subbasin is composed of two significant ecological units: the delta, identified by the alluvial floodplain, and the Wildcat Range, which describes the tributaries that originate in the Wildcat Hills and flow across the delta. As does the Estuary Subbasin, the Salt River Subbasin provides valuable areas for juvenile and adult estuarine fish species. The Wildcat tributaries provide habitat for freshwater fish, including coho, Chinook, and steelhead.

Issues and Findings

General Management Issues:

- Hydrologic energy in the Salt River has been reduced through the:
  - Loss of tidal prism through historic agricultural conversion of wetlands, sloughs and salt marshes;
  - Exclusion of periodic Eel River flood waters by the Leonardo Levee;
  - Diversion of the eastern 42% of the watershed into Perry Slough and Old River;
  - Prolific growth of nuisance instream vegetation, lessening water velocity and resulting in further sediment deposition;
- Highly erodible soils dominate the upper watershed;
- Seismically very active area and close proximity to the Mendocino Triple Junction;
- Potential of subsidence and uplift within in the Eel River Delta.

Socio-economic

- The Salt River is no longer a navigable waterway;
- Flooding has increased because a reduction of channel capacity of all watercourses in the Salt River Basin due to sediment deposition;
- Degradation of Francis Creek and the Salt River channel has resulted in the Ferndale Wastewater Treatment Plant to be in violation of water quality regulations leading to a cease and desist order issued by the North Coast Water Quality Control Board in 2008 and will most likely be re-permitted once it reaches a resolution;
- Health hazards are posed through water quality degradation;
- Agricultural production and land values are decreased by flooding;
- Most domestic and irrigation wells are less than 30 feet deep. Nitrates and fecal contaminants could easily contaminate the shallow ground water.

Land use

- The majority of Salt River Delta is in agricultural production;
- Livestock has access to streams in many locations within the Basin resulting in: stream bank erosion, no recruitment of riparian plant growth, direct input of fecal and urine contaminants, and trampling of stream banks;
- There have been negative impacts to streams and fish habitat from historic timber harvest practices;
- Channel realignment in the trans-delta reaches of some of the Wildcat tributaries from a distributory flow regime to a channelized flow regime has resulted in greater input of sediment in the mainstem Salt River;
- Urbanization and channelization has altered discharge and sediment deposition patterns of Francis Creek;
- Dairy farm waste management infrastructure is, in places, inadequate;
- Unknown, but suspected high quantities of nutrients from agricultural land may present water quality problems in the mainstem of the river as well as in the estuary;
- Erosion from roads and stream banks in the Salt River tributaries is a significant by indeterminate source of suspended sediment;
- Extensive system of levees and berms throughout the basin disrupt channel connectivity with adjacent floodplain;
- Sand quarries may have had a negative impact on the amount of sediment in the Salt River.

Fish and Wildlife

- Canopy cover and riparian vegetation is lacking in some portions of the Wildcat tributaries;
- 2,900 acres of tide land in the Salt River Basin were reclaimed in the late 1800's;
- Salmonid access into the Salt River system is severely impaired, and access to Williams Creek and Coffee Creek has been eliminated;
- Salmonid habitat throughout the entire basin is poor;
- Aquatic macroinvertebrate populations in basin indicate instream sediment impairments;
- Potential large woody debris (LWD) recruitment is generally poor;
- Spawning habitat is inadequate due to excess fine sediments;
- Mercury contamination has been found in the flesh of fish in the Eel River system (Stokes, 1981).

Middle Subbasin

The Middle Subbasin includes the area east of the Eel River from the confluence of Finch Creek to upstream of the confluence with Strongs Creek as well as a narrow strip west of the Eel River parallel. Stream elevations range from approximately 40 feet at the confluence of the Eel River with Finch Creek to approximately 1,700 feet in the headwaters of the tributaries.

The subbasin encompasses 24 square miles, occupying 14% of the total basin area. Lower elevations areas are mostly held in private parcels less than 40 acres in size while much of the higher elevation areas are owned by large timber companies and are managed for timber production. The streams in the Middle Subbasin are heavily affected by urbanization, as many flow directly through Fortuna, the area's population center. Fish surveys of the streams in this basin have identified coho, steelhead, and coastal cutthroat trout.

