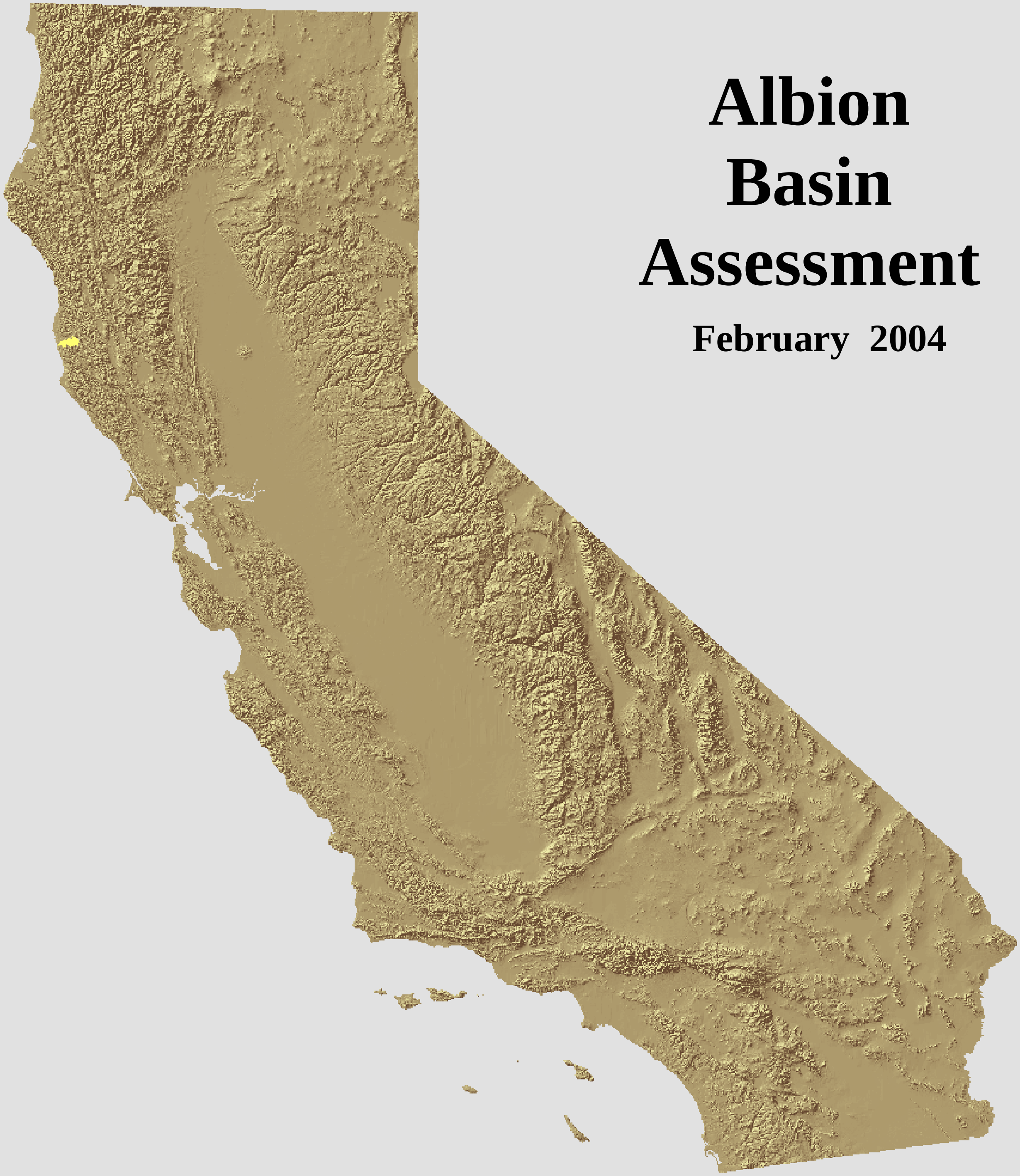
North Coast Watershed Assessment Program



Albion Basin Assessment

February 2004

North Coast Watershed Assessment Program Participants

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NCWAP Basin Assessment Products

Reports

Main products are basin level assessment reports for each subject watershed. These reports consist of an integrative synthesis report and a number of discipline-oriented appendices. A limited number of these synthesis reports and appendices were produced in printed media for program cooperators and partners, constituent groups, and agencies. Printed reports were also distributed to most major libraries. Printed documents are not currently available to the public; however, the entire synthesis report document, including appendices and maps, is available on a compact disk in PDF format or via the website www.ncwatershed.ca.gov. Basin assessment reports are currently available for the Gualala, Mattole, and Albion River basins. The Big River and Redwood Creek reports are in the process of being completed. CDs containing the reports, appendices, and maps may be requested from:

California Department of Fish and Game

Coastal Watershed Planning and Assessment Program

1487 Sandy Prairie Court, Ste. A

Fortuna, CA 95540

707.725.1070

Klamath Resource Information System CDs and Website

The Institute for Fisheries Resources (IFR) has produced Klamath Resource Information System (KRIS) projects for six North Coast watersheds. KRIS is a custom software program capable of managing watershed data sets, tables, charts, photos, and maps. An Albion KRIS product has not yet been produced. There are currently KRIS products for the Noyo, Big, Ten Mile, Gualala, and Mattole rivers, and Redwood Creek; they are available via the IFR website (www.krisweb.com), or on CD from:

Department of Forestry and Fire Protection

Fire and Resource Assessment Program

PO Box 944246

Sacramento, CA 94244-2460

(916) 327-3939

frap@fire.ca.gov

Maps of Landslides and Relative Landslide Potential

To date, the California Geological Survey has produced maps and GIS coverage of landslides and relative landslide potential on the Mattole, Gualala rivers, and Redwood Creek basins. To order additional maps contact one of the California Geological Survey offices:

Publications Sales-Sacramento	Publications and Information Office-Sacramento
(916) 445-6199 fax: (916)324-5644	(916) 445-5716
Southern California Regional Office-Los Angeles	Bay Area Regional Office-San Francisco
(213) 239-0878	(415) 904-7707

You may also download the order form from the web site: www.consrv.ca.gov/cgs/information/publications/ordering.htm

Data sets and GIS Products

A number of data sets and GIS products have been produced as a part of this work. Some of these products are available at www.ncwatershed.ca.gov

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Executive Summary

California Coastal Watershed Planning and Assessment Program

The Albion Basin Assessment began as a project of the North Coast Watershed Assessment Program (NCWAP). That program was established by the state Legislature in July 2000 and was managed by the California Resources Agency and the California Environmental Protection Agency. Participating Resource Agency departments included Fish and Game (CDFG), Forestry and Fire Protection (CDF), Conservation/California Geologic Survey (DOC/CGS), and Water Resources (DWR), in conjunction with the North Coast Regional Water Quality Control Board (NCRWQCB) and State Water Resources Control Board.

In July 2003, after conducting large scale assessments on the Mattole and Gualala rivers, and Redwood Creek, the program was eliminated because of reductions in the state budget. However, large scale watershed assessment efforts are ongoing by the CDFGs Coastal Watershed Planning and Assessment Program (CWPAP), with input from other Resources Agency departments as budgets allow.

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

Each of the program's participating departments developed data collection and analysis methods used in their basin assessments. The departments also jointly developed a number of tools for interdisciplinary synthesis of information. These tools included models, maps, and matrices for integrating information on basin, subbasin, and stream reach scales to explore linkages among watershed processes, current conditions, and land use. In basins where information was available, these tools provided a framework for identifying refugia areas and factors limiting salmonid productivity, as well as providing a basis for understanding the potential for cumulative impacts from natural and man caused impacts. This information is useful for developing restoration, management, and conservation recommendations.

The general steps in our large-scale assessments include:

- Form multi-disciplinary team;
- Conduct scoping and outreach workshops;
- Determine logical assessment scales;
- Discover and organize existing data and information according to discipline;
- Identify data gaps needed to develop the assessment;
- Collect field data;
- 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.

The roles of the five original participating NCWAP agencies in these efforts included these activities:

- DOC/CGS compiled, developed, and analyzed data related to the production and transport of sediment;
- CDF compiled, developed, and analyzed data related to historical land use changes in the watersheds;
- NCRWQCB compiled, developed, and analyzed water quality data for the assessment;
- DWR installed and maintained stream monitoring gages where needed to develop and analyze stream flow information.
- CDFG compiled, collected, and analyzed data related to anadromous fisheries habitat and populations.

Results of assessments conducted by various agency personnel on the Albion team were brought together in an integrated synthesis process. This process describes spatial and temporal relationships between watershed and stream conditions and dynamic watershed processes that have been at work to form them. To assist in this process, the team used Geographic Information System (GIS) based watershed data coverage and an Ecological Management Decision Support (EMDS) model to help evaluate watershed conditions and processes.

Scale of Assessment and Results

The Albion assessment team used the California Watershed Map (CalWater version 2.2a) to delineate the Albion Basin into two subbasins for assessment and analyses purposes (Figure 1). These study areas were demarked as the Coastal and Inland subbasins. In general, the CalWater 2.2a Planning Watersheds (PWs) contained within each of these assessment subbasins have common physical, biological, and/or cultural attributes. However, there is enough variance between the two 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 reporting of findings and making recommendations for watershed improvement activities that are generally applicable across a large, relatively homogeneous area.

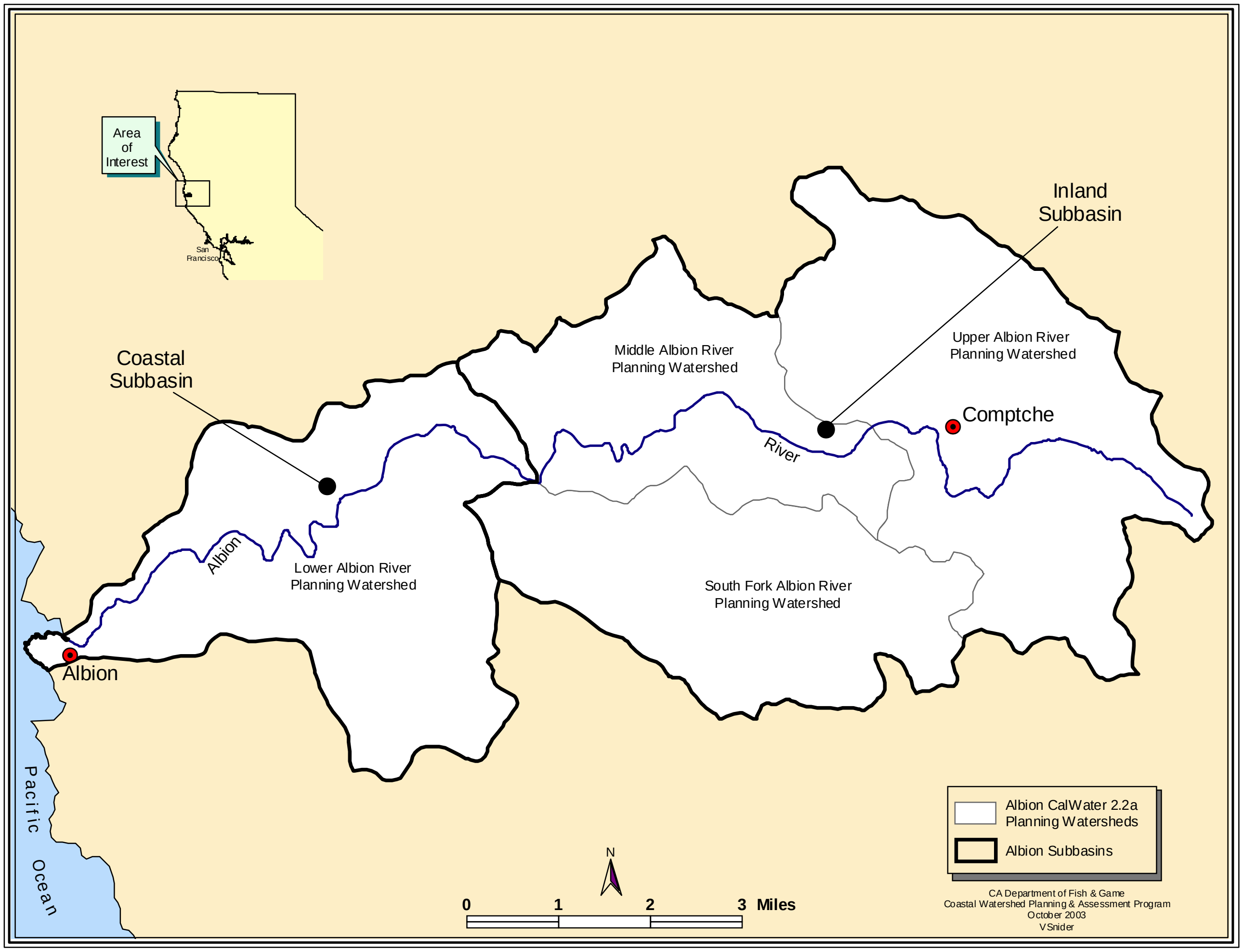


Figure 1. Albion Subbasins and CalWater2.2a Planning Watersheds.

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 include:

- A basin level geologic evaluation that includes:
  - Map of landslides and geomorphic features related to landsliding with accompanying text;
  - Relative landslide potential map with accompanying text.

Please Note: For above products, contact California Geological Survey, Sacramento, CA.

- A basin level Synthesis Report that includes:
  - Collection of Albion 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://ncwatershed.ca.gov/, and http://imaps.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 the 1955 and 1964 floods or major 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 like 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 the so-called "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.

Albion Basin

The Albion River is located about 125 miles north of San Francisco in central Mendocino County, California. The Basin encompasses approximately 43 square miles (27,520 acres) of Northern California's Coast Range

(Figure 1). Its headwaters are inland approximately 12 miles at an elevation of 600 feet. Mathison Peak, at 1,030 feet is the highest point in the Basin.

The Albion Basin has a Mediterranean climate characterized by a pattern of low-intensity rainfall in the winter and cool, dry summers with coastal fog. Mean annual precipitation is about 40 inches at Fort Bragg near the western margin of the basin and about 50-55 inches near the eastern margin. About 90% of the precipitation in this area falls between October and April, with the highest average precipitation in January. Snowfall in this basin is very rare and hydrologically insignificant.

CGS divided the Albion Basin into three geologic sub-regions with somewhat distinct landforms and fluvial environments reflective of differences in their geological development. The western sub-region consists mainly of a broad marine terrace that was greatly affected by regional uplift and the relative rise and fall of sea level during the Pleistocene (11,000 to 1.1 million years). The central sub-region appears to have experienced more intense structural deformation that, since uplift, has led to intense channel incision and the formation of debris slide slopes and bedrock bound inner gorges. The largest landslides flank mainly the northwest oriented slopes above the North and South Forks of the Albion River. Historically active landsliding has occurred more frequently in the vicinity of the large dormant rockslides than in other portions of the basin. The eastern sub-region consists of more mature landforms and stores large accumulations of fine-grained sediment probably deposited in a bay or estuary during the Pleistocene. Since uplift, subsequent streams now rework this sediment.

Fluvial sediment was more readily observed in aerial photos of the grasslands in the western sub-region and in the open estuary than in the heavily forested central sub-region. For the central and eastern sub-regions, comparison of aerial photos taken in 1984 with those taken in 2000 indicates a significant reduction in stream sediment deposits. However, in tidally influenced depositional reaches of the estuary little change in sediment levels was detected for the period between 1984 and 2000.

The Albion River has a large estuary relative to the size of its basin, with tidal influence extending as much as five miles upstream. The mouth of the river is defined by a narrow opening along the south side of Albion Cove, which is protected by a rock headland. This headland minimizes wave induced longshore sediment transport and allows the mouth of the Albion River to remain open to the sea throughout the year.

Prior to European exploration and colonization of the area, Pomo Indians inhabited the area. Known dwelling areas were around the present day location of Comptche and the town of Albion, though it is thought that these places were inhabited seasonally. Abalone, salmon, and other foods were utilized, as were important coastal plants.

In 1845, Mexico awarded English sea captain William Richardson a large land grant, stretching along the California coast from Mal Paso Creek to Big River (encompassing the land between the present-day towns of Elk and Mendocino). The word Albion is an archaic name for England or Great Britain. He chose the name because the coastal cliffs reminded him of those in England. By 1853, Richardson had built the first sawmill to operate along the Redwood Coast, located in the estuary. Richardson lost all his land in 1853, when the U.S. Land Commission refused to recognize his Mexican title (Levene 1977).

The subsequent history of the Albion River basin was dominated by timber harvest. Richardson's 1853 sawmill produced about 1900 board feet of lumber a day. Over the next sixty years, several additional mills were built that fire or winter rains destroyed. Some of these mills were capable of turning out over a million board feet of lumber a day. Splash dam logging practices were also widely used across the basin, and likely had lasting impacts on stream channels and salmonid populations.

Between 1881 and 1891, a railroad was constructed linking the original mill site in the estuary with Comptche and Keene's Summit, and also the ridge between the South Fork Albion and North Fork Navarro. Steam engines pulled cars loaded with logs from inland areas to the estuary where they were milled and loaded onto sailing vessels to be transported south to San Francisco Bay. Mills in the estuary area closed around 1928 and railroad service was discontinued in 1930. A number of smaller mills operated in the Comptche area between the mid 1930s and the 1960s. Relative to the 1890-1928 period, harvest levels were apparently far lower between 1930 and 1960. The forest had been depleted and was left to regenerate.

Primary methods of timber harvest since the 1940s have consisted of tractor yarding and the construction of roads, skid trails, and landings. The use of cable yarding on steeper slopes has increased substantially since the 1980s and tractor logging is generally restricted to gentler slopes.

CDF found that timber harvest levels have increased substantially since the 1990s with the maturity of second growth. Today, the Mendocino Redwood Company owns approximately 54% of the land with smaller industrial timberland ownerships, a few ranches, and numerous small parcels, typically private residences, making up the balance. The basin is privately owned with the exception of about 400 acres that were recently acquired as part of the Big River State Park, and a few small parcels owned by Mendocino County and various school districts.

Population centers are the towns of Albion and Comptche. Comptche is near the headwaters and Albion near the mouth. The total Albion Basin resident population in the year 2000 census was estimated at about 912 people.

The current vegetation is dominated by redwood and Douglas fir coniferous forest (59%). Thirty percent of the basin is composed of mixed forest consisting of both conifer and hardwood species, including redwood, Douglas fir, tan oak, and madrone. Four percent is composed of hardwood forest.

Documented fishery resources of the Albion Basin include coho salmon and winter-run steelhead trout. Incidental reports and anecdotal information also record Chinook and pink salmon. Other fish include sculpin and stickleback in the freshwater habitat and a diversity of marine species in the estuary.

There is little historic or quantitative data regarding salmonid abundance and distribution in the Albion Basin. Anecdotal evidence provides a convincing case that historic anadromous salmonid runs in the Albion Basin were large and there has been a decrease in the size of these runs since the mid 1950s.

The Albion River appears to have well established coho salmon and steelhead trout populations due to the suitable fresh water temperatures, year-round open connection with the ocean, and a large estuary. Most salmon and steelhead stocks on California's North Coast streams are depressed to levels which led to the listing of coho, Chinook, and steelhead under the authority of the Endangered Species Act.

Coastal basins such as the Albion provide vital habitat for native salmonid stocks. These stocks can be important for reestablishing viable salmonid populations in neighboring stream systems as instream and upslope conditions improve.

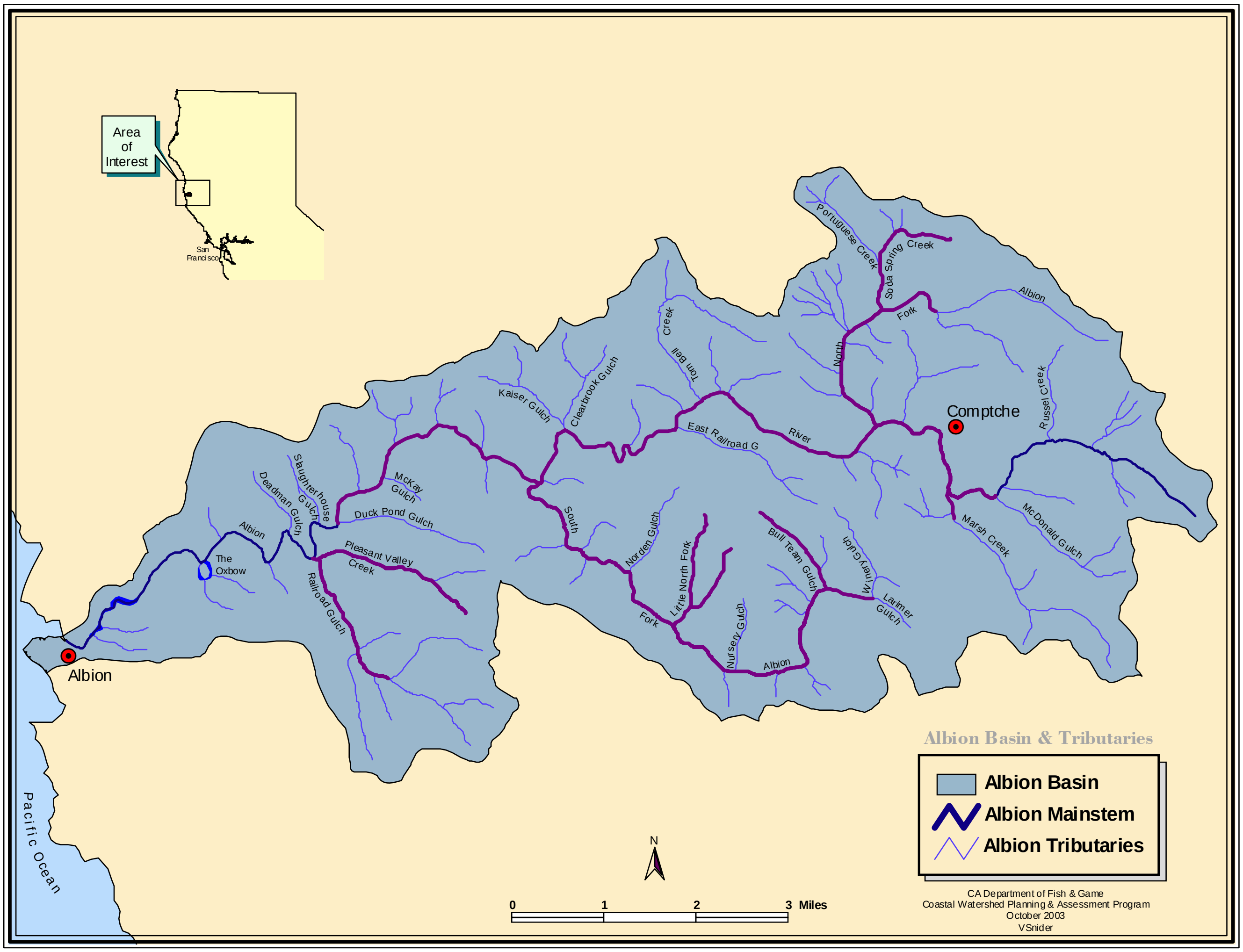


Figure 2. Albion River Basin.

General Issues, Assessment Questions, Findings and Conclusions, and Improvement Recommendations

Albion Basin General Issues

Public scoping meetings with Albion Basin residents and constituents and initial analyses of available data by watershed experts developed this working list of general issues and/or concerns:

- Low stream flow in the late summer and fall are exacerbated by water extraction and diversions in the Inland Subbasin;
- Water temperatures and dissolved oxygen in the mainstem estuary may be unsuitable for salmonids;
- Dissolved oxygen levels may be unsuitable in the North Fork Albion;
- Excessive fine sediment generated by surface erosion from residential winter road use;
- Sediment from poorly maintained and undersized County road culverts;
- Levels of fine sediment <6.4mm in some areas of the basin are unsuitable and therefore impact instream conditions;
- There is evidence of streambank erosion caused by livestock grazing within the riparian zone in some areas of the basin;
- Instream substrate particle size (D50) is generally small throughout the basin;
- Permeability samples at the South Fork Albion sample site were low;

- High road density throughout the watershed, both current and legacy;
- Large Woody Debris (LWD) recruitment potential is generally poor;
- There is a shortage of instream LWD in most stream reaches;
- Inadequate spawning habitat due to limited recruitment, sorting, and retention of cobble size substrate;
- Some fish passage barriers related to Mendocino County road stream crossings have been identified in the basin;
- Rural subdivision and development in the estuary and Albion Ridge areas;
- Limited information on salmonid populations;
- California sea lion predation impacts on fish populations;
- Lack of ground truthing by agency staff of privately collected data and/or data based on remote sensing;
- The estuary may be more shallow now than in the past and it currently lacks channel complexity;
- There is a dam on Marsh Creek which is a barrier to salmonid migration.

Assessment Sample Base

This assessment was based on the following information:

- CGS samples included two visits to ground truth landslides and potential landslides;
- CDF samples included air photo analysis and field verification on two field visits;
- NCRWQCB included three field visits for data collection in 2001, and utilized information provided by private and agency cooperators on water and substrate quality in various years from 1976 to 2002, with the majority of data from 1998 to 2002;
- Stream flow information compiled from the *Albion River Sediment Source Analysis and Preliminary Sediment Budget* (GMA 2001) and DWR;
- CDFG included over 30 field visits in addition to eleven stream surveys conducted between 1998 and 2003. Additionally, spawning surveys were conducted in 2001 and 2002. Private and agency cooperators also contributed various biological and physical data from 1988 to 2002.
- The assessment team as a group participated in an extensive two-day tour of the basin.

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 and NCRWQCB Appendices contain more specific assessment methods, findings, conclusions, and recommendations for stream and watershed improvements.

Albion Basin

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Albion Basin?

<u>Findings and Conclusions:</u>

- Historic accounts and stream surveys conducted in the 1960s by CDFG indicate that the Albion Basin supported populations of coho salmon and steelhead trout;
- Current data indicate that the Albion Basin continues to maintain coho and steelhead populations. Not enough data exists to comment on status or trends of coho and steelhead populations. Presence surveys since the 1960s indicate that the range of coho salmon and steelhead trout has not changed in that period;
- Mendocino Redwood Company (MRC) has conducted fishery surveys throughout their Albion ownership for the past ten years. These stream surveys indicate the presence of coho salmon and steelhead trout throughout their sample area;

- The National Marine Fisheries Service (NMFS 2001) analyzed data from six MRC index sites from 1988 to 1996. The data suggests that there was a general downward trend in juvenile coho salmon and steelhead abundance during that period. Following an observed peak abundance in 1993, numbers of juvenile salmonids remained constant through 1996;
- In 2002, CDFG made a population estimate of 720 coho spawners (95% confidence interval). The estimate was based on only one year of redd and carcass surveys, which can be highly variable.

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

Findings and Conclusions:

Erosion/Sediment

- Sources of fine sediment include Quaternary age deposits in the Inland Subbasin, geologically recent deposits in estuary, sediment stored in river terraces, historically active landslides, and turbid runoff from disturbed lands;
- Limited data collected in 1998 and 2001 reflect unsuitable levels of fine sediment <6.4mm, which exceed the TMDL target in some areas of the basin, while sediment <0.85 mm at the sample locations throughout the basin are below the TMDL target and therefore their suitability can not be determined at this time;
- In-channel fine sediment deposits in low gradient reaches of the Coastal Subbasin have contributed to poor habitat complexity.

Riparian Condition/Water Temperature

- Water temperatures are suitable at monitoring locations above tidal influence in the mainstem and all locations surveyed on tributaries, and generally suitable at the estuary sample site above Duck Pond Gulch (RM 5.6);
- Summer water temperatures may be deleterious for salmonids in areas within tidal influence in the mainstem estuary;

Instream Habitat

- There are several reaches of scoured bedrock dominated stream channels, a general lack of habitat complexity, and a shortage of gravel and gravel retention structures;
- Pool habitat, escape and ambush cover, and water depth are unsuitable for salmonids in many stream reaches;
- Low flow conditions during the summer and fall are causing intermittent pools and associated fish mortality on the upper mainstem, Marsh Creek, North Fork, Soda Springs Creek, and the upper South Fork;
- Two county road culverts have been identified to be problems for fish passage by a Mendocino County roads study
- There is a dam in Marsh Creek which is a barrier to salmonid migration.

Gravel/Substrate

- Available data from sampled streams reflects that there is a limited amount of suitable spawning substrate;
- The potential of recruiting and retaining appropriately sized gravel from natural processes appears to be poor;
- Gravel permeability at the location monitored on the South Fork Albion was low;
- Instream substrate particle size (D50) is generally small at monitoring locations throughout the basin;

Refugia Areas

- Salmonid habitat conditions in the Albion Basin are of medium potential; the refugia potential is somewhat better in the Inland Subbasin than in the Coastal Subbasin.

Other

- Water quality samples taken at sites in the estuary and North Fork indicate low levels of dissolved oxygen, although further study is necessary;
- Limited water quality data from mainstem sites above tidal influence appear to be suitable, as are pH levels at the North Fork site.

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

<u>Findings and Conclusions:</u>

- The basin has a 43 square mile catchment area and low elevation headwaters that normally do not receive or retain significant snowfall. This results in low winter flows that transport stream bedload only about 5% of the year. (GMA 2001);
- Large dormant rockslides and steep slopes are locations of many historically active landslides in the North and South forks of the basin;
- During the 19th and 20th centuries earthquakes were recorded that triggered landsliding throughout the basin. In addition, a tsunami in 1964 scoured the mouth of the river;
- The basin has been historically and is still dominated by conifer forests, primarily made up of redwood and Douglas fir;
- Poor fertility, an iron-rich hardpan layer, and associated soil wetness restricts vegetation growth and has created pygmy forests in areas along Albion Ridge;
- Vegetation in the basin has been influenced by a history of frequent, natural fires;
- Photo mapping of channel fluvial features suggesting sediment sources or depositions showed a reduction in the number and total length of mapped features (such as sediment bars) from 1984 to 2000;
- Air photo analysis of the lower Albion River at low tide shows a single thread channel, which has varied little in location within the stream channel from 1936 to 2000.

How has land use affected these natural processes?

<u>Findings and Conclusions:</u>

- Water diverted for irrigation and domestic uses is currently permitted for at least 0.5 cfs in upper areas of the basin (GMA 2001);
- Human activities have interacted with natural geologic instability to increase sediment production above natural background levels, although background levels remain indeterminate. Many of the impacts on instream habitat conditions are spatially and temporally separated from their upland disturbance sources, which makes the determination of cause and effect indefinite;
- Historic timber harvest activities reduced riparian canopy. The canopy is currently recovering from those activities;
- As a result of timber harvest, the current landscape is comprised of smaller diameter forest stands than in pre-European times;
- The small diameter of near stream trees limits the recruitment potential of large woody debris to streams and contributes to the lack of instream habitat complexity;
- Historic construction of splash dams and the straightening of stream channels for log transport likely simplified stream morphology and possibly helped scour the instream substrate to bedrock;
- Construction of near-stream railroads and roads have constricted stream channels and destabilized streambanks throughout the basin;
- Development on the Albion River flats has reduced wetland habitat.

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

Findings and Conclusions:

Based on available information for the Albion Basin, the team believes that salmonid populations are currently being limited by:

- A lack of habitat complexity throughout the basin;
- A general lack of instream LWD and poor recruitment potential nearstream;
- Elevated fine sediment <6.4mm in some reaches;
- Lack of available, appropriately-sized spawning substrate;
- Potential dissolved oxygen content in the some areas of the estuary and North Fork Albion;
- Elevated summer water temperatures in parts of the estuary;
- Summer low flow water conditions in the Inland Subbasin;
- Reduced basin-wide coho and possibly steelhead meta-populations;
- Low instream gravel permeability at the location monitored on South Fork Albion;
- Instream substrate particle size (D50) is generally small at monitoring locations throughout the basin.

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

- Encourage water conservation during summer low flow periods to improve stream surface flows and fish habitat in the Inland Subbasin;
- Increase the use of water storage and catchment systems that collect rainwater in the winter for use during the drier summer season.

Erosion and Sediment Delivery Reduction Activities

- Encourage the use of Best Management Practices for all land use development activities to minimize erosion and fine sediment delivery to streams;
- Expand road assessment efforts because of the potential for further fine sediment delivery from active and abandoned roads, many of which are in close proximity to stream channels;
- Encourage restricted access to unpaved roads in winter to reduce road degradation and fine sediment release. Where restricted access is not feasible, encourage rocking and other measures to decrease fine sediment production from roads;
- Inventory and map sources of streambank erosion and prioritize them according to present and potential fine sediment yield. Identified sites should then be treated to reduce the amount of fine sediments entering the stream;
- Provide technical assistance and incentives to landowners/managers in developing and implementing fine sediment reduction plans to meet requirements of the TMDL.

Riparian and Habitat Improvement Activities

- Ensure that stream reaches with high quality habitat and refugia are protected;
- Support progress of CDFG/Mendocino County fish passage improvement projects;
- Work with landowners and managers to increase large organic debris and shelter structures in streams in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids;
- Improve gravel retention and recruitment by adding instream structures where appropriate/feasible;

- Encourage use of exclusion fencing where there is evidence of streambank erosion caused by grazing livestock;
- Where feasible, design and engineer pool enhancement structures to increase the number of pools. This must be done where the banks are stable or in conjunction with streambank armor to prevent erosion;
- Investigate the suitability and feasibility of introducing appropriate, local substrate to spawning reaches if studies show instream structures fail to retain sufficient gravel due to short supply from the system.

Education, Research, and Monitoring Activities

- Conduct salmonid surveys to develop population estimates, which are needed to help evaluate the viability of habitat improvement activities;
- Develop and support local education efforts about water conservation, water catchment, and storage systems;
- Support and expand ongoing efforts that monitor summer water and air temperatures on a continuous 24-hour basis to detect long-range trends and short-term effects on the aquatic/riparian community;
- Conduct studies in the estuary to determine conclusively whether water temperature and dissolved oxygen are suitable for salmonids;
- Encourage ongoing habitat inventories and fishery surveys of tributaries throughout the Albion Basin;
- Encourage macroinvertebrate surveys throughout the Albion Basin;
- Train local landowners throughout the basin to conduct stream and fishery surveys on their own lands;
- Continue long-term monitoring at current locations and establish new stations for water chemistry, thalweg, and in-channel sediment parameters;
- Determine the cause of low gravel permeabilities at the location monitored on the South Fork Albion;
- Investigate the North Fork Albion River to determine whether dissolved oxygen levels are suitable for salmonids;
- Establish a local cooperative group to help facilitate restoration funding efforts and monitoring activities;
- Develop a bulk sediment sample wet to dry conversion factor for the Albion River Basin. Until this occurs, it is encouraged that all bulk sediment samples be wet sieved to directly compare them to the TMDL target value.

Coastal Subbasin

The Albion River estuary extends approximately five miles from the ocean. It encompasses 12.6 square miles and occupies 29% of the total basin area. The mouth is approximately 50 feet in width where it enters the Pacific Ocean via Albion Bay. Almost 99% of this subbasin is privately owned and it is largely managed for timber production and recreation. The town of Albion is located in this subbasin on the southern upslope area above the estuary. The subbasin supports populations of coho salmon and steelhead trout with incidental sightings of Chinook and pink salmon.

Key Findings

- Both historic and current data are limited. Little data are available on population trends, relative health, or diversity. According to NOAA Fisheries listing investigations, the populations of salmonids have likely decreased in the Albion Basin as they have elsewhere along California and the Pacific Coast;
- Based on MRC and CDFG presence surveys since the 1960s, the distribution of coho salmon and steelhead trout have not changed;
- Coho salmon were observed more frequently than steelhead trout by CDFG in all surveyed reaches;
- The California Coastal Zone Conservation Commission Preliminary Report (1976) suggested that no further development be allowed in the Albion River estuarine area or surrounding lands;

- **Erosion/Sediment**
    - Data collected at the monitoring location on the mainstem below the South Fork Albion reflect unsuitable levels of instream fine sediment <6.4mm, which are above the TMDL target, while fine sediment <0.85 mm were below the target and therefore their suitability was undetermined.
- **Riparian/Water Temperature**
    - High summer water temperatures in surveyed reaches of the lower mainstem Albion below Railroad Gulch within tidal influence are deleterious to summer rearing salmonid populations, while water temperatures at the sample site in the lower mainstem above Duck Pond Gulch, an unnamed tributary, Duck Pond, Slaughter House, Railroad, Pleasant Valley, and Deadman gulches were all suitable.
- **Instream Habitat**
    - In the estuary, escape and ambush cover are unsuitable for salmonids;
    - In the mainstem Albion above tidal influence LWD recruitment potential is low;
    - CDFG surveyed reaches of Pleasant Valley and Railroad gulches documented flow, water temperature, and canopy cover as positive attributes;
    - CDFG surveyed reaches of Pleasant Valley and Railroad gulches documented embeddedness, pool depth and frequency, and shelter cover as negative attributes.
- **Gravel Substrate**
    - Data from the lower mainstem Albion below the South Fork reflect a limited amount and distribution of high quality spawning gravels for salmonids;
    - Instream substrate particle size (D50) is small at monitored locations on the lower mainstem, Duck Pond, Railroad, and Pleasant Valley gulches.
- **Other**
    - A seawall located on the north side of the estuary at the Albion Flats campground is incomplete at this time and is deleterious to anadromous salmonids because of its lack of natural roughness and tendency to accelerate the velocity of flows;
    - Dissolved oxygen samples at river miles (RM) 1.3, 2.1, and 3.7 on the mainstem estuary reflect conditions that may be potentially limiting for salmonids;
    - Limited water quality data from the lower mainstem Albion site above tidal influence appears to be suitable for salmonids.

Key Recommendations:

- Improve instream structures for ambush cover and escape where appropriate/feasible;
- Consider limiting development that encroaches upon the estuarine area on both the north and south sides of the lower Albion Flats estuary area;
- Establish monitoring stations to track instream sediment in the upper portion of the estuary, lower mainstem above tidal influence, and Railroad and Pleasant Valley gulches;
- Support and encourage existing and active road management programs undertaken by MRC and the large percentage of small landowners with NTMPs to improve road standards throughout the basin;
- Completion of the seawall is a high priority. It should be done according to the plan developed by CDFG, Central Coast Region. To complete the seawall, the following steps are recommended: 1) backfilling of the existing wall; 2) compaction of the back filled soil; 3) completion of the "dead men" anchors along the wall; 4) completion and repair of the broken support/retainer beams (whalers); 5) removal of the jagged vinyl panel ends; 6) planting of the area; and 7) development of provisions for storm water runoff from the unpaved road into the channel. Additionally, roughness elements should be incorporated into the project to develop complex near shore, emergent fry habitat;
- Conduct studies in the estuary to determine whether water temperature and dissolved oxygen are suitable for salmonids.
- Continue water temperature monitoring at current locations and sustain conditions which contribute to suitable temperatures;

- Establish long-term water chemistry monitoring stations in the lower mainstem Albion. If there are indications of problems, monitoring should be implemented in tributaries as necessary to determine the source of the issue;
- Conduct salmonid surveys of the mainstem Albion River and tributaries considered as salmonid habitat;
- Develop more stream inventories and fishery surveys of tributaries within this subbasin.

Inland Subbasin

The Inland Subbasin begins at the confluence of the mainstem Albion River and the South Fork Albion River. Seven perennial and numerous intermittent streams drain an area of 30.4 square miles (19,442 acres). Elevations range from 40 feet at the confluence with the South Fork Albion River to approximately 600 feet in the headwaters of the tributaries. The highest point in the subbasin is Mathison Peak at 1,030 feet. The town of Comptche is located on the upper mainstem Albion. The Subbasin supports populations of coho salmon and steelhead trout with incidental sightings of Chinook salmon.

Key Findings

- Both historic and current data are limited on salmonid population trends, relative health, or diversity;
- Historic accounts and stream surveys from the 1960s by CDFG describe healthy populations of coho and steelhead trout;
- Current data indicate that the Inland Subbasin continues to maintain a coho population and that scientific data are not well developed on steelhead;
- Based on MRC and CDFG presence surveys since the 1960s, the range of coho salmon and steelhead trout have not changed;
- Coho salmon continue to be observed more frequently than steelhead trout;
- Little specific, scientific data are available on population abundance trends, relative health, or diversity. NOAA Fisheries listing investigations suggest that populations of salmonids have probably decreased in the Albion Basin as they have elsewhere along the Pacific Coast.
- **Erosion/Sediment**
  - Limited data collected in 1998 and 2001 at sites on the middle mainstem and lower South Fork Albion River indicate unsuitable levels of instream fine sediment (<6.4mm, which are above the TMDL target); while fine sediment <0.85 mm at sites throughout this subbasin were below the target (suitability undetermined) ;
  - Roads are listed in the Total Maximum Daily Loads as a major source of human-related sediment into streams;
  - There are erosion problems associated with the County road drainage system;
- **Riparian/Water Temperature**
  - Water temperatures at sites on the middle and upper mainstem, South Fork Albion, Marsh Creek, Anderson, Gunari, and East Railroad gulches are suitable for salmonids;
- **Instream Habitat**
  - In general, a high incidence of shallow pools, and a lack of cover and large woody debris have contributed to a simplification of instream salmonid habitat, with the exception of the mainstem;
  - Canopy cover was fully suitable within this subbasin;
- **Gravel Substrate**
  - Some of the streams are dominated by bedrock, indicating ongoing scouring of the channel;
  - Available data from sites on the middle and upper mainstem and lower North and South Fork Albion rivers reflect a limited amount and distribution of high quality spawning gravels for salmonids;
  - Gravel permeability at the location monitored on the South Fork Albion was low;
  - Instream substrate particle size (D50) is generally small at monitoring locations on the middle mainstem, East Railroad Gulch, Little North Fork, and the North and South Fork Albion rivers;

- **Refugia Areas**
  - The middle mainstem has the best refugia conditions in the basin. The North Fork, Upper mainstem, Bull Team Gulch, Little North Fork, South Fork, and East Railroad Gulch also provide refugia areas;
- **Other**
  - County culverts located where Flynn Creek Road crosses the Albion River and Marsh Creek have been identified as fish passage problems by a Mendocino County roads study;
  - Dissolved oxygen levels at the location monitored on the North Fork Albion may be unsuitable for salmonids;
  - Limited water quality data from the middle mainstem Albion site appear to be suitable, as are pH levels at the North Fork site;
  - The Dam on Marsh Creek is a total barrier to salmonids.