Issues and Findings

Altered flow regimes:

- Low summer flows are exacerbated by land and stream disturbances and result in dry or intermittent reaches on streams, which are stressful to salmonids;
- Fortuna operates five groundwater extraction wells near the Eel River;
- Increased development in Fortuna, especially in the southern and eastern parts of the city, has increased runoff from newly created impervious areas (FEMA 1981, cited in Mintier and Associates 2006);
- Many of the storm drains and culverts in Fortuna are undersized (Winzler and Kelly 2005), increasing the velocity of flows during precipitation events;
- Strongs and Rohner creeks have been modified where they flow through Fortuna to eliminate their floodplains, increasing the volume and velocity of flows during precipitation events;
- Winter floods are increasingly common due to high winter precipitation levels, increased runoff, and undersized storm water drainage structures. Areas with current flooding include the North Fortuna Drainage Area, Rohner Creek, the lower reaches of Strongs Creek, and Jameson Creek at the confluence with Strongs Creek (Winzler and Kelly 2005);
- Undersized drainage capacity has also been identified in several areas including Rohner Creek and the Mill Creek drainage. Rohner Creek has the highest potential for serious flooding (Winzler and Kelly 2005).

Addition of pollutants:

- When flows are sufficiently high, the Eel River floods into treatment ponds of the Fortuna Wastewater Treatment Plant;
- The Fortuna Wastewater Treatment Plant received a cease and desist order in 1997. The issue was resolved and the order was rescinded that same year;
- The treatment plant had three chlorine limit violations - one maximum and two minimum values that violated the permit level in 2004. Sewer overflows that occurred in the system were caused by high flows and collection system stoppages;
- Increased development in Fortuna, especially in the southern and eastern parts of the city, has increased runoff from newly created impervious areas (FEMA 1981, cited in Mintier and Associates 2006). Although no specific tests of chemicals have been conducted in Fortuna's streams, urban runoff in general is known to mobilize chemicals such as trace elements, pesticides, copper, and volatile organic compounds (Hamilton et al. 2004);
- Livestock grazing likely occurs in 23% of the subbasin and has been noted along Strongs and North Fork

Strongs creeks. Although no specific tests of nutrients and/or coliform bacteria have been conducted in these creeks, levels of these constituents often exceed water quality standards in areas with extensive livestock use;

Fish passage barriers where roads cross streams:

- A culvert on Mill Creek (RM 1.3) and Rohnerville Road may not meet CDFG and NOAA Fisheries fish passage guidelines;
- A culvert on Jameson Creek and Rohnerville Road does not meet CDFG and NOAA Fisheries fish passage guidelines;
- Palmer Creek has problems with fish passage due to a barrier in the 800 foot culvert under Highway 101.

Natural processes effects stream conditions:

- Natural erosion rates are high due to:
  - The major rock underlying the subbasin is alluvium, which constitutes 70% of the subbasin. The other bedrock, also sedimentary, is Pliocene marine. Both of these geologic types are highly erodible;
  - Rapid incision rates of the mainstem and its tributaries have left a series of river terrace deposits perched steeply above the current stream channels which contribute fine sediments through slope instability and dry ravel;
  - The Little Salmon fault cuts through this basin, weakening bedrock and increasing the potential for seismic triggering of landslides;
  - During the winter rainy season, heavily silted water flows through the steep upstream terrain, which affects turbidity and sediment levels in streams.