Key Recommendations:

- Encourage reducing any unnecessary use of water to improve summer stream surface flows and fish habitat;
- Increase the use of water storage and catchment systems that collect rainwater in the winter for use during the dry summer and fall seasons;
- Support efforts to educate landowners about water storage and catchment systems, and to find ways to subsidize development of these systems;
- Continue water temperature monitoring at current locations and sustain conditions that are leading to suitable temperatures;
- Install LWD or other structures in the mainstem, South Fork and North Fork Albion rivers to retain gravel and create habitat;
- Investigate the suitability and feasibility of introducing appropriate, local substrate to spawning reaches if studies show instream structures to fail to retain gravel due to short supply from the system;
- Support stream gage installation and maintenance to establish a long term record of Albion hydrologic conditions;
- Support and encourage existing and active road management programs undertaken by MRC and the large percentage of small landowners with NTMPs to improve road standards throughout the basin, specifically in the middle and upper mainstem Albion River, North and South Fork Albion rivers, and Marsh Creek;
- Continue existing and develop new monitoring sites for in-channel sediment in this subbasin, with emphasis on the upper mainstem Albion River, the South Fork Albion and its tributaries;
- Investigate the affects to anadromous salmonids, other fish and wildlife, and the Albion community, as well as the feasibility of the removal of the earthen dam on Marsh Creek. Charlotte Ambrose from NOAA fisheries states that "NOAA Fisheries is in strong support of collaborative efforts to remove the Marsh Creek dam on the Albion River. Any restoration activities in this watershed are extremely important to the recovery of our listed salmonids, especially coho salmon. There are several funding sources for this type of activity through NOAA. We would be happy to facilitate discussions to procure funds and necessary permits to expedite dam removal."
- There is a minor problem with cattle trampling of the riparian zone in the areas of the North Fork Albion, upper mainstem Albion River, and Marsh Creek. Containment options should be explored with the landowner/manager;
- Conduct salmonid surveys of the mainstem Albion River, South and North Forks;
- Determine the cause of low gravel permeability at the location monitored on the South Fork Albion;
- Investigate the North Fork Albion River to determine whether dissolved oxygen levels are suitable for salmonids;
- Support progress of CDFG/Mendocino County fish passage improvement projects. Replace two county road culverts on the upper mainstem Albion River and Marsh Creek to allow unimpeded fish passage;

- Support upgrade and maintenance of the county road drainage system associated with the upper mainstem;
- Establish long-term water chemistry monitoring stations in the middle and upper mainstem Albion. If there are indications of problems, implement monitoring in tributaries as necessary to determine the source of the issue.

Propensity for Improvement in the Albion Basin

Advantages

The Albion Basin has several advantages for planning and implementing successful salmonid habitat improvement activities that include:

- An expanding group of cooperative landowners that includes both public and private landowners from both subbasins in the Albion that are interested in improving watershed and fishery conditions. The effect of this is the ability to choose locations for projects where the best result can be achieved in the shortest time period;
- This assessment provides focus on watershed conditions and processes from the basin scale, through the subbasin scale, and down to the level of specific tributaries. This helps focus project design efforts so that local landowners can pursue the development of site specific improvement projects on an adaptive basis;
- Like most river systems, Albion coho salmon and steelhead trout meta-populations have evolved and adapted to the basin's unique conditions. Although these meta-populations are likely below historic levels, there remain local stocks that can take advantage of improved conditions.

Challenges

The Albion Basin also has some challenges confronting efforts to improve watershed and fish habitat conditions, and increase anadromous fish populations:

- Not all landowners are interested in salmonid habitat improvement efforts. Without a watershed wide cooperative land-base, treatment options are limited. In some cases this can remove some key areas from consideration of project development;
- Current reduced levels of coho salmon and steelhead meta-populations could limit the amount of needed straying to colonize fish into improved or expanded habitat conditions.

Table 1. Summary of Albion subbasins stream and basin conditions and recommended actions.

Identified Conditions	Coastal Subbasin	Inland Subbasin
Instream sediment	~	~
Water temperature	~	+
Water chemistry	~	~
Pools	-	-
Flow	+	~
Escape cover	-	-
Fish passage barriers	+	-
Natural sediment sources	~	~
Management related sediment sources	-	-
Recommended Improvement Activity Focus Areas		
Flow		X
Erosion/Sediment	X	X
Riparian/Water temperature	X	
Instream habitat	X	X
Gravel/Substrate	X	X
Fish passage barriers		X

\+ Condition is favorable for anadromous salmonids
\- Condition is not favorable for anadromous salmonids
~ Condition is mixed or indeterminate for anadromous salmonids
X Recommended improvement activity focus areas

Conclusion

The likelihood that any North Coast basin will react in a responsive manner to management improvements and restoration efforts is a function of existing watershed conditions. In addition, the status of processes influencing watershed condition will affect the success of watershed improvement activities. A good knowledge base of these current watershed conditions and processes is essential for successful watershed improvement.

Acquiring this knowledge requires property access. Access is a requirement to design, implement, monitor, and evaluate suitable improvement projects. Thus, systematic improvement project development is dependent upon the cooperative attitude of resource agencies, watershed groups and individuals, and landowners and managers.

The Albion assessment has considered a great deal of available information regarding watershed conditions and processes in the Albion Basin. This long assessment process has identified problems and made recommendations to address them while considering the advantages and challenges of conducting watershed improvement programs in the Albion Basin.

After considering these problems, recommendations, advantages and challenges, the Albion Basin appears to be an excellent candidate for a successful long-term, programmatic watershed improvement effort. According to the current refugia analysis, the Albion has medium potential to become a basin with high quality fishery refugia. Reaching that goal is dependent upon the formation of a well organized and thoughtful improvement program founded on broad based community support for the effort.

Program Introduction and Overview

Assessment Needs for Salmon Recovery & Watershed Protection

The Albion Basin Assessment began as project of the North Coast Watershed Assessment Program (NCWAP, hereafter referred to as the program). The program, an interagency effort between the California Resources Agency and the California Environmental Protection Agency, was established in 2000 to provide a consistent scientific foundation for collaborative watershed restoration efforts and to better meet the States needs for protecting and restoring salmon species and their habitats under State and Federal laws. The program was developed by a team of managers and technical staff from the following departments with watershed responsibilities for the North Coast:

- California Resources Agency
- California Department of Fish and Game (CDFG)
- California Department of Forestry and Fire Protection (CDF)
- California Department of Conservation/California Geological Survey (DOC/CGS)
- California Department of Water Resources (DWR)
- North Coast Regional Water Quality Control Board (NCRWQCB) of the State Water Resources Control Board.

In 2003, budgetary changes and constraints within the participating agencies have caused the program to be reorganized. The California Department of Fish and Game as the Coastal Watershed Planning and Assessment Program (CWPAP) now administer the program, with some input from other Resources Agency departments as budgets allow.

The California Resources Agency in coordination with CalEPA, initiated the program in part in response to specific requests from landowners and watershed groups that the State take a leadership role in conducting scientifically credible, interdisciplinary assessments that could be used for multiple purposes. The need for comprehensive watershed information grew in importance with listings of salmonids as threatened species, the Total Maximum Daily Load (TMDL) consent decree, and the increased availability of assistance grants for protecting and restoring watersheds.

Listings under the federal Endangered Species Act for areas within the North Coast region (the North Coast Hydrologic Unit) began with coho salmon in 1997, followed by Chinook salmon in 1999, and steelhead in 2000. In 2001, coho was proposed for listing under the California Endangered Species Act. Concerns about the potential impacts of salmonid listings and TMDLs on the economy are particularly strong on the North Coast where natural resource-dependent industries predominate. Cumulative impacts related to human activities including landslides, flooding, timber harvest, mining, ranching, agricultural uses, and development; along with natural processes can adversely affect watershed conditions and fish habitat. In order to recover California's salmonid fisheries, it is necessary to first assess and understand the linkages among management activities, dominant ecological processes and functions, and factors limiting populations and their habitat.

The program integrates and augments existing watershed assessment programs to conform to proven methodologies and manuals available from each participating department. The program also responds to recommendations from a Scientific Review Panel (SRP) which was created under the auspices of the State's Watershed Protection and Restoration Council as required by the March, 1998 Memorandum of Understanding (MOU) between the National Marine Fisheries Service (NMFS) and the California Resources Agency. The MOU required a comprehensive review of the California Forest Practice Rules (FPRs) with regard to their adequacy for the protection of salmonid species. In addition, the promise of significant new state and federal salmon restoration funds highlighted the need for watershed assessments to ensure that those dollars are well spent.

Program Assessment Region and Agency Roles

Originally, the program was to provide baseline environmental and biological information for approximately 6.5 million acres of public and private lands over a several-year period. This area was to include all coastal drainages from Sonoma County north to Oregon, corresponding with the North Coast Region water Quality Control board's region (Figure 3). The Albion river assessment is one of five watershed assessments to be completed under this program: three full assessments including public comments (Gualala, Mattole, and Redwood Basins), and two assessments in draft form (Albion and Big Basins). The Albion and Big assessments will not have full Geologic and Fluvial components.

Figure 3. Original NCWAP basin assessment area.

The roles of the five participating agencies in these efforts are as follows:

- CDFG collected, developed, and analyzed data related to anadromous fisheries habitat and populations. It also led an interagency evaluation of factors affecting anadromous fisheries production at the watershed level, provided recommendations for restoration and monitoring in the final synthesis report.
- CDF collected, developed, and analyzed data related to historical land use changes in the watersheds.
- DOC/CGS included a baseline mapping of landslide potential.
- NCRWQCB compiled, collected, and analyzed water quality data for the assessments. The assessment included comparison of recently collected and past available information comprised of water temperature, sediment, and water chemistry data sets.
- DWR installed and maintained stream monitoring gages where needed to develop and analyze stream flow information.

Program Guiding Questions

The program's work intends to provide answers to the following assessment questions at the basin and subbasin scales in California's North Coast 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?

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

Program Goals

The program was developed to improve decision-making by landowners, watershed groups, agencies, and other stakeholders with respect to restoration projects and management practices to protect and improve salmonid habitat. It was therefore essential that the program took steps to ensure its assessment methods and products would be understandable, relevant, and scientifically credible. As a result, the interagency team developed the following 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 assist landowners, local watershed groups, and individuals to develop successful projects. This will help guide programs, like the CDFG Fishery Restoration Grants Program, toward those watersheds and project types that can efficiently and effectively improve freshwater habitat and support recovery of salmonid populations;
- Provide assessment information to help focus cooperative interagency, nonprofit and private sector approaches to protect the best watersheds and streams through watershed stewardship, conservation easements, and other incentive programs; and
- 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.

Salmon, Stream, and Watershed Issues

Pacific coast anadromous salmonids are dependent upon a high quality freshwater environment at the beginning and end of their life cycles. As such, they thrive or perish during their freshwater phases depending upon the availability of cool, clean water, free access to migrate up and down their natal streams, clean gravel suitable for successful spawning, adequate food supply, and protective cover to escape predators and ambush prey. These life requirements must be provided by diverse and complex instream habitats as the fish move through their life cycles. If any life requirements are missing or in poor condition at the time a fish or stock requires it, fish survival can be impacted. These life requirement conditions can be identified and evaluated on a spatial and temporal basis at the stream reach and watershed levels. They comprise the factors that support or limit salmonid stock production.

The specific combination of these factors in each stream sets the carrying capacity for salmonids of that stream. The carrying capacity can thus be changed if one or more of the factors are altered. The importance of individual factors in setting the carrying capacity differs with the life stage of the fish and time of year. All of the important factors for salmonid health must be present in a suitable, though not always optimal, range in streams where fish live and reproduce (Bjorrn and Reiser 1991).

Two important watershed goals are the protection and maintenance of high quality fish habitats. In addition to preservation of high quality habitat, reparation of streams damaged by poor resource management practices of the past is important for anadromous salmonids. Science-based management has progressed significantly and “enough now is known about the habitat requirements of salmonids and about good management practices that further habitat degradation can be prevented, and habitat rehabilitation and enhancement programs can go forward successfully” (Meehan 1991).

Through the course of natural climatic events, hydrologic responses and erosion processes interact to shape freshwater salmonid habitats. These processes influence the kind and extent of a watershed’s vegetative cover as well, and act to supply nutrients to the stream system. When there are no large disturbances, these natural processes continuously make small changes in a watershed. Managers must constantly judge these small natural changes as well as changes made by human activity. Habitat conditions can be drastically altered when major disruptions of these small interactions occur (Swanston 1991).

Major watershed disruptions can be caused by catastrophic events, such as the 1964 north coast flood. They can also be created over time by multiple small natural or human disturbances. These disruptions can drastically alter instream habitat conditions and the aquatic communities that depend upon them. Thus, it is important to understand the critical, interdependent relationships of salmon and steelhead with their natal streams during their freshwater life phases, and their streams' dependency upon the watersheds within which they are nested, and the energy of the watershed processes that binds them together.

In general, natural disturbance regimes like landslides and wildfires do not impact larger basins like the 43 square mile Albion in their entirety at any given time. Rather, they normally rotate episodically across the entire basin as a mosaic composed of the smaller subbasin, watershed, or sub-watershed units over long periods. This creates a dynamic variety of habitat conditions and quality over the larger basin (Reice 1994).

The rotating nature of these relatively large, isolated events at the regional or basin scale assures that at least some streams in the area will be in suitable condition for salmonid stocks. A dramatic, large-scale example occurred in May 1980 in the Toutle River, Washington, which was inundated in slurry when Mt. St. Helens erupted. The river rapidly became unsuitable for fish. In response, returning salmon runs avoided the river that year and used other nearby suitable streams on an opportunistic basis, but returned to the Toutle two years later as conditions improved. This return occurred much sooner than had been initially expected (Quinn et al. 1991; Leider 1989).

Human disturbance sites, although individually small in comparison to natural disturbance events, usually are spatially distributed widely across basin level watersheds (Reeves et al. 1995). For example, a rural road or building site is an extremely small land disturbance compared to a forty-acre landslide or wildfire covering several square miles. However, when all the roads in a basin the size of the Albion are looked at collectively, their disturbance effects are much more widely distributed than a single large, isolated landslide that has a high, but relatively localized impact to a single sub-watershed.

Human disturbance regimes collectively extend across basins and even regional scales and have lingering effects. Examples include water diversions, conversion of near stream areas to urban usage, removal of large mature vegetation, widespread soil disturbance leading to increased erosion rates, construction of levees or armored banks that can disconnect the stream from its floodplain, and the installation of dams and reservoirs that disrupt normal flow regimes and prevent free movement of salmonids and other fish. These disruptions often develop in concert and in an extremely short period of time on the natural, geologic scale.

Human disturbances are often concentrated in time because of newly developed technology or market forces such as the California Gold Rush or the post-WWII logging boom in Northern California. The intense human land use of the last century, combined with the transport energy of two mid-century record floods on the North Coast, created stream habitat impacts at the basin and regional scales. The result of these recent combined disruptions has overlain the pre-European disturbance regime process and conditions.

Consequently, stream habitat quality and quantity are generally depressed across most of the North Coast region. It is within this widely impacted environment that both human and natural disturbances continue to occur, but with vastly fewer habitat refugia lifeboats than were historically available to salmon and steelhead. Thus, a general reduction in salmonid stocks can at least partially be attributed to this impacted freshwater environment.

Although no long-term fish counts exist for the Albion River, Department of Fish and Game fish ladder counts at Benbow Dam and Cape Horn Dam, in the Eel River system, reflect an over 80% decline in coho salmon, Chinook salmon, and steelhead trout populations over the span of the last century (Figure 4 and Figure 5). The Eel River, especially the South Fork Eel River, which is the location of Benbow Dam, although much larger than the Albion, has similar basin conditions and land use history. Anecdotal evidence from anglers and longtime local residents supports the likelihood of a similar decline in Albion fisheries (see Albion Basin Profile).

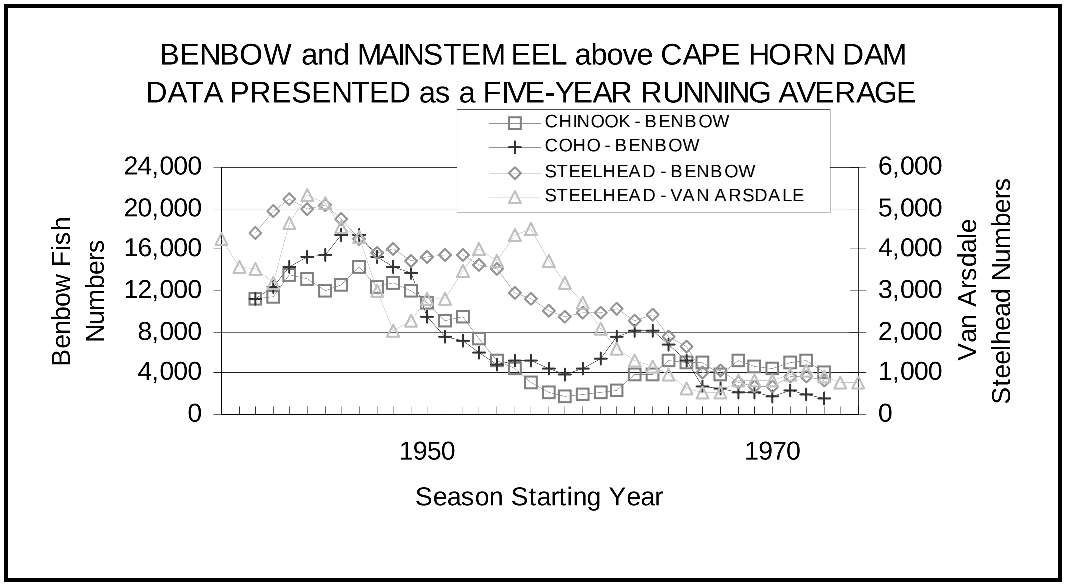


Figure 4. Five-year running average of salmonids at Benbow Dam, South Fork Eel River, and mainstem Eel River above Cape Horn Dam.

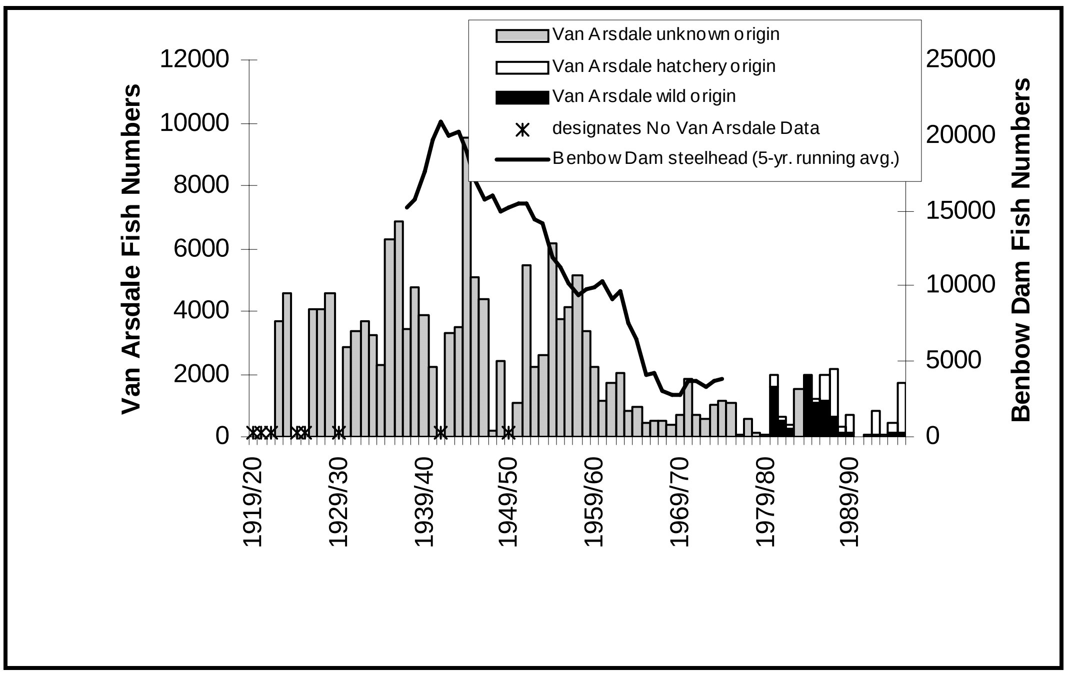


Figure 5. Historical steelhead trout ladder counts at Van Arsdale Fisheries Station, mainstem Eel River, and Benbow Dam, South Fork Eel River.

Factors Affecting Anadromous Salmonid Production

A main component of the program is the analyses of the freshwater factors in order to identify whether any of these factors are at a level that limits production of anadromous salmonids in North Coast basins. This limiting factors analysis (LFA) provides a means to evaluate the status of a suite of key environmental factors that affect anadromous salmonid life history.1 These analyses are based on comparing measures of habitat components such as water temperature and pool complexity to a range of reference conditions determined from empirical studies and/or peer reviewed literature. If a component's condition does not fit

[1] The concept that fish production is limited by a single factor or by interactions between discrete factors is fundamental to stream habitat management (Meehan 1991). A limiting factor can be anything that constrains, impedes, or limits the growth and survival of a population.

within the range of reference values, it may be viewed as a limiting factor. This information will be useful to identify underlying causes of stream habitat deficiencies and help reveal if there is a linkage to watershed processes and land use activities.

Chinook salmon, coho salmon, and steelhead trout all utilize headwater streams, larger rivers, estuaries, and the ocean for parts of their life history cycles. There are several factors necessary for the successful completion of an anadromous salmonid life history.

In the freshwater phase in salmonid life history, adequate flow, free passage, good stream conditions, and functioning riparian areas are essential for survival. Adequate instream flow during low flow periods is essential for fish passage in the summer time, and is necessary to provide juvenile salmonids free forage range, cover from predation, and utilization of localized temperature refugia from seeps, springs, and cool tributaries.

Free passage describes the absence of barriers to the free instream movement of adult and juvenile salmonids. Free movement in streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can disrupt.

Stream condition includes several factors; adequate stream flow, suitable water quality, suitable stream temperature, and complex habitat. For successful salmonid production, stream flows should follow the natural hydrologic regime of the basin. A natural regime minimizes the frequency and magnitude of storm flows and promotes better flows during dry periods of the water year. Salmonids evolved with the natural hydrograph of coastal watersheds, and changes to the timing, magnitude, and duration of low flows and storm flows can disrupt the ability of fish to follow life history cues.