Changes in basin due to land use:

- Sedimentation and in-filling as a result of land development and subdivision activities, gravel mining and timber harvesting practices have resulted in an overall reduction in channel area, and consequently in available salmonid habitat;
- Fortuna grew from one square mile in 1950 to 4.68 square miles in size in 2006. This represents a change from approximately 4% to 19.5% of the subbasin;
- The Fortuna annual average population growth rate from 1980 to 2005 was 1.6%. If the city continues to grow at this rate the population will rise from 11,250 to approximately 17,000 in the next 25 years (Mintier and Associates 2006);
- There were 4,729 housing units in Fortuna in 2005. If current growth rates continue, Fortuna will require 2,298 new housing units by 2030 (Mintier and Associates 2006);
- Additionally, it is projected that there will be a need for an additional 852,866 square feet of commercial, retail, and manufacturing space by 2030 (Mintier and Associates 2006).

Possible effects seen in stream conditions:

- Instream habitat conditions for salmonids are thought to be poor;
- Projects related to the expansion of Fortuna's urbanization have adversely affected the area's streams in both water quality and riparian and instream habitats;
- Development of the commercial shopping center along Mill Creek has greatly reduced the riparian area and hydrology of the stream channel. During large precipitation events, the stream overflows its banks and has caused stranding of steelhead in the adjacent fields;
- Excessive sediment in stream channels has resulted in an overall loss of spawning, rearing, and feeding

habitat for salmonids. High sediment levels are confirmed by embeddedness measurements in surveyed reaches. Moreover, none of the surveyed streams met target values of pool depth;

- The Fortuna Creeks Project found that stressful turbidity levels are reached during the rainy winter months. These high levels of turbidity, which are particularly apparent in Strongs and Rohner creeks, occur during spawning season;
- Quality pool structure is generally lacking in Middle Subbasin streams; no surveyed streams met standards for pool shelter. Pool shelter ratings ranged from fully unsuitable to somewhat unsuitable levels;
- Spawning gravels in Strongs and North Fork Strongs creeks are found in only a limited number of reaches. Additionally, crowded and superimposed redds have been observed during spawning surveys;
- None of the CDFG surveyed streams of the Middle Subbasin met target values for cobble embeddedness.

There is concern about unrestricted stream access of livestock in agricultural areas:

- Impacts from livestock grazing have been noted during stream surveys on Strongs and North Fork Strongs creeks;
- Livestock grazing operations occur in approximately 23% of subbasin.

Erosion related to timber harvest on unstable soils is a concern:

- The impact of previous techniques and harvest amounts are evident in the braiding of the Eel River from the mouth of Van Duzen River to Fernbridge that has occurred since 1956. A general flattening and widening of the river bed is also apparent (Humboldt County 1992);
- Timber harvest, while less of an issue than in the past, still occurred in the headwaters of all of the creeks in this subbasin from 1988 to 2005. Erosion related to timber harvest on unstable soil is a concern, such as the recent timber harvesting in the headwaters of Strongs and North Fork Strongs creeks. This area is made up of the Wildcat Formation, which is largely comprised of fine sediment and is highly erosive.

There is concern about the impacts of historic and current gravel mining operations on the mainstem Eel River:

- There are eleven gravel mining sites in this subbasin that remove over 5,000 cy/yr of aggregate. The volume of aggregate removed has decreased significantly since 1996. Prior to 1996, average extraction volumes ranged from 500,000cy/yr to 700,000cy/yr;
- The USACE has concluded that sand and gravel mining extractions are not excessive or occurring at rates that are too high to negatively impact channel morphology in the basin based on the increase of shoreline sediment. However, as bed-load data are not well known, it is difficult to set adequate extraction rates and volumes;
- Most of the concern in managing gravel mines is in the reconfiguration of the low flow channel. To this end, trench, alcove, or wetland pit mining are recommended over bar skimming, which has been shown to increase low flow channel width (USACOE 2003). Without the revision of extraction amounts and techniques, impacts to salmonids would be significant and would likely include loss of deep holding pools during adult migration, and loss of cover, suitable temperature, and complex habitat for juvenile salmonids.

Upper Subbasin

The Upper Subbasin includes the watershed area along the Eel River from Barber Creek to Dean Creek. It also includes the Van Duzen River from its mouth to Cummings Creek, approximately 9 miles above its confluence with the Eel. Stream elevations range from approximately 40 feet at the confluence of the Eel River with Barber Creek to approximately 2,160 feet in the headwaters of the tributaries. This subbasin is the largest of the Lower Eel Basin at 75 square miles, 43% of the total basin area. This subbasin is mostly held in private parcels 40-500 acres in size with large sections owned by large timber companies and managed for timber production. Chinook, coho, and steelhead have each been documented in fish surveys of the Upper Subbasin.