Habitat diversity for salmonids is created by a combination of deep pools, riffles, and flatwater habitat types. Pools, and to some degree flatwater habitats, provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas, particularly for young coho salmon. They are also necessary for adult resting areas. A high level of fine sediment fills pools and flatwater habitats. This reduces depths and can bury complex niches created by large substrate and woody debris. Riffles provide clean spawning gravels and oxygenate water as it tumbles across them. Steelhead fry use riffles during rearing. Flatwater areas often provide spatially divided pocket water units that separate individual juveniles which helps promote reduced competition and successful foraging (Flosi et al. 1998).

Important aspects of water quality for anadromous salmonids are water temperature, turbidity, water chemistry, and sediment load. In general, suitable water temperatures for salmonids are between 48-56°F for successful spawning and incubation, and between 50-52°F and 60-64°F, depending on species, for growth and rearing. Additionally, cool water holds more oxygen, and salmonids require high levels of dissolved oxygen in all stages of their life cycle.

A second important aspect of water quality is turbidity. Fine suspended sediments (turbidity) affect nutrient levels in streams that in turn affect primary productivity of aquatic vegetation and insect life. This eventually reverberates through the food chain and affects salmonid food availability. Additionally, high levels of turbidity interfere with a juvenile salmonids' ability to feed and can lead to reduced growth rates and survival (Bill Trush, McBain & Trush; personal communication).

A third important aspect of water quality is stream sediment load. Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Eggs and embryos suffocate under excessive fine sediment conditions because oxygenated water is prevented from passing through the egg nest, or redd. Additionally, high sediment loads can cap the redd and prevent emergent fry from escaping the gravel into the stream at the end of incubation. High sediment loads can also cause abrasions on fish gills, which may increase susceptibility to infection. At extreme levels, sediment can clog the gills causing death. Additionally, materials toxic to salmonids can cling to sediment and be transported through downstream areas.

A functional riparian zone helps to control the amount of sunlight reaching the stream, provides vegetative litter, and contributes invertebrates to the local salmonid diet. 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).

Riparian zone functions are important to anadromous salmonids for numerous reasons. Riparian vegetation helps keep stream temperatures in the range that is suitable for salmonids by maintaining cool stream temperatures in the summer and insulating streams from heat loss in the winter. Larval and adult macroinvertebrates are important to the salmonid diet and they are in turn dependent upon nutrient contributions from the riparian zone. Additionally, stream bank cohesion and maintenance of undercut banks provided by riparian zones in good condition maintains diverse salmonid habitat, and helps reduce bank failure and fine sediment yield to the stream. Lastly, the large woody debris provided by riparian zones shapes channel morphology, helps retain organic matter and provides essential cover for salmonids (Murphy and Meehan 1991).

Therefore, excessive natural or man-caused disturbances to the riparian zone, as well as directly to the stream and/or the basin itself can have serious impacts to the aquatic community, including anadromous salmonids. Generally, this seems to be the case in streams and watersheds in the North Coast of California. This is borne out by the recent decision to include many North Coast Chinook and coho salmon, and steelhead trout stocks on the Endangered Species Act list.

Disturbance and Recovery of Stream and Watershed Conditions

Natural and Human Disturbances

The forces shaping streams and watersheds are numerous and complex. Streams and watersheds change through dynamic processes of disturbance and recovery (Madej 1999). In general, disturbance events alter streams away from their equilibrium or average conditions, while recovery occurs as stream conditions return towards equilibrium after disturbance events. Given the program's focus on anadromous salmonids, an important goal is to determine the degree to which current stream and watershed conditions in the region are providing salmonid habitat capable of supporting sustainable populations of anadromous salmonids. To do this, we must consider the habitat requirements for all life stages of salmonids. We must look at the disturbance history and recovery of stream systems, including riparian and upslope areas, which affect the streams through multiple biophysical processes.

Disturbance and recovery processes can be influenced by both natural and human events. A disturbance event such as sediment from a natural landslide can fill instream pools providing salmon habitat just as readily as sediment from a road failure. On the recovery side, natural processes (such as small stream-side landslides) that replace instream large woody debris washed out by a flood flow help to restore salmonid habitat, as does large woody debris placed in a stream by a landowner as a part of a restoration project.

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 have included large flood events such as occurred in 1955 and 1964 (Lisle 1981a) and 1974 (U.S. EPA 2001) ground shaking and related tectonic uplift associated with the 1992 Cape Mendocino earthquake (Carver et al. 1994).

Major human disturbances (e.g., post-European development, dam construction, agricultural and residential conversions, and the methods of 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 also was degraded during parts of the last century by well-intentioned but misguided restoration actions such as removing large woody debris from streams (Ice 1990). More recently, efforts at watershed restoration have been made, generally at the local level. For example, in California and the Pacific Northwest, minor dams from some streams have been removed to clear barriers to spawning and juvenile anadromous fish. For a thorough treatment of stream and watershed recovery processes, see the publication by the Federal Interagency Stream Restoration Working Group (FISRWG 1998).

Defining Recovered

There is general agreement that improvements in a condition or set of conditions constitute recovery. In that context, recovery is a process. One can determine a simple rate of recovery by the degree of improvement over some time period, and from only two points in time. And one can discuss recovery and rates of recovery in a general sense. However, a simple rate of recovery is not very useful until put into the context of its position on a scale to the endpoint of recovered.

In general, recovered fish habitat supports a suitable and stable fish population. Recovered not only implies, but necessitates, knowledge of an endpoint. In the case of a recovered watershed, the endpoint is a set of conditions deemed appropriate for a watershed with its processes in balance and able to withstand perturbations without large fluctuations in those processes and conditions. However, the endpoint of recovered for one condition or function may be on a different time and geographic scale than for another condition or function.

Some types and locations of stream recovery for salmonids can occur more readily than others can. For example, in headwater areas where steeper source reaches predominate, suspended sediment such as that generated by a streamside landslide or a road fill failure may start clearing immediately, while coarser sediments carried as bedload tend to flush after a few years (Lisle 1981a; Madej and Ozaki 1996). Broadleaf riparian vegetation can return to create shading, stabilize banks, and improve fish habitat within a decade or so. In contrast, in areas lower in the watershed where lower-gradient response reaches predominate, it can take several decades for deposited sediment to be transported out (Madej 1982; Koehler et al. 2001), for widened stream channels to narrow, for aggraded streambeds to return to pre-disturbance level, and for streambanks to fully revegetate and stabilize (Lisle 1981b). Lower reach streams will require a similar period for the near-stream trees to attain the girth needed for recruitment into the stream as large woody debris to help create adequate habitat complexity and shelter for fish, or for deep pools to be re-scoured in the larger mainstems (Lisle and Napolitano 1998).

Factors and Rates of Recovery

Over the past quarter-century, several changes have allowed the streams and aquatic ecosystems to move generally towards recovery. The rate of timber harvest on California's north coast has slowed during this period, with declining submissions of timber harvesting plans (THPs) and smaller average THPs (T. Spittler, pers. comm.). However, in the Albion Basin, the amount of acreage harvested has increased sharply since 1990 as timber stands mature into merchantable second-growth timber and as selection and other partial harvest silvicultural prescription are widely implemented.

Timber-harvesting practices have greatly improved over those of the post-war era, due to increased knowledge of forest ecosystem functions, changing public values, advances in road building and yarding techniques, and regulation changes such as mandated streamside buffers that limit equipment operations and removal of timber. Cafferata and Spittler (1998) found that almost all recent landslides occurring in an area logged in the early 1970s were related to legacy logging roads. In contrast, in a neighboring watershed logged in the late 1980s to early 1990s, landslides to date have occurred with about equal frequency in the logged areas as in unlogged areas.

Further, most north coast streams have not recently experienced another large event on the scale of the 1964 flood. Therefore, we would expect most north coast streams to show signs of recovery (i.e., passive restoration [FISRWG 1998]). However, the rates and degrees of stream and watershed recovery will likely vary across a given watershed and among different north coast drainages.

In addition to the contributions made to recovery through better land management practices and natural recovery processes, increasing levels of stream and watershed restoration efforts are also contributing to recovery. Examples of these efforts include road upgrades and decommissioning, removal of road-related fish passage barriers, installation of instream fish habitat structures, etc. While little formal evaluation or quantification of the contributions of these efforts to recovery has been made, there is a general consensus that many of these efforts have made important contributions.

Continuing Challenges to Recovery

Given improvements in timber harvesting practices in the last 30 years, the time elapsed since the last major flood event, and the implementation of stream and watershed restoration projects, it is not surprising that many north coast streams show indications of trends towards recovery (Madej and Ozaki 1996). Ongoing challenges associated with past activities that are slowing this trend include:

- Chronic sediment delivery from legacy (pre-1975) roads due to inadequate crossing design, construction and maintenance (California State Board of Forestry, Monitoring Study Group 1999);

- Skid trails and landings (Cafferata and Spittler 1998);
- A lack of improvements in stream habitat complexity, largely from a dearth of large woody debris for successful fish rearing;
- The continuing aggradation of sediments in low-gradient reaches that were deposited as the result of activities and flooding in past decades (Koehler et al. 2001).

Increasing subdivision on several north coast watersheds raises concerns about new stream and watershed disturbances. Private road systems associated with rural development have historically been built and maintained in a fashion that does little to mitigate risks of chronic and catastrophic sediment inputs to streams. While more north coast counties are adopting grading ordinances that will help with this problem, there is a significant legacy of older residential roads that pose an ongoing risk for sediment inputs to streams. Other issues appropriate to north coast streams include potential failures of roads during catastrophic events, erosion from house pads and impermeable surfaces, removal of water from streams for domestic uses, effluent leakages, and the potential for deliberate dumping of toxic chemicals used in illicit drug labs.

Some areas of the North Coast have seen rapidly increasing agricultural activity, particularly conversion of grasslands or woodlands to grapes. Such agricultural activities have typically been subject to little agency review or regulation and can pose significant risk of chronic sediment, chemical, and nutrient inputs to streams.

Associated with development and increased agriculture, some north coast river systems are seeing increasing withdrawal of water, both directly from stream and groundwater sources connected to streams, for human uses. Water withdrawals pose a chronic disturbance to streams and aquatic habitat. Such withdrawals can result in lowered summer stream flows that impede the movement of salmonids and reduce important habitat elements such as pools. Further, the withdrawals can contribute to elevated stream water temperatures that are harmful to salmonids.

Key questions for landowners, agencies, and other stakeholders revolve around whether the trends toward stream recovery will continue at their current rates, and whether those rates will be adequate to allow salmonids to recover their populations in an acceptable time frame. Clearly, the potential exists for new impacts from both human activities and natural disturbance processes to compromise recovery rates to a degree that threatens future salmonid recovery. To predict those cumulative effects will likely require additional site-specific information on sediment generation and delivery rates and additional risk analyses of other major disturbances. Also, our discussion here does not address marine influences on anadromous salmonid populations. While these important influences are outside of the scope of this program, we recognize their importance for sustainable salmonid populations and acknowledge that good quality freshwater habitat alone is not adequate to ensure sustainability.

Policies, Acts, and Listings

Several federal and state statutes have significant implications for watersheds, streams, fisheries, and their management. Here, we present only a brief listing and description of some of the laws.

Federal Statutes

One of the most fundamental of federal environmental statutes is the **National Environmental Policy Act (NEPA)**. NEPA is essentially an environmental impact assessment and disclosure law. Projects contemplated or plans prepared by federal agencies or funded by them must have an environmental assessment completed and released for public review and comment, including the consideration of more than one alternative. The law does not require that the least impacting alternative be chosen, only that the impacts be disclosed.

The federal **Clean Water Act** has a number of sections relevant for watersheds and water quality. Section 208 deals with non-point source pollutants arising from silvicultural activities, including cumulative impacts. Section 303 deals with water bodies that are impaired to the extent that their water quality is not suitable for the beneficial uses identified for those waters. For water bodies identified as impaired, the US Environmental Protection Agency (US EPA) or its state counterpart (locally, the North Coast Regional

Water Quality Control Board and the State Water Resources Control Board) must set targets for Total Maximum Daily Loads (TMDLs) of the pollutants that are causing the impairment. Section 404 deals with the alterations of wetlands and streams through filling or other modifications, and requires the issuance of federal permits for most such activities.

The federal **Endangered Species Act (ESA)** addresses the protection of animal species whose populations are dwindling to critical levels. Two levels of species risk are defined. A threatened species is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. An endangered species is any species that is in danger of extinction throughout all or a significant portion of its range. In general, the law forbids the take of listed species. Taking is defined as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting a species or attempting to engage in any such conduct. A take of a species listed as threatened may be allowed where specially permitted through the completion and approval of a Habitat Conservation Plan (HCP). An HCP is a document that describes how an agency or landowner will manage their activities to reduce effects on vulnerable species. An HCP discusses the applicant's proposed activities and describes the steps that will be taken to avoid, minimize, or mitigate the take of species that are covered by the plan. Many of California's salmon runs are listed under the ESA, including the Chinook and coho salmon found in the Albion Basin. Steelhead trout, which are also found in the Albion Basin, have been proposed for listing.

State Statutes

The state analogue of NEPA is the **California Environmental Quality Act (CEQA)**. CEQA goes beyond NEPA in that it requires the project or plan proponent to select for implementation the least environmentally impacting alternative considered. When the least impacting alternative would still cause significant adverse environmental impacts, a statement of overriding considerations must be prepared.

The **Porter-Cologne Water Quality Control Act** establishes state water quality law and defines how the state will implement the federal authorities that have been delegated to it by the US EPA under the federal Clean Water Act. For example, the US EPA has delegated to the state certain authorities and responsibilities to implement TMDLs for impaired water bodies and NPDES (national pollution discharge elimination system) permits to point-source dischargers to water bodies.

Sections 1600 et seq. of the Fish and Game Code are implemented by the Department of Fish and Game. These agreements are required for any activities that alter the beds or banks of streams or lakes. A 1600 agreement typically would be involved in a road project where a stream crossing was constructed. While treated as ministerial in the past, the courts have more recently indicated that these agreements constitute discretionary permits and thus must be accompanied by an environmental impact review per CEQA.

The **California Endangered Species Act (CESA)**. The California Endangered Species Act (Fish & Game Code §§ 2050, et seq.) generally parallels the main provisions of the Federal Endangered Species Act and is administered by the California Department of Fish and Game (CDFG). Coho salmon in the Albion Basin are listed as threatened under CESA

The **Z'Berg-Nejedly Forest Practice Act (FPA)** and associated **Forest Practice Rules** establish extensive permitting, review, and management practice requirements for commercial timber harvesting. Evolving in part in response to water quality protection requirements established by the 1972 amendments to the federal Clean Water Act, the FPA and Rules provide for significant measures to protect watersheds, watershed function, water quality, and fishery habitat.

Assessment Strategy and General Methods

In 2003, the NCWAP released a Methods Manual that identified a general approach to conducting a watershed assessment, described or referenced methods for collecting and developing new watershed data, and provided a preliminary explanation of analytical methods for integrating interdisciplinary data to assess watershed conditions.

This chapter provides brief descriptions of data collection and analysis methods used by each of the program's participating departments, and an introduction to methods for analyzing data across departments and disciplines. While the information contained in the report is extensive, more detail is included in a set of appendices to this report:

- California Department of Forestry
- Ecological Management Decision Support
- North Coast Regional Water Quality Control Board
- California Department of Fish & Game

The reader is referred to these appendices for more detail on methods, data used in the assessment, and assessments of the data.

Basin Assessment Approach

The steps in the large-scale assessment included:

Form multi-disciplinary team. In order to assess watershed conditions and processes, several specialists were needed and included: geologists, fluvial geo-morphologists, foresters, water quality analysts, fisheries biologists, habitat specialists, and planners;

Conduct scoping and outreach workshops. A series of meetings were held during the course of the Albion assessment;

Determine logical assessment scales. The Albion assessment team used the California Watershed Map (CalWater version 2.2a) to delineate the Albion Basin into two subbasins (Coastal and Inland) for assessment and analyses purposes (Figure 6). The subbasins are the Coastal and Inland;

Discover and organize existing data and information according to discipline. This information was used to form the basis of the disciplinary appendices to the assessment report;

Identify data gaps needed to develop the assessment. Working with limited time and resources constrained the amount of fieldwork that was performed. Limited data existed prior to this effort in the Albion Basin;

Collect field data. Over 15 miles of new stream data and numerous fishery surveys were performed for this assessment. Foresters and geologists were able to check air photo analyses with field verification at several locations. Water Quality data were collected for this assessment at several locations in the basin, and additional data were provided by private and agency cooperators;

Amass and analyze information. Each agency (except California Geological Survey, which contributed limited information and maps) assembled, interpreted, and summarized data to create various specific reports for inclusion into the Assessment Report. Each agency's reports were also included in the Albion Basin appendices;

Construct Integrated Analysis Tables (IA). Through the use of IA Tables the information from CDFG and NCRWQCB were compared to one another. This, along with information from CDF and CGS, were used to respond to the Assessment Questions. The IA process also helped to identify watershed conditions;

Conduct limiting factors analysis (LFA). The Ecological Management Decision Support system (EMDS) was used, along with expert analysis and local input, to evaluate factors at the tributary scale. These factors were rated to be either beneficial or restrictive to the well being of fisheries. The CDFG Restoration Manual (Flosi et al. 1998), and other literature, provided habitat condition values to help set EMDS reference curves;

Conduct refugia rating analysis. The assessment team created worksheets for rating refugia at the tributary scale (page 34). The worksheets have multiple condition factors rated on a sliding scale from high to low quality. Tributary ratings are determined by combining the results of air photo analyses, EMDS, Water Quality data, data in the CDFG tributary reports, and by a multi-disciplinary team of expert analysts. Ratings of various factors are combined to determine an overall refugia ratings on a scale from high to low quality. The tributary ratings are subsequently aggregated at the subbasin scale and expressed as a general estimate of subbasin refugia conditions. Factors with limited or missing data are noted and discussed in the comments section as needed. In most cases, there are data limitations on one to three factors. A discussion of the rating system is located at the end of this summary;

Develop conclusions and recommendations. Recommendation tables for watershed and stream improvement activities were developed at the tributary scale based upon stream inventory information, air photo analysis, field verification samples, workshop inputs, and other information. The recommendation tables are presented at the end of each Profile chapter as answers to the sixth assessment guiding question;

Facilitate monitoring of conditions. CDFG is developing a monitoring program and will facilitate it in the Albion and other assessed watersheds.

Guiding Assessment Questions and Responses

The NCWAP assessment team developed lists of questions that they considered important to understanding and implementing watershed assessments. From those lists, a short list of guiding assessment questions evolved and was adopted to provide focus for the assessments and subsequent analyses, conclusions, and recommendations.

- What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this?
- What are the current salmonid habitat conditions in this subbasin? 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?
- Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

These six questions focus the assessment procedures and data gathering within the individual disciplines and also provide direction for those areas of analyses that require more interagency, interdisciplinary syntheses, including the analysis of factors limiting anadromous salmonid production. The questions systematically progress from the relative status of the salmon and steelhead resource, to the focus of the assessment effort, and lastly to the watershed components encountered directly by the fish – flow, water quality, nutrients, and instream habitat elements, including free passage at all life stages. The products delivered to streams by watershed processes and the influence of human activities on those processes shape these habitat elements. The watershed processes and human influences determine what factors might be limiting fishery production and what can be done to make improvements for the streams and fish.

The first two assessment questions point out the importance of salmonid population information for validating the assessment and predicting habitat conditions. In many watersheds, robust population data may not be available, implying a need for future monitoring efforts. In some watersheds, a need for additional physical habitat sampling may be indicated.

The third and fourth assessment questions consider the past and present conditions of the watersheds and their natural and man-caused watershed processes. The answers to these questions provide us with insights into the future of assessed watersheds and streams, and the feasibility of different management techniques for salmon and steelhead in each watershed.

The last two assessment questions consider factors directly encountered by fish that could be limiting salmonid production. These questions seek to identify opportunities and locations for prudent management practices and pro-active salmonid habitat improvement activities.

These six guiding assessment questions are presented and answered in the overall basin section and in each of the subbasin sections of the assessment report. They are also considered in the DFG Refugia Rating process at the subbasin and tributary scales. The responses become more specific as the assessment focuses from the course to the finer scales.

Report Utility and Usage

This report is intended to be useful to landowners, watershed groups, agencies, and individuals to help guide restoration, land use, and management decisions. As noted above, the assessment operates on multiple scales ranging from the detailed and specific stream reach level to the very general basin level. Therefore, findings and recommendations also vary in specificity from being particular at the finer scales, and general at the basin scale.

A goal of this program is to help guide, and therefore accelerate the recovery process, by focusing stewardship and improvement activities where they will be most effective. Scaling down through finer levels guided by the recommendations should help accomplish this focus.

To do so, the report is constructed to help provide guidance for that focus of effort. A user can scale down from the general basin finding and recommendation concerning high sediment levels, for example, to the subbasin sections, to the stream reach level information to determine which streams in the subbasin may be most affected by sediment.

There is a list of surveyed streams in each subbasin section. In the general recommendation section, a tributary finding and recommendation summary table indicates the findings and recommendations for the surveyed streams within the subbasin. If indicated, field investigations at the stream reach or project site level can be conducted to make an informed decision on a land use project, or to design improvement activities.

Program Products

The program will produce and make available to the public a set of products for each basin assessed.

These products include:

- A basin level Synthesis Report that includes:
  - Collection of Albion Basin historical and sociological information;
  - Description of historic and current vegetation cover and change, land use, geology and, water quality, stream flow, water use, and instream habitat conditions;
  - List of issues developed by agency team members and constituents;
  - 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://ncwatershed.ca.gov/, and http://imaps.dfg.ca.gov/, and ArcIMS site.

Assessment Report Conventions

Subbasins

In order to be more specific and useful to planners, managers, and landowners, it is useful to subdivide the larger Albion Basin into smaller subbasin units whose size is determined by the commonality of many distinguishing traits. Variation among subbasins is at least partially a product of natural and human disturbances. Other variables that can distinguish areas, or subbasins, in larger basins include differences in elevation, geology, soil types, aspect orientation, climate, vegetation, fauna, human population, land use and other social-economic considerations.

The Albion assessment team subdivided the Albion Basin into two subbasins for assessment and analyses purposes (Figure 6). These are the Coastal and Inland subbasins. In general, both subbasins have distinguishing attributes common to the CalWater 2.2a Planning Watersheds (PWs) contained within them. These PWs are explained below.

CalWater 2.2a Planning Watersheds

The California Watershed Map (CalWater Version 2.2a) is used to delineate planning watershed units (Figure 6). This hierarchy of watershed designations consists of six levels of increasing specificity: Hydrologic Region, Hydrologic Unit, Hydrologic Area, Hydrologic Sub-Area, Super Planning Watershed, and Planning Watershed (PW). CalWater version 2.2a is the third version of CalWater (after versions 1.2 and 2.0) and is a descendent of the 1:500,000-scale State Water Resources Control Board Basin Plan Maps drawn in the late 1970s.

The PW level of specificity is used in many analyses. PWs generally range from 3,000-10,000 acres in size and each PW consists of a specific watershed polygon, which is assigned a single unique code. The program used PWs for mapping, reporting, EMDS, and statistical analysis of geology, vegetation, land use, and fluvial geomorphology.

An important aspect of CalWater 2.2a PWs is that individual PWs often do not represent true watersheds. In other words, PWs often cut across streams and ridgelines and do not cover the true catchment of a stream or stream system. Streams, such as the mainstem Albion River, can flow through multiple PWs. In addition, a stream may serve as a border between two CalWater 2.2a PWs. This disconnect with hydrologic stream drainage systems is an artifact of the creation of CalWater 2.2a as a tool for managing forest lands in fairly consistent sized units.

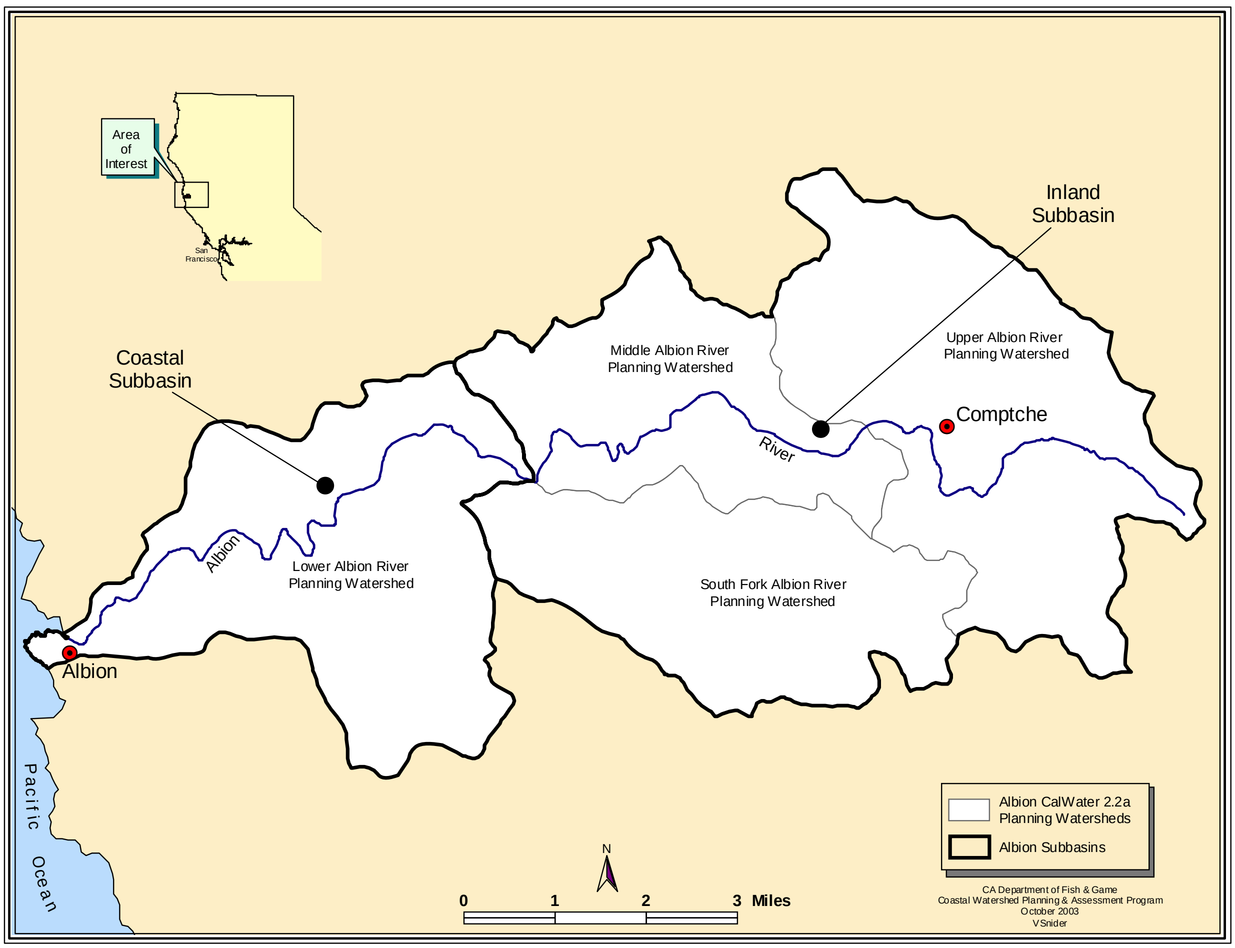


Figure 6. Albion Subbasins and CalWater 2.2a Planning Watersheds.

Hydrology Hierarchy

Watershed terminology often becomes confusing when discussing different scales of watersheds involved in planning and assessment activities. The conventions used in the Albion Basin assessment follow guidelines established by the Pacific Rivers Council. The descending order of scale is from *basin* level (e.g., Albion Basin) – *subbasin* level (e.g., Inland Subbasin) – *watershed* level (e.g., South Fork Albion River) – *sub-watershed* level (e.g., Little North Fork Albion) (Figure 7).

The subbasin is the assessment and planning scale used in this report as a summary framework; subbasin findings and recommendations are based upon the more specific watershed and sub-watershed level findings. Therefore, there are usually exceptions at the finer scales to subbasin findings and recommendations. Thus, findings and recommendations at the subbasin level are somewhat more generalized than at the watershed and sub-watershed scales. In like manner, subbasin findings and recommendations are somewhat more specific than the even more generalized, larger scale basin level findings and recommendations that are based upon a group of subbasins.

The term watershed is used in both the generic sense, as to describe watershed conditions at any scale and as a particular term to describe the *watershed* scale introduced above, which contains, and is made up from multiple, smaller sub-watersheds. The watershed scale is often approximately 20 – 40 square miles in area; its sub-watersheds can be much smaller in area, but for our purposes contain at least one perennial, un-branched stream. Please be aware of this multiple usage of the term watershed, and consider the context of the term's usage to reduce confusion.

Another important watershed term is river mile (RM). River mile refers to a point that is a specific number of miles upstream from the mouth of a river. In this report, RM is used to locate points along the Albion River.

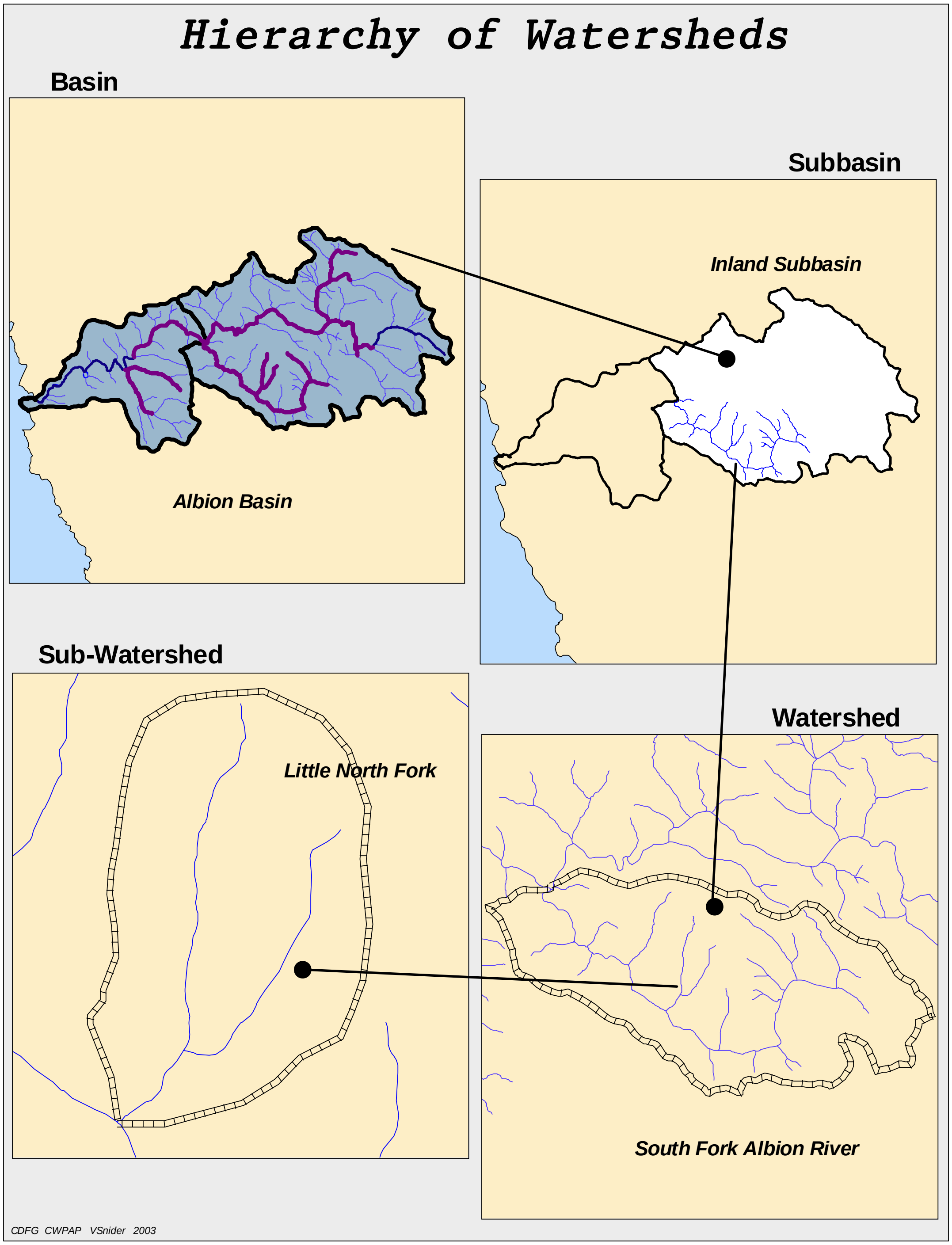


Figure 7. Hydrography hierarchy.

Electronic Data Conventions

The program collected or created hundreds of data records for synthesis and analysis purposes and most of these data were either created in a spatial context or converted to a spatial format. Effective use of these data between the four remaining partner departments required establishing standards for data format, storage, management and dissemination. Early in the assessment process, we held a series of meetings designed to gain consensus on a common format for the often widely disparate data systems within each department. Our objective was to establish standards which could be used easily by each department, that were most useful and powerful for selected analysis, and would be most compatible with standards used by potential private and public sector stakeholders.

As a result, we agreed that spatial data used in the program and base information disseminated to the public through the program would be in the following format (see the data catalog at the end of this report for a complete description of data sources and scale):

Data form: standard database format usually associated with a Geographic Information System (GIS) shapefile or coverage (©Environmental System Research Institute, Inc. [ESRI]). Data were organized by watershed and distributed among watershed synthesis teams. Electronic images were retained in their current format.

Spatial Data Projection: spatial data were projected from their native format to Teale Albers, North American Datum (NAD) 1927 and Universal Transverse Mercator (UTM), Zone 10, NAD 1983. Both formats were used in data analysis and synthesis.

Scale: most data were created and analyzed at 1:24,000 scale to (1) match the minimum analysis scale for planning watersheds, and (2) coincide with base information (e.g., stream networks) on USGS quadrangle maps (used as Digital Raster Graphics [DRG]).

Data Sources: data were obtained from a variety of sources including spatial data libraries with partner departments or were created by manually digitizing from 1:24,000 DRG.

The metadata available for each spatial data set contain a complete description of how data were collected and attributed for use in the program. Spatial data sets that formed the foundation of most analysis included the 1:24,000 hydrography and the 10 meter scale Digital Elevation Models (DEM). Hydrography data were created by manually digitizing from a series of 1:24,000 DRG then attributing with direction, routing, and distance information using a dynamic segmentation process (for more information, please see http://arconline.esri.com/arconline/whitepapers/ao/ArcGIS8.1.pdf). The resulting routed hydrography allowed for precise alignment and display of stream habitat data and other information along the stream network. The DEM was created from base contour data obtained from the USGS for the entire study region.

Source spatial data were often clipped to watershed, planning watershed, and subbasin units prior to use in analysis. Analysis often included creation of summary tables, tabulating areas, intersecting data based on selected attributes, or creation of derivative data based on analytical criteria. For more information regarding the approach to analysis and basis for selected analytical methods, see Chapter 2, Assessment Strategy and General Methods, and Chapter 4, Interdisciplinary Synthesis and Findings.

Methods by Department

Hydrology

Data Collection

In 2001, Graham Mathews and Associates (GMA) examined streamflow records as a part of the Albion River Sediment Source Analysis and Preliminary Sediment Budget on contract to the Environmental Protection Agency (EPA) for development of their total maximum daily sediment load estimates (TMDLs). GMA operated four continuous streamflow stations in the watershed as a part of their study between November 2000 and April 2001. Due to a relatively short streamflow record on the Albion River and the unavailability of continuous streamflow records for much of the watershed, it was necessary to develop synthetic streamflow records for several Water Years. Once synthetic data were developed, they were used to perform various hydrologic and sediment transport analyses. The Albion River, like most of northwestern California, is a flashy basin, one that rises very quickly in response to precipitation inputs, and drops back to its base flow levels nearly as quickly.

Streamflow data previously collected in the basin by the United States Geological Survey (USGS) are limited to a single gage (USGS#11468070) located on the Albion downstream from Comptche at RM 15.2, a short distance downstream of the confluence with the North Fork. The gage measured streamflow from 30% of the 43.0 square miles of the watershed, including the wetter upper watershed areas. It is expected that unit peak discharges (cubic feet per second/square mile) for the entire watershed would be lower than from those recorded at the gaging site because of generally lower rainfall depths in the lower basin. Location of the gage was selected based on access and constraints in accurately measuring streamflow in the extensive lower reaches affected by tides. The period of record for the USGS extends from October 1, 1961 to September 30, 1969, when continuous measurements at the gage were discontinued. The gage operated to measure peak annual discharges through Water Year 1978 and was reactivated by DWR from Water Year 2001 through Water Year 2003.

A second gage on the Albion River was operated by DWR just downstream from the confluence with the South Fork from November 28, 2001 to October 30, 2003 (DWR#F80040). Data from this gage were not available.

Mean Daily Discharge

The USGS publishes mean daily discharge records for each of its gages on an annual basis. These values are typically used to construct annual streamflow hydrographs and perform flow duration analyses. Due to the extremely short period of record for the Albion River (eight years), modeling was employed to extend or create a mean daily discharge record for each fork of the Albion River. Mean daily discharge measurements were scaled from the Noyo Watershed using watershed area and mean annual precipitation as the scaling factors.

Flow Duration

A flow duration analysis was performed using a combination of historic data from the USGS gage on the Albion River and synthetic mean daily discharge data calculated as described above.

Annual Runoff

Annual runoff was calculated for the Middle Fork Albion River watershed using the USGS streamflow gage records for the period of record and computed from the synthetic data generated for the rest of the watershed.

Peak Discharge

USGS peak discharge records are available for a 17-year period, 1962-1978. In addition, synthetic peak discharges for the Albion River were developed using peak correlation analysis between the Noyo River and the Albion River basins in order to extend the record. Peak discharges were estimated back to 1952 and forward to 1998, based on the record available from the Noyo River. In addition, peak discharge for Water Year 2001 was measured at the Albion USGS gage during streamflow data collection.

Flood Frequency

Flood frequency analysis is a method used to predict the magnitude of a flood that would be expected to occur, on average, in a given number of years (recurrence interval) or have a specific probability of occurrence in any one year (a 100-year flood has a 1% chance of occurring in any given year, for example). Typically, the observed maximum peak discharges are fitted to the distribution using a generalized or station skew coefficient, although numerous other distributions may also be used. When long records are available, the station skew is used exclusively. Although the log-Pearson Type III distribution is the most commonly applied method, GMA found that it had a very poor fit to the combined observed and synthetic data, and instead GMA selected a 3-parameter log-normal distribution for their flood frequency analysis. See GMA for further details.

Vegetation and Land Use

Land use was delineated by placing transparent plastic sleeves directly over the photos and classifying land use change while viewing through a stereoscope. Categories that were delineated were fire, timber harvest, pasture, irrigated crops, orchard, buildings, and urban. Since this is a land use change classification, not all grassland or timberland was delineated or typed. While the full extent of many areas burned by fire could not be estimated, if the fire created a change in vegetation, it was recorded. For example, in 1937 aerial photographs, the area of the 1931 Comptche wildfire was evident by the amount of grassy understory, open canopies, and areas of brush. The area of the wildfire itself was derived from an existing electronic database but portions of the burned area were recorded as a permanent conversion, usually subjectively determined by evidence of continued burning, proximity to existing grasslands, barns or other buildings, and roads.

Timber harvest activity was broken into silviculture and logging system categories using the closest approximation to the standard definitions. There is no way of knowing from air photos whether the trees removed were old- growth stands that were present prior to European-American settlement or if these were trees that had grown in due to changes in land-use practices between 1860 and 1937. In some instances, trees had been removed or killed and the closest silvicultural category was used. In many of the earliest photographs, there were no roads or skid trails visible and no logging system was recorded.

Minimum acreage mapped varied by land use classification. Crops and orchards were mapped when seen. It was assumed that fenced grassland was grazed. Silvicultural treatments were difficult to categorize. The large proportion amount of hardwood and brush was very apparent because there was often a lot of vegetative cover remaining after a harvest that removed most of the conifer. The resultant silviculture was highly variable in many instances. Seed tree removal step was delineated as the silvicultural system used when it appeared that the dominant conifer cover was removed, but considerable hardwood and/or brush remained. When the excluded areas were large relative to the adjacent harvested areas, they were also excluded from the harvest land use polygon.

Disturbance categories were broadly grouped into low, medium and high. Disturbance was based on potential sediment delivery to watercourses. High intensity fire areas, cultivated land and grazed areas immediately adjacent to streams or on steep slopes, and virtually all tractor logging during this time period were classified as high disturbance potential areas. Slides were not mapped although sometimes included as a comment.

The information from the Mylar sleeves was input as polygon features into the ArcView GIS system by onscreen or "heads-up" digitizing using 1993 black and white orthographic quadrangles as the background. Distortion was corrected by using watercourses, ridges, and roads as reference indicators. The scale distortion apparent in the aerial photographs compared to the orthoquads during the heads-up digitizing was manually corrected by changing the scale of the orthoquad to match the area near the polygon to provide the best fit.

These data are similar to other aerial photograph interpretations of various types of land use. The aerial photos used appeared to be of the same age as the flight date. Many were faded and had hand-drawn line work on them from past projects. When using the data, it is important to note that timber harvesting is often used as a surrogate for a change in vegetation type, size, or density. In a general sense, this is true, but early harvesting did not follow the classic silvicultural methodology and even-aged harvests in particular varied widely in the application on the ground. Disturbance was based on potential sediment delivery to watercourses and was evaluated on the project level. The data are used to describe conditions as they appeared in the earliest basin-wide photographic record and as input variables to the EMDS model.

CDF Northern Region Forest Practice GIS Timber Harvesting Plan data

Spatial timber harvesting plan data are digitized into the GIS at a scale of 1:12,000 or better using the on-screen or "heads-up" digitizing method. Digital USGS 1:24,000 topographic quadrangles and USGS 1:24,000 DLGs (Digital Line Graphs) serve as base data layer. Timber harvesting plan data (THP) are derived from THP maps, amendments, and completion reports contained in the THP of record on file with the California of Forestry and Fire Protection in Santa Rosa, California. The USGS 1:24,000 DLG data are augmented with features derived from the THP of record.

The State of California and the Department of Forestry and Fire Protection make no representations or warranties regarding the accuracy of data or maps. Neither the State nor the Department shall be liable under any circumstances for any direct, special, incidental, or consequential damages with respect to any claim by any user or third party on account of or arising from the use of data or maps.

These records are not fitted to aerial photographs or digital ortho photo quads and may not be precise in location, but timber harvesting plan boundaries appeared to fit pretty well when qualitatively viewed with 1993 digital ortho photo quads and 2000 aerial photographs. As mentioned previously, one should be cautious about using silviculture as a surrogate for vegetative cover descriptions; some of the rehabilitation and seed tree removal step prescriptions were almost indistinguishable to the pre-harvest condition when viewing aerial photographs. The files are organized by the date of THP submittal. The time between plan submittal and actual harvest varies, often by several years. This time delay occurs for a variety of reasons including long THP review periods for controversial plans, litigation, and landowner attempts to harvest when the market is most favorable. In addition, Non-industrial Timber Management Plans (NTMPs) are only included in the database when a Notice of Operations is filed. The current policy is to digitize all newly submitted NTMPs as they arrive and to retroactively digitize older NTMPs as resources allow.