Issues and Findings

Sediment level in streams is high and creates a multitude of problems for fish habitat:

- Filling of pools by sediment is an issue in every creek surveyed in this subbasin. The majority of streams were of the lowest suitability in terms of pool depth and frequency;
- Pool shelter is a widespread issue in the subbasin. Every stream surveyed in this subbasin with the exception of Oil Creek has pool shelter values that were below suitable and none met target values. Sedimentation of coarse material can affect recruitment of large woody debris, and both fine and coarse sediment can fill in hiding places around shelter components such as boulders and logs;
- Substrate embeddedness was very high on Wolverton Gulch, Wilson Creek, Dean Creek, Nanning Creek, and Westfork Howe Creek. With the exception of Oil Creek, all streams surveyed were poorly suited for spawning;
- The two most common geologic formations in this subbasin are the Wildcat Formation, which is comprised of uniformly fine sediment and is highly erosive, and the Coastal Belt Melange Formation, which is even more erosive but contains a wide range of sediment sizes from boulders to silt;
- Logging occurs (1989-2005) in both the Wildcat Formation and the Coastal Belt Melange Formation. Some areas have been entered more than once, and different yarding and harvesting methods have been used across the subbasin; these all influence the impact logging can make on a watershed;
- Kelsey (1977) posits that the Van Duzen River has aggraded significantly since the 1964 flood upstream of, but likely applying to this study area. This has probably exacerbated the broadening of the low flow channel near the mouth.

Gravel mining practices have created a seasonal fish passage barrier at the mouth of the Van Duzen River:

- Bar skimming had been the preferred method of gravel extraction on the Lower Van Duzen River up until 1996. This method has been shown to widen channels thus creating a shallow, braided reach;
- In 2001, 136 adult migrating salmonids were stranded at the mouth of the Van Duzen River due to years of widening of the low flow channel from gravel mining and aggradation;
- The lower four miles of the Van Duzen River are purposefully blocked to salmonids by three temporary culverts from the time the first adults arrive at the mouth until flows increase enough to ensure upstream passage.

Accessibility to habitat is potentially blocked at various points in the subbasin:

- The mouth of the Van Duzen River, if left alone, creates a barrier to adult fish passage due to its broad, braided and shallow low flow channel;
- Log debris accumulations occur on Cummings, Dean, Atwell, West Fork Howe, Adams, and Nanning creeks, and Wolverton Gulch;
- Culverts on Adams and Oil creeks may be barriers to fish passage;
- Rock dams occur on Price Creek and may pose as barriers to fish passage;
- The mouth of Dean Creek is a perched sediment delta and potentially acts as a barrier to fish passage;
- Connectivity at the mouths of Fiedler and Cummings creeks and Wolverton Gulch may be an issue due to sedimentation.

Urban and agricultural wastewater disposal poses a problem to aquatic ecosystems in the mainstem Eel River:

- In 2003, Rio Dell's wastewater treatment facility received a 'cease and desist' order from the Regional Water Quality Control Board for problems arising from sludge removal and summer discharge into the Eel River through gravel bar percolation. These problems are ongoing, and the city has until 2009 to correct them;
- Livestock grazing operations occur in 11% of basin;
- Water temperatures are stressful to salmonids in the mainstem Van Duzen and Eel rivers and are unsuitable in some tributaries;
- A 1998 study done by Humboldt County RCD showed maximum weekly temperatures above 20 degrees Celsius (68°F) in the Eel River at the confluence with the Van Duzen River from July 1st through mid September, 1996, as well as in the Van Duzen River at the 101 bridge during that same timeframe;
- Sites monitored in Howe and Price creeks in were found unsuitable, recording maximum weekly temperatures above 65°F in June through October over several years.