Road Networks

A roads layer was developed to provide additional information for the assessment of the Albion Basin as part of the program. This dataset is based on 1:24,000 for road segment spatial accuracy. The data set incorporates existing data sets and maps while also adding road segments digitized from 1947-1988 aerial photographs and 1993 USGS Orthographic quadrangles. The number of miles of roads increased a small amount compared to the previous watershed-wide data set developed for the Albion TMDL. Information describing road segments is partial and biased since some areas are more completely characterized than others (Mendocino Redwood Company lands in particular) due to the incorporation of existing data sets for portions of the watershed. While this data set contains the most comprehensive roads information for the watershed, it is still partial and may be useful for resource management or land use purposes. It does not contain "addressing" information used by emergency services.

Vegetation

A land cover data set was developed based on 1:24,000 aerial photograph interpretation of land cover (primarily vegetation) as the foundation for an automated, systematic processing of 1998 LANDSAT imagery and is the only available data set that characterizes vegetation at the Albion watershed scale. The minimum mapping size is 2.5 acres for contrasting types and there is no minimum mapping size for lakes and conifer plantations.

An accuracy assessment of this data was recently released. It indicates that within the conifer cover type accuracies are high for the redwood (RW), Redwood/Douglas fir (RD), and pure Douglas fir (DF) types - 100%, 81%, and 81% respectively, though the majority of the assessed RD sites were equally or better represented by pure RW or DF. Many of the sites mapped as RD are dominated by redwood not Douglas fir though the RD type was defined as having a dominance of Douglas fir. Hardwood accuracy operator was lower – 68%-80%. Most of the confusion was with respect to the shrub and grassland classes. There are many more errors of commission than omission in the hardwood class indicating an over-mapping of hardwood. There are not enough reference sites in shrub map labels to provide any meaningful accuracy assessment.

In canopy cover mapping, there were many more errors of commission than omission in all the higher canopy cover classes, averaging 57% accuracy for the 50-80% class that covered 28% of the analysis section. There were many more errors of omission than commission in the lower cover classes, averaging 37% accuracy for the 10-50% class covering 12% of the analysis area. The fundamental difficulty of mapping low tree canopy cover in densely vegetated conditions results in an over-estimation of canopy closure in tree cover conditions below 50%. Overall weighted accuracy of conifer crown size (translated into average stand diameter sizes) classes was 69%.

There were adequate samples for assessment of only size classes 2, 3, and 4. There was an inverse relationship between size class and accuracy, size 2, the smallest crown diameter class, having the highest accuracy (78%) and size 4 having the lowest (65%). Size classes three and four both had significantly more errors of commission than omission indicating that the larger sizes were over-mapped in extent. Overall, size class 4 (25-40 ft diameters) was over-mapped and much of the confusion was with size classes three and two. Overall weighted accuracy of hardwood crown size classes was 77%, larger sizes tended to be over-mapped, similar to the conifer size map.

The relatively low accuracy in assigning correct values for some attributes such as tree canopy size and density limits the use of these data to a general descriptor and broad analysis efforts. In a forest vegetation type, these data do not register habitat attributes of low or occasional frequency such as large trees or snags that may play a vital role in large woody debris recruitment. It is also limited in selecting thin ribbons of higher canopy closure along streams or narrow tree and shrub ribbons of vegetation along streams in a grassland vegetation type although improving the ability to capture this characteristic is one of the objectives of this new data set.

Water Quality

The Regional Water Board compiled and evaluated existing water quality data as well as collecting new information. Data analyzed by the Regional Water Board includes basic water chemistry, water temperature, instream sediment, and channel geometry. Data were contributed by the following: Coastal Land Trust, Forest Science Project, Graham Matthews and Associates, Mendocino County Water Agency, and the Mendocino Redwood Company. The methods used to collect these data are described in the Water Quality Appendix. In an effort to maximize the amount of information available for analysis, the Regional Water Quality Control Board collected additional data in 2001, in accordance with the protocols described in the NCWAP Methods Manual (Bleier et al. 2003). A complete list of the site names, locations, data contributors, and years of data collection for all water quality information is available, in the subbasin sections of this document. Summary data tables and figures are available in the attachments to the Water Quality Appendix.

All data for the Albion Basin were compiled into electronic formats appropriate for the information, such as spreadsheets, databases, etc. The exact method of data analysis was specific to the data type and its quality. A detailed explanation of the importance of each parameter in relation to salmonids, how each parameter was analyzed, and any limitations of the data are available in the Water Quality Appendix. A brief explanation of how each parameter relates to salmonid health and survival is available in the Integrated Analysis tables of this document.

Based on analysis of the data and data quality, broader hypotheses about potential causes for the exceedences, patterns, or abnormalities were developed. Often, these hypotheses concerned factors that the other program partners were assessing. Therefore, as the synthesis of the data from each of the program agencies proceeded, the water quality data were further evaluated in the context of influencing factors such as canopy for temperature and land use and/or erosional features/fluvial geomorphology for sediment. As such, it was an interdisciplinary effort in recognizing and hypothesizing about the linkages and understanding the data in a broader context.

Water quality objectives from the Basin Plan, TMDL targets, EMDS dependency relationships (thresholds), and a variety of ranges and thresholds from other sources were used as the criteria to which water quality data in this report are compared. With the exception of the Basin Plan objectives and various numeric targets from the Marshack (2000) document, these ranges and thresholds are not enforceable. Rather, they are criteria based on information available at the time of this assessment and may change as new data, analyses, and research becomes available. Table 2 lists the criteria against which certain water quality data were evaluated.

Table 2. Criteria used in the assessment of water quality data.

Water Quality Parameter	Range or Threshold	Reference
WATER COLUMN CHEMISTRY		
pH	6.5 - 8.5	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
Dissolved Oxygen	7.0 mg/L (minimum)	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
Nutrients (Biostimulatory Substances)	No increase in concentrations that promote growths and cause nuisance or adversely affect beneficial uses	Basin Plan, p 3-3.00 (RWQCB 2001)
General Inorganic & Organic Compounds	Various	Basin Plan, Table 3-2, p.3-8.00 (RWQCB 2001) Water Column Chemistry, p.39 et seq. (Marshack 2000)
TEMPERATURE		
Water Temperature	50-60°F MWAT [2] – fully suitable 61-62°F MWAT – moderately suitable 63°F MWAT – somewhat suitable 64°F MWAT – undetermined 65-66°F MWAT – somewhat unsuitable 67°F MWAT– moderately unsuitable ≥68°F MWAT –unsuitable 75°F daily max (lethal) No alteration that affects BUs[1] No increase above natural > 5°F	Basin Plan, p 3-3.00 (RWQCB 2001) Basin Plan, p 3-4.00 (RWQCB 2001) EMDS[3] Cold water fish rearing, RWQCB (2000), p. 37
SEDIMENT		
Sediment	Cannot cause nuisance or adversely affect BUs	Basin Plan, P.3-3.00 (RWQCB 2001)
Settleable Material	Cannot cause nuisance or adversely affect BUs	Basin Plan, p 3-2.00 (RWQCB 2001)
Suspended Material/Load	Cannot cause nuisance or adversely affect BUs	Basin Plan, p 3-2.00, 3-3.00 (RWQCB 2001)
Turbidity	No more than 20 % increase above natural occurring background levels	Basin Plan, p 3-3.00 (RWQCB 2001)
V* in 3rd order streams with slopes 1-4 %	≤0.21 (mean) ≤0.45 (maximum) ≤0.30 – low pool filling	Albion River TMDL (US EPA 2001) Basin Plan, p 4-36.00, Table 4-3 (RWQCB 2001) Knopp (1993)

Water Quality Parameter	Range or Threshold	Reference
	>0.30 and ≤ 0.40 – moderate pool filling >0.40 – high pool filling	
Spawning Substrate Size	6 mm–102 mm	Habitat Requirements of Salmonids in Streams (Bjornn et al 1991)
Percent fines <0.85 mm	<14% in fish-bearing streams[4]	Albion River TMDL (US EPA 2001)
Percent fines <6.4 mm	<30% in fish-bearing streams	Albion River TMDL (US EPA 2001)
CHANNEL GEOMETRY		
Thalweg (change)	Increasing variation from the mean	Albion River TMDL (US EPA 2001)

[1] BUs = Basin Plan beneficial uses
[2] MWAT= maximum average weekly temperature, to be compared to a 7-day moving average of daily average temperature
[3] EMDS = Ecological Management Decision Support model used as a tool in the fisheries limiting factors analysis. These ranges and thresholds were derived from the literature and agreed upon by a panel of program experts.
[4] Fish-bearing streams are streams with cold-water fish species

The following parameters were evaluated by the Regional Water Board and included in this assessment:

- Water chemistry parameters: dissolved oxygen, pH, specific conductance, salinity in the estuary and other parameters which exceeded various water quality standards.
- Continuous water temperature readings from data loggers and limited grab sample data.
- In-stream sediment related parameters: pebble counts, bulk sediment samples, V* (fine sediment in pools), and substrate permeability.

Data were also evaluated for thalweg profiles and stream cross-sections, suspended sediment, turbidity, and stream discharge. Due to the limited data available, no conclusions were drawn about these parameters in the Albion Basin and they are not specifically discussed in the text, although they are included in the Integrated Analysis Tables. A brief discussion of these parameters and summary data tables and figures are available in the Water Quality Appendix.

Fish Habitat and Populations

Data Compilation and Gap Identification

CDFG collected new and compiled existing available data and gathered anecdotal information pertaining to salmonids and the instream habitat on the Albion River and its tributaries and entered it into a database. Anecdotal and historic information was cross-referenced with other existing data whenever possible and rated for quality. Both were used when the information was of good quality and applicable. Instream habitat gaps were mapped and matched with corresponding land parcels. Where data gaps were identified, access was requested from landowners to conduct habitat inventory and fisheries surveys.

Data Collection

Habitat inventories and biological data were collected following the protocol presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998). Two-person crews trained in those methods conducted physical habitat inventories June through November 2001. Stream reaches were stratified based upon Rosgen channel types, and the habitat type and stream length determined for all habitat units within a survey reach.

The parameters measured were stream flow, channel type, temperature, fish habitat type, embeddedness (level of fine sediment surrounding cobble sized substrate particles) , shelter rating (habitat complexity based on elements such as overhanging banks, boulders, large woody debris, submerged vegetation, etc.), substrate composition (percent of different sizes), riparian canopy cover, bank composition, and bank vegetation. The data reflect instream conditions at the time of the survey.

During basin level habitat typing, full sampling of each habitat unit requires recording all characteristics of each habitat unit as per the “Instructions for completing the Habitat Inventory Data Form” (Part III). It was determined that similar stream descriptive detail could be accomplished with a sampling level of approximately 10% (Flosi et al. 1998).

When sampling 10% of the units all habitat types are measured when encountered for the first time. Thereafter, approximately 10% of the habitat units are randomly selected for measurement of all the physical parameters. The habitat unit type, mean length, mean width, mean depth, and maximum depth are determined for the other 90 % of the units. Pool habitat types are also measured for, instream cover and embeddedness.

Streams were surveyed until surveyors encountered physical barriers to fish passage, a steep channel gradient of 8-10% for at least 1,000 feet with no anadromous fish above it, or a dry section of the stream 1,000 feet or more in length.

Canopy cover, embeddedness, pool depth, pool frequency, and pool shelter/cover were reported in bar charts for each of the streams surveyed.

In an attempt to estimate the coho spawner population, we used the carcass survey methods used by MRC, which were taken from Albion WAU Salmonid Spawning Survey (1998-1999). Salmonid spawning surveys were attempted one day each week. The survey date was selected depending on river conditions. A two-person crew surveyed each reach. Crews began at the point of the reach furthest upstream, on the mainstem Albion River, at the point farthest downstream on the South Fork. Measuring sticks were used to measure carcasses and to estimate the length of live fish. Carcasses were identified, sexed, and fork lengths (cm) were measured when possible. Fresh carcasses were tagged with a hog ring and numbered metal tags. A fresh carcass was defined as having at least one clear eye (i.e. no milky color). Non-fresh carcasses were marked with just a hog ring. When a numbered carcass was found in subsequent survey weeks, it was recorded as a "recovery." Skeletons and decomposed carcasses were counted and recorded in the comments section. Live fish and redds were also counted. A population estimate was calculated using the Petersen model. The model incorporates the following formula: $N=MC/R$; Where, N = population estimate, M = total number of tagged carcasses, C = total number of carcasses (number. fresh carcasses tagged + number recovered carcasses + number non-fresh tagged carcasses), R = total number of tags recovered from fresh carcasses.

Fish Passage Barriers

Free passage is essential for juvenile and adult anadromous fish. Free movement in streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels impede free passage for salmonids. Temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity. Of these, poorly installed or worn road culverts commonly disrupt fish passage and disconnect fish passage.

Culverts constructed of steel, aluminum or plastic are the most common stream crossing devices found in rural road systems. Culverts often create temporary, partial, or complete barriers for adult and/or juvenile salmonids during their freshwater migration activities (Table 3). Passage barriers that can be created by culverts include an excessive drop at the culvert outlet (too high of an entry jump is required); an excessive velocity within the culvert; a lack of depth within the culvert; an excessive velocity and/or turbulence at the culvert inlet; and a debris accumulation at and/or within the culvert. The cumulative effect of numerous culvert-related passage barriers in a river system can be significant to anadromous salmonid populations. Inventories and fish passage evaluations of culverts within the coastal Mendocino County road system were conducted between August 1998 and December 2000 by Ross Taylor and Associates, under contract with the Department of Fish and Game's Fishery Restoration Grants Program. These inventories included 26 stream crossings in Mendocino County, of which two were in the Albion Basin (Taylor 2001).

Table 3. Definitions of barrier types and their potential impacts to salmonids (from Taylor 2001).

Barrier Category	Definition	Potential Impact
Temporary	Impassable to all fish some of the time.	Delay in movement beyond the barrier for some period of time.
Partial	Impassable to some fish at all times.	Exclusion of certain species and life stages from portions of a watershed.
Total	Impassable to all fish at all times.	Exclusion of all species from portions of a watershed.

These culvert inventories and fish passage evaluations followed a standardized assessment procedure. First, all culverts in stream crossings that may inhibit fish passage were located and counted. Second, each culvert location was visited during both late-summer/early fall low flow conditions and after early storm events. Third, information was collected regarding culvert specifications. Fourth, fish passage at each culvert was assessed using culvert specifications and passage criteria for juvenile and adult salmonids (from scientific literature and Fish Xing computer software) and on-site observations of fish movement. Last, the quality and quantity of stream habitat above and below each culvert was assessed. Habitat information was obtained from habitat typing surveys conducted by CDFG, the Coastal Land Trust, and the Mendocino Redwood Company.

Following the culvert inventory and fish passage assessment, a prioritized list of culverts that impede fish spawning and rearing activities was compiled for Humboldt and Mendocino counties. Criteria for priority ranking included salmonid species diversity, extent of barrier problem present, culvert risk of failure, current culvert condition, salmonid habitat quantity, salmonid habitat quality, and a total salmonid habitat score. The reports of the culvert inventories and fish passage surveys were provided to the Humboldt and Mendocino counties' Public Works, Natural Resources and Engineering Divisions, the CDFG Native Anadromous Fish and Watershed Branch, and the CDFG North Coast, Northern California, Region Headquarters.

Analytic Tools and Interdisciplinary Synthesis

Integrated Analysis Tables

The multi-discipline Albion team constructed a series of subject specific data tables, referred to as Integrated Analysis (IA) tables, to track the history and status of watershed processes. Through the use of IA tables the information from CDFG and NCRWQCB were compared to one another, and along with information from CDF and CGS, were used to respond to the six guiding assessment questions. The IA process also helped to identify and explain current watershed conditions. These integrated analyses are presented at both basin and subbasin levels. Land use and vegetation analyses have been further divided at the CalWater 2.2a Planning Watershed level.

The IA approach follows the down-slope movement of the five watershed products commonly delivered to streams by natural or human caused energy: water, sediment, organic woody debris, nutrients, and heat. Fundamental to these watershed processes and products are the underlying geology and geomorphology of the watershed. Geologic conditions determine, in large part, the landslide and sediment production potential of the terrain. Geologic processes are influenced in varying degrees by the vegetative community, which is often linked to human activities across the landscape. Current watershed conditions combine with natural events like fire, flood, and earthquakes to affect the fluvial geomorphology and water quality in the stream reaches of a watershed. Finally, the effects of these combined processes are expressed in stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead.

Ecological Management Decision Support System

The assessment program selected the Ecological Management Decision Support system software to help synthesize information on watershed and stream conditions. The EMDS system was developed at the USDA-Forest Service, Pacific Northwest Research Station (Reynolds 1999). It employs a linked set of software that includes MS Excel, NetWeaver, the Ecological Management Decision Support (EMDS) ArcView Extension, and ArcView™. The NetWeaver software, developed at Pennsylvania State University, helps scientists model linked frameworks of various environmental factors called knowledge base networks (Reynolds et al. 1996).

These networks specify how various environmental factors will be incorporated into an overall stream or watershed assessment. The networks resemble branching tree-like flow charts, graphically show the assessment's logic and assumptions, and are used in conjunction with spatial data stored in a Geographic Information System (GIS) to perform assessments and render the results into maps. This combination of software is currently being used for watershed and stream reach assessment on federal lands included in the Northwest Forest Plan (NWFP).

Forest Plan scientists constructed knowledge base models to identify and evaluate environmental factors (e.g. watershed geology, land use impacts, water quality, stream sediment loading, stream temperature, etc.) that shape anadromous salmonid habitat. Using this adaptive model structure, EMDS evaluated available NWFP watershed data to provide insight into stream and watershed conditions in relationship to target conditions known to be favorable to salmonids.

Development of the North Coast California EMDS Model

Staff began development of EMDS knowledge base models with a three-day workshop in June of 2001 organized by the University of California, Berkeley. In addition to the assessment program staff, model developer Dr. Keith Reynolds and several outside scientists also participated. As a starting point, analysts used an EMDS knowledge base model developed by the Northwest Forest Plan for use in coastal Oregon. Based upon the workshop, subsequent discussions among staff and other scientists, examination of the literature, and consideration of localized California conditions, the assessment team scientists then developed preliminary versions of the EMDS models.

The Knowledge Base Network

For California's north coast watersheds, the assessment team originally constructed two knowledge base networks: 1) The Stream Reach Condition Model; and 2) The Watershed Condition Model. These models were reviewed in April 2002 by an independent nine-member science panel, which provided a number of suggestions for model improvements. According to their suggestions, the team revised the two original models and added three others focused on the analysis of specific components of instream and watershed conditions that affect salmonids:

- **The Stream Reach Condition** model (Figure 9) addresses conditions for salmon on individual stream reaches and is largely based on data collected using CDFG stream survey protocols found in the *California Salmonid Stream Habitat Restoration Manual,* (Flosi et al. 1998). This model was used in the Albion Basin assessment.
- **The Sediment Production Risk** model evaluates the magnitudes of the various sediment sources in the basin according to whether they are natural or management related. This model was not used in the Albion Basin assessment;
- **The Water Quality** model has not yet been developed, but will offer a means of assessing characteristics of instream water (flow and temperature) in relation to fish;
- **The Fish Habitat Quality** model has not yet been developed, but will incorporate the Stream Reach model results in combination with data on accessibility to spawning fish and a synoptic view of the condition of riparian vegetation for shade and large woody debris;
- **The Fish Food Availability** model has not yet been developed, but will evaluate the watershed based upon conditions for producing food sources for anadromous salmonids.

In creating these EMDS models, the team used what is termed a tiered, top-down approach. For example, the Stream Reach Condition model tested the truth of the proposition: *The overall condition of the stream reach is suitable for maintaining healthy populations of native Chinook, coho, and steelhead trout.* A knowledge base network was then designed to evaluate the truth of that proposition, based upon existing data from each stream reach. The model design and contents reflected the specific data and information analysts believed were needed, and the manner in which they should be combined, to test the proposition.

In evaluating stream reach conditions for salmonids, the model uses data from several environmental factors. The first branching tier of the knowledge base network shows the data based summary nodes on: 1) in-channel condition; 2) stream flow; 3) riparian vegetation and: 4) water temperature (Figure 8). These nodes are combined into a single value to test the validity of the stream reach condition suitability proposition. In turn, each of the four summary branch node's values is formed from the combination of its more basic data components. The process is repeated until the knowledge base network incorporates all information believed to be important to the evaluation (Figure 9).

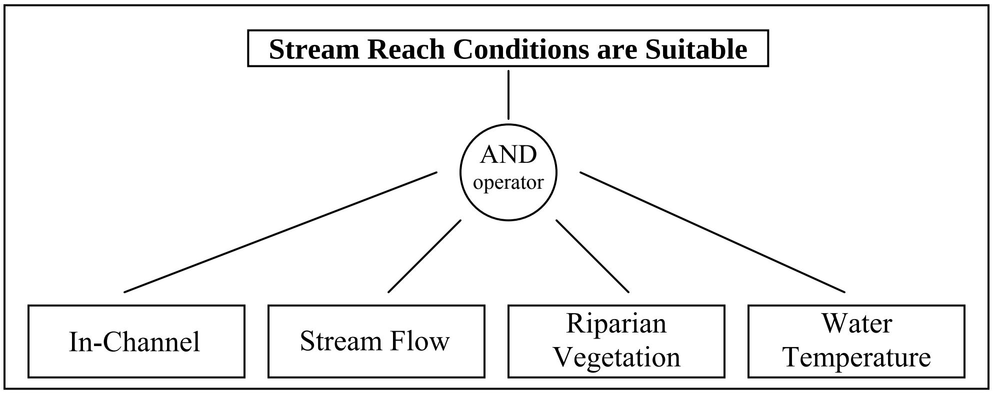


Figure 8. Tier one of the EMDS stream reach knowledge base network.

In Figure 8, the AND operator indicates a decision node that means that the lowest, most limiting value of the four general factors determined by the model will be passed on to indicate the potential of the stream reach to sustain salmonid populations. In that sense, the model mimics nature. For example, if summertime low flow is reduced to a level deleterious to fish survival or well being, regardless of a favorable temperature regime, instream habitat, and/or riparian conditions, the overall stream condition is not suitable to support salmonids.

Although model construction is typically done top-down, models are run in EMDS from the bottom up. That is, stream reach data are usually entered at the lowest and most detailed level of the several branches of the network tree (the leaves). The data from the leaves are combined progressively with other related attribute information as the analysis proceeds up the network. Decision nodes are intersections in the model networks where two or more factors are combined before passing the resultant information on up the network (Figure 9).

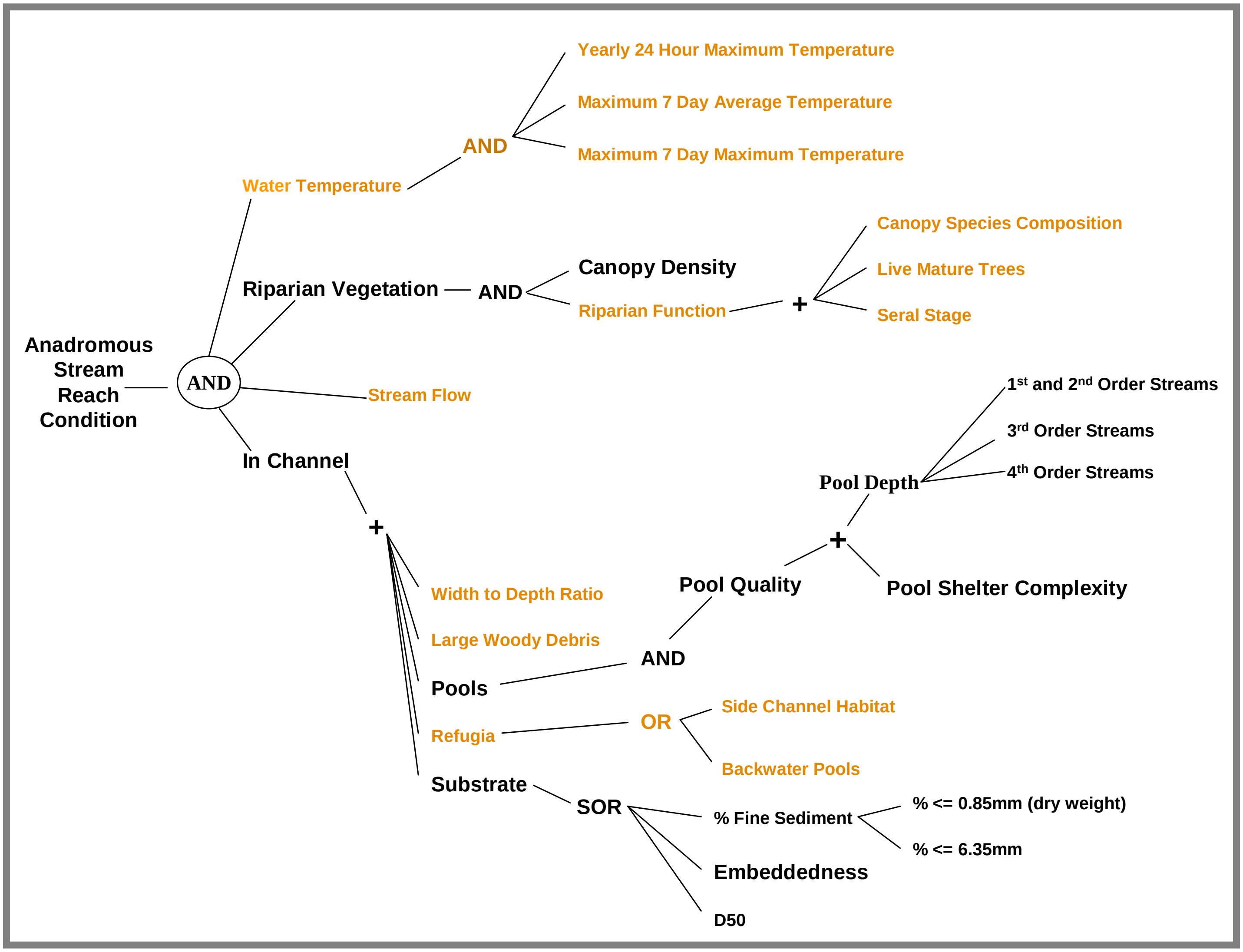


Figure 9. Graphic representation of the Stream Reach Condition model. Habitat factors populated with data in the Albion assessment model are shown in black. Other habitat factors considered important for stream habitat condition evaluation, but data limited in the Albion assessment, are included in orange.

EMDS models assess the degree of truth (or falsehood) of each model proposition. Each proposition is evaluated in reference to simple graphs called reference curves that determine its degree of truth/falsehood, according to the data's implications for salmon. Figure 10 shows an example reference curve for the proposition *stream temperature is suitable for salmon*. The horizontal axis shows temperature in degrees Fahrenheit ranging from 30-80° F, while the vertical axis is labeled Truth Value and ranges from values of +1 to -1. The upper horizontal line arrays the fully suitable temperatures from 50-60°F (+1). The fully unsuitable temperatures are arrayed at the bottom (-1). Those in between are ramped between the fully suitable and fully unsuitable ranges and are rated accordingly. A similar numeric relation is determined for all attributes evaluated with reference curves in the EMDS models.

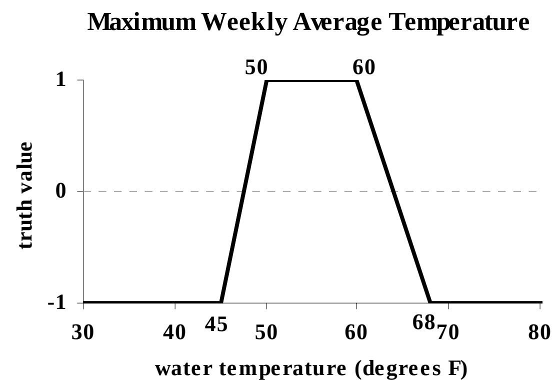


Figure 10. EMDS reference curve for stream temperature.

EMDS uses this type of reference curve in conjunction with data specific to a stream reach. This example reference curve evaluates the proposition that the stream's water temperature is suitable for salmonids. Break points on the curve can be set for specific species, life stage, or season of the year. Curves are dependent upon the availability of data in order to be included in an analysis.

For each evaluated proposition in the EMDS model network, the result is a number between –1 and +1. The number relates to the degree to which the data support or refute the proposition. In all cases a value of +1 means that the proposition is completely true, and –1 implies that it is completely false, while in-between values indicate degrees of truth (i.e. values approaching +1 being closer to true and those approaching –1 converging on completely untrue). A zero value means that the proposition cannot be evaluated based upon the data available. Breakpoints occur where the slope of the reference curve changes. For example, in Figure 10 breakpoints occur at 45°, 50°, 60°, and 68° F.

EMDS map legends use a seven-class system for depicting the truth-values. Values of +1 are classed as the highest suitability; values of –1 are classed as the lowest suitability; and values of 0 are undetermined. Between 0 and 1 are two classes which, although unlabeled in the legend, indicate intermediate values of better suitability (0 to 0.5; and 0.5 to 1). Symmetrically, between 0 and –1 are two similar classes which are intermediate values of worse suitability (0 to –0.5; and –0.5 to –1). These ranking values are assigned based upon condition findings in relationship to the criteria in the reference curves. The following table summarizes important EMDS Stream Reach Condition model information.

Table 4. Reference curve metrics for EMDS stream reach condition model.

Stream Reach Condition Factor	Definition and Reference Curve Metrics
Aquatic / Riparian Conditions	
Summer MWAT	Maximum 7-day average summer water temperature < 45°F fully unsuitable, 50-60°F fully suitable, > 68°F fully unsuitable. Water temperature was not included in current EMDS evaluation.
Riparian Function	Under development
Canopy Density	Average percent of the thalweg within a stream reach influenced by tree canopy. < 50% fully unsuitable, ≥ 85% fully suitable.
Seral Stage	Seral stage composition of near stream forest. Under development
Vegetation Type	Forest composition Under development
Stream Flow	Under development
In-Channel Conditions	
Pool Depth	Percent of stream reach with pools of a maximum depth of 2.5, 3, and 4 feet deep for first and second, third, and fourth order streams respectively. ≤ 20% fully unsuitable, 30 – 55% fully suitable, ≥ 90% fully unsuitable
Pool Shelter Complexity	Relative measure of quantity and composition of large woody debris, root wads, boulders, undercut banks, bubble curtain, overhanging and instream vegetation. ≤ 30 fully unsuitable, ≥ 100 - 300 fully suitable
Pool Frequency	Percent of pools by length in a stream reach. Under development
Substrate Embeddedness	Pool tail embeddedness is a measure of the percent of small cobbles (2.5" to 5" in diameter) buried in fine sediments. EMDS calculates categorical embeddedness data to produce evaluation scores between –1 and

Stream Reach Condition Factor	Definition and Reference Curve Metrics
	+1. The proposition is fully true if evaluation scores are 0.8 or greater and -0.8 evaluate to fully false
Percent Fines in Substrate <0.85mm (dry weight)	Percent of fine sized particles <0.85 mm collected from McNeil type samples. < 10% fully suitable, > 15% fully unsuitable. There was not enough of percent fines data to use percent fines in EMDS evaluations
Percent Fines in Substrate < 6.4 mm	Percent of fine sized particles < 6.4 mm collected from McNeil type samples. <15% fully suitable, >30% fully unsuitable. There was not enough of percent fines data to use percent fines in EMDS evaluations
Large Woody Debris (LWD)	The reference values for frequency and volume is derived from Bilby and Ward (1989) and is dependent on channel size. See EMDS Appendix for details. Most watersheds do not have sufficient LWD surveys for use in EMDS.
Winter Refugia Habitat	Winter refugia is composed of backwater pools and side channel habitats and deep pools (> 4 feet deep). Under development.
Pool to Riffle Ratio	Ratio of pools to riffle habitat units. Under development.
Width to Depth Ratio	Ratio of bankfull width to maximum depth at velocity crossovers. Under development.

Advantages Offered by EMDS

EMDS offers a number of advantages for use in watershed assessments. Instead of being a hidden black box, each EMDS model has an open and intuitively understandable structure. The explicit nature of the model networks facilitates open communication among agency personnel and with the general public through simple graphics and easily understood flow diagrams. The models can be easily modified to incorporate alternative assumptions about the conditions of specific environmental factors (e.g., stream water temperature) required for suitable salmonid habitat.

Using ESRI Geographic Information System (GIS) software, EMDS maps the factors affecting fish habitat and shows how they vary across a basin. At this time, no other widely available package allows a knowledge base network to be linked directly with a geographic information system such as ESRI's ArcView™. This link is vital to the production of maps and other graphics reporting the watershed assessments. EMDS models also provide a consistent and repeatable approach to evaluating watershed conditions for fish. In addition, the maps from supporting levels of the model show the specific factors that, taken together, determine overall watershed conditions. This latter feature can help to identify what is most limiting to salmonids, and thus assist to prioritize restoration projects or modify land use practices.

Another feature of the system is the ease of running alternative scenarios. Scientists and others can test the sensitivity of the assessments to different assumptions about environmental factors and how they interact, through changing the knowledge-based network and breakpoints. What-if scenarios can be run by changing the shapes of reference curves, or by changing the way the data are combined and synthesized in the network.

NetWeaver/EMDS/ArcView tools can be applied to any scale of analysis, from reach specific to entire watersheds. The spatial scale can be set according to the spatial domain of the data selected for use and issue(s) of concern. Alternatively, through additional network development, smaller scale analyses (i.e., sub-watersheds) can be aggregated into a large hydrologic unit. With sufficient sampling and data, analyses can be done even upon single or multiple stream reaches.

Limitations of the EMDS Model and Data Inputs

While EMDS-based syntheses are important tools for watershed assessment, they do not by themselves yield a course of action for restoration and land management. EMDS results require interpretation, and how they are employed depends upon other important issues, such as social and economic concerns. In addition to the accuracy of the EMDS model constructed, the currency and completeness of the data available for a stream or watershed will strongly influence the degree of confidence in the results. External validation of the EMDS model using fish population data and other information should be done.

One disadvantage of linguistically based models such as EMDS is that they do not provide results with readily quantifiable levels of error. Therefore, EMDS should only be used as an indicative model, one that indicates the quality of watershed or instream conditions based on available data and the model structure. It is not intended to provide highly definitive answers, such as from a statistically based process model. It does provide a reasonable first approximation of conditions through a robust information synthesis approach; however, its outputs need to be considered and interpreted in the light of other information sources and the inherent limitations of the model and its data inputs. It also should be clearly noted that EMDS does not assess the marine phase of the salmonid life cycle, nor does it consider fishing pressures.

Program staff has identified some model or data elements needing attention and improvement in future iterations of EMDS. These currently include:

- Completion of quality control evaluation procedures;
- Adjust the model to better reflect differences between stream mainstems and tributaries, for example, the modification of canopy density standards for wide streams;
- Develop a suite of Stream Reach Model reference curves to better reflect the differences in expected conditions based upon various geographic watershed locations considering geology, vegetation, precipitation, and runoff patterns.

At this time, all of the recommendations made by our peer reviewers have not been implemented into the models. Additionally, EMDS results should be used as valuable but not necessarily definitive products, and their validation with other observations is necessary. The EMDS Appendix provides added detail concerning the system's structure and operations.

Management Applications of Watershed Synthesis Results

EMDS syntheses can be used at the basin scale- to show current watershed status. Maps depicting those factors that may be the largest impediments, as well as those areas where conditions are very good, can help guide protection and restoration strategies. The EMDS model can also help to assess the cost-effectiveness of different restoration strategies. By running sensitivity analyses on the effects of changing different habitat conditions, it can help decision makers determine how much effort is needed to significantly improve a given factor in a watershed and whether the investment is cost-effective.

At the project planning level, EMDS model results can help landowners, watershed groups, and others select the appropriate types of restoration projects and places (i.e., planning watersheds or larger) that can best contribute to recovery. Agencies will also use the information when reviewing projects on a watershed basis.

The main strength of using NetWeaver/EMDS/ArcView knowledge base software in performing limiting factors analysis is its flexibility, and through explicit logic, easily communicated graphics, and repeatable results, it can provide insights as to the relative importance of the constraints limiting salmonids in North Coast watersheds. Thus the results have utility to assess fish habitat conditions in watersheds and to help prioritize restoration efforts. They also facilitate an improved understanding of the complex relationships among environmental factors, human activities, and overall habitat quality for native salmon and trout.

Adaptive Application for EMDS and CDFG Stream Habitat Evaluations

CDFG has developed habitat evaluation standards, or target values, to help assess the condition of anadromous salmonid habitat in California streams (Flosi et al. 1998). These standards are based upon data analyses of over 1500 tributary surveys, and considerable review of pertinent literature. The EMDS reference curves have similar standards. These have been adapted from CDFG, but following peer review and professional discussion, they have been modified slightly due to more detailed application in EMDS. As such, slight differences occur between values found in Flosi et al. (1998) and those used by EMDS. The reference curves developed for the EMDS are provided in the EMDS Appendix of this report.

Both habitat evaluation systems have similar but slightly different functions. Stream habitat standards developed by CDFG are used to identify habitat conditions and establish priorities among streams considered for improvement projects based upon standard CDFG tributary reports. The EMDS compares select components of the stream habitat survey data to reference curve values and expresses degrees of habitat suitability for fish on a sliding scale. In addition, the EMDS produces a combined estimate of overall stream condition by combining the results from several stream habitat components. In the fish habitat relationship section of this report, we utilize target values found in Flosi et al. (1998), field observations, and results from EMDS reference curve evaluations to help describe and evaluate stream habitat conditions.

Due to the wide range of geology, topography and diverse stream channel characteristics which occur within the North Coast region, there are streams that require more detailed interpretation and explanation of results than can be simply generated by EMDS suitability criteria or tributary survey target values.

For example, pools are an important habitat component and a useful stream attribute to measure. However, some small fish-bearing stream channels may not have the stream power to scour pools of the depth and frequency considered to be high value "primary" pools by CDFG target values, or to be fully suitable according to EMDS. Often, these shallow pool conditions are found in low gradient stream reaches in small watersheds that lack sufficient discharge to deeply scour the channel. They also can exist in moderate to steep gradient reaches with bedrock/boulder dominated substrate highly resistant to scour, which also can result in few deep pools.

Therefore, some streams may not have the inherent ability to attain conditions that meet the suitability criteria or target values for pool depth. These scenarios result in pool habitat conditions that are not considered highly suitable by either assessment standard. However, these streams may still be very important because of other desirable features that support valuable fishery resources. As such, they receive additional evaluation with our refugia rating system and expert professional judgment. Field validation of any modeling system's results is a necessary component of watershed assessment and reporting.

Limiting Factors Analysis

A main objective of CDFG watershed assessment is to identify factors that limit production of anadromous salmonid populations in North Coast watersheds. This process is known as a limiting factors analysis (LFA). The limiting factors concept is based upon the assumption that eventually every population must be limited by the availability of necessary support resources (Hilborn and Walters 1992) or that a population's potential may be constrained by an over abundance, deficiency, or absence of a watershed ecosystem component. Identifying stream habitat factors that limit or constrain anadromous salmonids is an important step towards setting priorities for habitat improvement projects and management strategies aimed at the recovery of declining fish stocks and protection of viable fish populations.

Although several factors have contributed to the decline of anadromous salmonid populations, habitat loss and modification are major determinants of their current status (FEMAT 1993). Our approach to a LFA integrates two habitat based methods to evaluate the status of key aspects of stream habitat that affect anadromous salmonid production- species life history diversity and the stream's ability to support viable populations.

The first method uses priority ranking of habitat categories based on a CDFG team assessment of data collected during stream habitat inventories. The second method uses the EMDS to evaluate the suitability of key stream habitat components to support anadromous fish populations. These habitat-based methods assume that stream habitat quality and quantity play important roles in a watershed's ability to produce viable salmonid populations.

The LFA assumes that poor habitat quality and reduced quantities of favorable habitat impairs fish production. The program LFA is focused mainly on those physical habitat factors within freshwater and estuarine ecosystems that affect spawning and subsequent juvenile life history requirements during low flow seasons. Two general categories of factors or mechanisms limit salmonid populations:

- Density independent; and
- Density dependent mechanisms.

Density independent mechanisms generally operate without regard to population density. These include factors related to habitat quality such as stream flow and water temperature or chemistry. In general, fish will die regardless of the population density if flow is inadequate, or water temperatures or chemistry reach lethal levels. Density dependant mechanisms generally operate according to population density and habitat carrying capacity. Competition for food, space, and shelter are examples of density dependant factors that affect growth and survival when populations reach or exceed the habitat carrying capacity.

The program's approach considers these two types of habitat factors before prioritizing recommendations for habitat management strategies. Priority steps are given to preserving and increasing the amount of high quality (density independent) habitat in a cost effective manner. More details of the LFA are presented in the CDFG Appendix.

Restoration Needs/Tributary Recommendations Analysis

CDFG inventoried 13 tributaries to the Albion River and the headwaters of the Albion from 1994 to 2003 using protocols in the *California Salmonid Stream Habitat Restoration Manual*. The tributaries and the headwaters of the Albion River surveyed were composed of 30 stream reaches, defined as Rosgen channel types. The stream inventories are a combination of several stream reach surveys: habitat typing, channel typing, biological assessments, and in some reaches LWD and riparian zone recruitment assessments. An experienced biologist and/or habitat specialist conducted QA/QC on field crews and collected data, performed data analysis, and determined general areas of habitat deficiency based upon the analysis and synthesis of information.

CDFG biologists selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories, and updated the recommendations with the results of the stream reach condition EMDS and the refugia analysis (Table 5). It is important to understand that these selections are made from stream reach conditions that were observed at the times of the surveys and do not include upslope watershed observations other than those that could be made from the streambed. They also reflect a single point in time and do not anticipate future conditions. However, these general recommendation categories have proven to be useful as the basis for specific project development, and provide focus for on-the-ground project design and implementation. Bear in mind that stream and watershed conditions change over time and periodic survey updates and field verification are necessary if watershed improvement projects are being considered.

Table 5. List of tributary recommendations in stream tributary reports.

Recommendation	Explanation
Temp	Summer water temperatures were measured to be above optimum for salmon and steelhead
Pool	Pools are below CDFG target values in quantity and/or quality
Cover	Escape cover is below CDFG target values
Bank	Stream banks are failing and yielding fine sediment into the stream
Roads	Fine sediment is entering the stream from the road system
Canopy	Shade canopy is below CDFG target values
Spawning Gravel	Spawning gravel is deficient in quality and/or quantity
LDA	Large debris accumulations are retaining large amounts of gravel and could need modification
Livestock	There is evidence that stock is impacting the stream or riparian area and exclusion should be considered
Fish Passage	There are barriers to fish migration in the stream

In general, the recommendations that involve erosion and sediment reduction by treating roads and failing stream banks, and riparian and near stream vegetation improvements precede the instream recommendations in reaches that demonstrate disturbance levels associated with watersheds in current stress. Instream improvement recommendations are usually a high priority in streams that reflect watersheds in recovery or good health. Various project treatment recommendations can be made concurrently if watershed and stream conditions warrant.

Fish passage problems, especially in situations where favorable stream habitat reaches are being separated by a man-caused feature (e.g., culvert), are usually a treatment priority. Good examples of these are the recent and dramatically successful Humboldt County/CDFG culvert replacement projects in tributaries to Humboldt Bay. In these regards, the program's more general watershed scale upslope assessments can go a long way in helping determine the suitability of conducting instream improvements based upon watershed health. As such, there is an important relationship between the instream and upslope assessments.

Additional considerations must enter into the decision process before these general recommendations are further developed into improvement activities. In addition to watershed condition considerations as a context for these recommendations, there are certain logistic considerations that enter into a recommendation's subsequent ranking for project development. These can include work party access limitations based upon lack of private party trespass permission and/or physically difficult or impossible locations of the candidate work sites. Biological considerations are made based upon the propensity for benefit to multiple or single fishery stocks or species. Cost benefit and project feasibility are also factors in project selection for design and development.

Potential Salmonid Refugia

Establishment and maintenance of salmonid refugia areas containing high quality habitat and sustaining fish populations are activities vital to the conservation of our anadromous salmonid resources (Moyle and Yoshiyama 1992; Li et al. 1995; Reeves et al. 1995). Protecting these areas will prevent the loss of the remaining high quality salmon habitat and salmonid populations. Therefore, a refugia investigation project should focus on identifying areas found to have high salmonid productivity and diversity. Identified areas should then be carefully managed for the following benefits:

- Protection of refugia areas to avoid loss of the last best salmon habitat and populations. The focus should be on protection for areas with high productivity and diversity;
- Refugia area populations which may provide a source for re-colonization of salmonids in nearby watersheds that have experienced local extinctions, or are at risk of local extinction due to small populations;
- Refugia areas provide a hedge against the difficulty in restoring extensive, degraded habitat and recovering imperiled populations in a timely manner (Kaufmann et al. 1997).

The concept of refugia is based on the premise that patches of aquatic habitat provide habitat that retains the natural capacity and ecologic functions to support wild anadromous salmonids in such vital activities as spawning and rearing. Anadromous salmonids exhibit typical features of patchy populations; they exist in dynamic environments and have developed various dispersal strategies including juvenile movements, adult straying, and relative high fecundity for an animal that exhibits some degree of parental care through nest building (Reeves et al. 1995). Conservation of patchy populations requires conservation of several suitable habitat patches and maintaining passage corridors between them.

Potential refugia may exist in areas where the surrounding landscape is marginally suitable for salmonid production or altered to a point that stocks have shown dramatic population declines in traditional salmonid streams. If altered streams or watersheds recover their historic natural productivity, through either restoration efforts or natural processes, the abundant source populations from nearby refugia can potentially re-colonize these areas or help sustain existing salmonid populations in marginal habitat. Protection of refugia areas is noted as an essential component of conservation efforts to ensure long-term survival of viable stocks, and a critical element towards recovery of depressed populations (Sedell 1990; Moyle and Yoshiyama 1992; Frissell 1993, 2000).

Refugia habitat elements include the following:

- Areas that provide shelter or protection during times of danger or distress;
- Locations and areas of high quality habitat that support populations limited to fragments of their former geographic range; and
- A center from which dispersion may take place to re-colonize areas after a watershed and/or sub-watershed level disturbance event and readjustment.

Spatial and Temporal Scales of Refugia

These refugia concepts become more complex in the context of the wide range of spatial and temporal habitat required for viable salmonid populations. Habitat can provide refuge at many scales from a single fish to groups of them, and finally to breeding populations. For example, refugia habitat may range from a piece of wood that provides instream shelter for a single fish, or individual pools that provide cool water for several rearing juveniles during hot summer months, to watersheds where conditions support sustaining populations of salmonid species. Refugia also include areas where critical life stage functions such as migrations and spawning occur. Although fragmented areas of suitable habitat are important, their connectivity is necessary to sustain the fisheries. Today, watershed scale refugia are needed to recover and sustain aquatic species (Moyle and Sato 1991). For the purpose of this discussion, refugia are considered at the fish bearing tributary and subbasin scales. These scales of refugia are generally more resilient to the deleterious effects of landscape and riverine disturbances such as large floods, persistent droughts, and human activities than the smaller, habitat unit level scale (Sedell et al. 1990).

Standards for refugia conditions are based on reference curves from the literature and CDFG data collection at the regional scale. The program uses these values in its EMDS models and stream inventory, improvement recommendation process. Li et al. (1995) suggested three prioritized steps to use the refugia concept to conserve salmonid resources.

- Identify salmonid refugia and ensure they are protected;
- Identify potential habitats that can be rehabilitated quickly;
- Determine how to connect dispersal corridors to patches of adequate habitat.

Refugia and Meta-population Concept

The concept of anadromous salmonid meta-populations is important when discussing refugia. The classic metapopulation model proposed by Levins (1969) assumes the environment is divided into discrete patches of suitable habitat. These patches include streams or stream reaches that are inhabited by different breeding populations or sub-populations (Barnhart 1994; McElhany et al. 2000). A metapopulation consists of a group of sub-populations which are geographically located such that over time, there is likely genetic exchange between the sub-populations (Barnhart 1994). Metapopulations are characterized by 1) relatively isolated, segregated breeding populations in a patchy environment that are connected to some degree by migration between them, and 2) a dynamic relationship between extinction and re-colonization of habitat patches.

Anadromous salmonids fit nicely into the sub-population and metapopulation concept because they exhibit a strong homing behavior to natal streams forming sub-populations, and have a tendency to stray into new areas. The straying or movement into nearby areas results in genetic exchange between sub-populations or seeding of other areas where populations are at low levels. This seeding comes from abundant or source populations supported by high quality habitat patches which may be considered as refugia.

Habitat patches differ in suitability and population strength. In addition to the classic metapopulation model, other theoretical types of spatially structured populations have been proposed (Li et al. 1995; McElhany et al. 2000). For example, the core and satellite (Li et al. 1995) or island-mainland population (McElhany et al. 2000) model depicts a core or mainland population from which dispersal to satellites or islands results in smaller surrounding populations. Most straying occurs from the core or mainland to the satellites or islands. Satellite or island populations are more prone to extinction than the core or mainland populations (Li et al. 1995; McElhany et al. 2000). Another model termed source-sink populations is similar to the core-satellite or mainland-island models, but straying is one way, only from the highly productive source towards the sink subpopulations. Sink populations are not self-sustaining and are highly dependant on migrants from the source population to survive (McElhany et al. 2000). Sink populations may inhabit typically marginal or unsuitable habitat, but when environmental conditions strongly favor salmonid production, sink population areas may serve as important sites to buffer populations from disturbance events (Li et al. 1995) and increase basin population strength. In addition to testing new areas for potential suitable habitat, the source-sink strategy adds to the diversity of behavior patterns salmonids have adapted to maintain or expand into a dynamic aquatic environment.

The metapopulation and other spatially structured population models are important to consider when identifying refugia because in dynamic habitats, the location of suitable habitat changes (McElhany et al. 2000) over the long term from natural disturbance regimes (Reeves et al. 1995) and over the short term by human activities. Satellite, island, and sink populations need to be considered in the refugia selection process because they are an integral component of the metapopulation concept. They also may become the source population or refugia areas of the future.

Methods to Identify Refugia

Currently there is no established methodology to designate refugia habitat for California's anadromous salmonids. This is mainly due to a lack of sufficient data describing fish populations, meta-populations and habitat conditions and productivity across large areas. This lack of information holds true for all study basins especially in terms of meta-population dynamics. Studies are needed to determine population growth rates and straying rates of salmonid populations and sub-populations to better utilize spatial population structure to identify refugia habitat.

Classification systems, sets of criteria and rating systems have been proposed to help identify refugia type habitat in north coast streams, particularly in Oregon and Washington (Moyle and Yoshiyama 1992; FEMAT 1993; Li et al. 1995; Frissell et al. 2000; Kisup County 2000). Upon review of these works, several common themes emerge. A main theme is that refugia are not limited to areas of pristine habitat. While ecologically intact areas serve as dispersal centers for stock maintenance and potential recovery of depressed sub-populations, lower quality habitat areas also play important roles in long-term salmonid metapopulation maintenance. These areas may be considered the islands, satellites, or sinks in the metapopulation concept. With implementation of ecosystem management strategies aimed at maintaining or restoring natural processes, some of these areas may improve in habitat quality, show an increase in fish numbers, and add to the metapopulation strength.

A second common theme is that over time within the landscape mosaic of habitat patches, good habitat areas will suffer impacts and become less productive, and wink out and other areas will recover and wink in. These processes can occur through either human caused or natural disturbances or succession to new ecological states. Regardless, it is important that a balance be maintained in this alternating, patchwork dynamic to ensure that adequate good quality habitat is available for viable anadromous salmonid populations (Reeves et al. 1995).

Approach to Identifying Refugia

The program's interdisciplinary refugia identification team identified and characterized refugia habitat by using expert professional judgment and criteria developed for North Coast watersheds. The criteria used considered different values of watershed and stream ecosystem processes, the presence and status of fishery resources, water quality, and other factors that may affect refugia productivity. The expert refugia team encouraged other specialists with local knowledge to participate in the refugia identification and categorization process.

The team also used results from information processed by the programs EMDS at the stream reach and planning watershed/subbasin scales. Stream reach and watershed parameter evaluation scores were used to rank stream and watershed conditions based on collected field data. Stream reach scale parameters included pool shelter rating, pool depth, embeddedness, and canopy cover. Water temperature data were also used when available. The individual parameter scores identified which habitat factors currently support or limit fish production (see EMDS and limiting factors sections).

Professional judgment, analyzing field notes, local expert opinion, habitat inventory survey results, water quality data results, and EMDS scores determined potential locations of refugia. If a habitat component received a suitable ranking from the EMDS model, it was cross-referenced to the survey results from that particular stream and to field notes taken during that survey. The components identified as potential refugia were then ranked according to their suitability to encourage and support salmonid health.

When identifying anadromous salmonid refugia, the program team took into account that anadromous salmon have several non-substitutable habitat needs for their life cycle. A minimal list (NMFS 2000) includes:

- Adult migration pathways;
- Spawning and incubation habitat;
- Stream rearing habitat;
- Forage and migration pathways;
- Estuarine habitat.

The best refugia areas are large, meet all of these life history needs, and therefore provide complete functionality to salmonid populations. These large, intact systems are scarce today and smaller refugia areas that provide for only some of the requirements have become very important areas, but cannot sustain large numbers of fish. These must operate in concert with other fragmented habitat areas for life history support and refugia connectivity becomes very important for success. Therefore, the refugia team considered relatively small, tributary areas in terms of their ability to provide at least partial refuge values, yet contribute to the aggregated refugia of larger scale areas. Therefore, the team's analyses used the tributary scale as the fundamental refugia unit.

CDFG created a tributary scale refugia-rating worksheet, (Table 6, page 38). The worksheet has 21 condition factors that were rated on a sliding scale from high quality to low quality. Twenty-one factors were grouped into five categories:

- Stream condition;

- Riparian condition;
- Native salmonid status;
- Present salmonid abundance;
- Management impacts (disturbance impacts to terrain, vegetation, and the biologic community).

Additionally, NCRWQCB created a worksheet specifically for rating water quality refugia, Table 7. The worksheet has 13 condition factors that were rated on a sliding scale from high quality to low quality. Thirteen factors were grouped into three categories:

- In-stream sediment related;
- Stream temperature
- Water chemistry.

Tributary ratings were determined by combining the results of NCRQCB water quality results, EMDS results, and data in CDFG tributary reports by a multi-disciplinary, expert team of analysts. The various factors' ratings were combined to determine an overall tributary rating on a scale from high to low quality refugia. Tributary ratings were subsequently aggregated at the subbasin scale and expressed a general estimate of subbasin refugia conditions. Factors with limited or missing data were noted. In most cases there were data limitations on 1–3 factors. These were identified for further investigation and inclusion in future analysis.

The program has created a hierarchy of refugia categories that contain several general habitat conditions. This descriptive system is used to rank areas by applying results of the analyses of stream and watershed conditions described above and are used to determine the ecological integrity of the study area. A basic definition of biotic integrity is "the ability [of an ecosystem] to support and maintain a balanced, integrated, and functional organization comparable to that of the natural habitat of the region" (Karr and Dudley 1981).

The Report of the Panel on the Ecological Integrity of Canada's National Parks submitted this definition:

A Definition of Ecological Integrity

The Panel proposes the following definition of ecological integrity: "An ecosystem has integrity when it is deemed characteristic for its natural region, including the composition and abundance of native species and biological communities, rates of change and supporting processes." "In plain language, ecosystems have integrity when they have their native components (plants, animals and other organisms) and processes (such as growth and reproduction) intact."

Salmonid Refugia Categories and Criteria:

High Quality Habitat, High Quality Refugia

- Maintains a high level of watershed ecological integrity (Frissell 2000);
- Contains the range and variability of environmental conditions necessary to maintain community and species diversity and supports natural salmonid production (Moyle and Yoshiyama 1992; Frissell 2000);
- Relatively undisturbed and intact riparian corridor;
- All age classes of historically native salmonids present in good numbers, and a viable population of an ESA listed salmonid species is supported (Li et al. 1995);
- Provides population seed sources for dispersion, gene flow and re-colonization of nearby habitats from straying local salmonids;
- Contains a high degree of protection from degradation of its native components.

High Potential Refugia

- Watershed ecological integrity is diminished but remains good (Frissell 2000);
- Instream habitat quality remains suitable for salmonid production and is in the early stages of recovery from past disturbance;

- Riparian corridor is disturbed, but remains in fair to good condition;
- All age classes of historically native salmonids are present including ESA listed species, although in diminished numbers;
- Salmonid populations are reduced from historic levels, but still are likely to provide straying individuals to neighboring streams;
- Currently is managed to protect natural resources and has resilience to degradation, which demonstrates a strong potential to become high quality refugia (Moyle and Yoshiyama 1992; Frissell 2000).

Medium Potential Refugia

- Watershed ecological integrity is degraded or fragmented (Frissell 2000);
- Components of instream habitat are degraded, but support some salmonid production;
- Riparian corridor components are somewhat disturbed and in degraded condition;
- Native anadromous salmonids are present, but in low densities; some life stages or year classes are missing or only occasionally represented;
- Relative low numbers of salmonids make significant straying unlikely;
- Current management or recent natural events have caused impacts, but if positive change in either or both occurs, responsive habitat improvements should occur.

Low Quality Habitat, Low Potential Refugia

- Watershed ecological integrity is impaired (Frissell 2000);
- Most components of instream habitat are highly impaired;
- Riparian corridor components are degraded;
- Salmonids are poorly represented at all life stages and year classes, but especially in older year classes;
- Low numbers of salmonids make significant straying very unlikely;
- Current management and / or natural events have significantly altered the naturally functioning ecosystem and major changes in either of both are needed to improve conditions.

Other Related Refugia Component Categories:

Potential Future Refugia (Non-Anadromous)

- Areas where habitat quality remains high but does not currently support anadromous salmonid populations;
- An area of high habitat quality, but anadromous fish passage is blocked by man made obstructions such as dams or poorly designed culverts at stream crossings etc.

Critical Contributing Areas

- Area contributes a critical ecological function needed by salmonids such as providing a migration corridor, conveying spawning gravels, or supplying high quality water (Li et al. 1995);
- Riparian areas, floodplains, and wetlands that are directly linked to streams (Huntington and Frissell 1997).

Data Limited

- Areas with insufficient data describing fish populations, habitat conditions, watershed conditions, or management practices.

Table 6. Refugia rating worksheet.

Stream Name:			**Date:**
Raters:			
Ecological Integrity - Overall Refugia Summary Ratings:	High Quality; High Potential; Medium Potential; Low Quality (Other: *Non-Anadromous; Contributing Functions; Data Limited*)		
Stream Condition:	**High Quality**	**Medium Quality**	**Low Quality**
Stream Flow			
Water Temperature			
Free Passage			
Gravel			
Pools			
Shelter			
In-Channel Large Wood			
Canopy			
Nutrients			
Stream Summary Rating:			
Riparian Condition:	**High Quality**	**Medium Quality**	**Low Quality**
Forest Corridor Seral Stage			
Fluvial Dis-equilibrium			
Aquatic/Riparian Community			
Riparian Summary Rating:			
Native Salmonids Status: (Native Species and Age Classes)	**Present**	**Diminished**	**Absent**
Chinook			
Coho			
Steelhead			
Species Summary Rating:			
Salmonid Abundance:	**High**	**Medium**	**Low**
Chinook			
Coho			
Steelhead			
Abundance Summary Rating:			
Management Impacts:	**Low Impacts**	**Medium Impacts**	**High Impacts**
Disturbed Terrain			
Displaced Vegetation			
Native Biologic Integrity			
Impacts Summary Rating:			
Comments:			

Table 7. Water quality refugia rating sheet.

Stream Name:			**Date:**
Rater(s):			
In-stream Sediment Related:	**Suitable**	**Somewhat Suitable**	**Unsuitable**
Pebble Counts (D50)			
Mc Neil			
Spawning Substrate			
% Fines <0.85 mm			
% Fines <6.4 mm			
V*			
Permeability			
Turbidity/Suspended Sediment			
Thalweg			
Stream Summary Rating:			
Stream Temperature:	**Suitable**	**Undetermined**	**Unsuitable**
MWAT			
Seasonal Maximum			
Riparian Summary Rating:			
Water Chemistry:	**Suitable**	**Somewhat Suitable**	**Unsuitable**
Dissolved Oxygen			
pH			
Specific Conductance			
Species Summary Rating:			
Ecologic Integrity - Overall Refugia Summary Rating:	**Category:** High Quality; High Potential; Potential; Low Quality; (Non-Anadromous; Contributing Functions; Data Limited)		
Comments:			

NI= No Information NR= Not Rated

Guiding Assessment Questions and Responses

The NCWAP assessment team developed lists of questions that they considered important to understanding and implementing watershed assessments. From those lists, a short list of guiding assessment questions evolved and was adopted to provide focus for the assessments and subsequent analyses, conclusions, and recommendations.

- 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?

These six questions focus the assessment procedures and data gathering within the individual disciplines and also provide direction for those areas of analyses that require more interagency, interdisciplinary syntheses, including the analysis of factors limiting anadromous salmonid production. The questions systematically progress from the relative status of the salmon and steelhead resource, to the focus of the NCWAP assessment effort, and lastly to the watershed components encountered directly by the fish - flow, water quality, nutrients, and instream habitat elements, including free passage at all life stages. The products delivered to streams by watershed processes and the influence of human activities on those processes shape these habitat elements. The watershed processes and human influences determine what factors might be limiting fishery production and what can be done to make improvements for the streams and fish.

The first two assessment questions point out the importance of salmonid population information for validating the assessment and predicting habitat conditions. In many watersheds, robust population data may not be available, implying a need for future monitoring efforts. In some watersheds, a need for additional physical habitat sampling may be indicated.

The third and fourth assessment questions consider the past and present conditions of the watersheds and their natural and man-caused watershed processes. The answers to these questions provide us with insights into the future of NCWAP watersheds and streams, and the feasibility of different management techniques for salmon and steelhead in each watershed.

The last two assessment questions consider factors directly encountered by fish that could be limiting salmonid production. These questions seek to identify opportunities and locations for prudent management practices and pro-active salmonid habitat improvement activities.

These six guiding assessment questions are presented and answered in the overall basin section and in each of the subbasin sections of the assessment report. They are also considered in the DFG Refugia Rating process at the subbasin and tributary scales. The responses become more specific as the assessment focuses from the course to the finer scales.

Albion Basin Profile and Synthesis

Looking upstream from the Estuary, 1863.

Introduction

English sea captain William Richardson came to the area in 1845 as part of a Mexican land grant. He named the area Albion because the coastal cliffs reminded him of his native England. The word Albion is an archaic name for England or Great Britain. Prior to European exploration and colonization of the area, migrant bands of Pomo Indians would frequent the area for abalone, salmon, and other food, and to gather important coastal plants.

There is little historic data regarding salmonid abundance and distribution in the Albion Basin. There are no quantitative data from which to estimate the historic population size of coho salmon and steelhead trout although coast wide trends indicate it is likely the populations of both species have decreased.

Most salmon and steelhead stocks on California's North Coast streams are depressed to levels which led to the listing of coho, Chinook, and steelhead under the authority of the Federal or State Endangered Species Acts and are a State listed species. Although undoubtedly impacted, the Albion River appears to sustain established coho salmon and steelhead trout populations. Coastal basins, like the Albion may be vital in protecting native stocks from extirpation and important to reestablishing viable populations as instream and upslope conditions improve.

Location and Area

The Albion River is located about 125 miles north of San Francisco in central Mendocino County, California. The basin encompasses approximately 43 square miles (27,520 acres) of Northern California's

Coast Range (Figure 11). Its headwaters are inland approximately 12 miles at an average elevation of 600 feet. Mathison Peak, at 1,030, feet is the highest point in the basin.

The Albion River has a large estuary with tidal influence extending as much as five miles. The mouth of the river is defined by a narrow opening along the south side of the bay, which is protected by rock headlands that in turn protect the bay by reducing long ocean swell and sea height. It also minimizes wave-induced longshore sediment transport, which causes the mouths of many California Rivers to close during low flow periods due to sand bar formation. The mouth is aligned so that it discharges at the point of lowest wave energy, which allows the stream to remain open to the sea year around.

The Albion Basin is primarily characterized by Coastal Belt Franciscan geology and dominated by bedrock. The distribution of steep slopes and landslides generally occurs as four parallel northwest oriented belts develop by the processes of faulting and folding. Regionally, the most prominent belts extend to the southeast along the unusually straight Flynn Creek and the linear Anderson Valley, both located in the Navarro Basin adjacent and south of the Albion Basin.

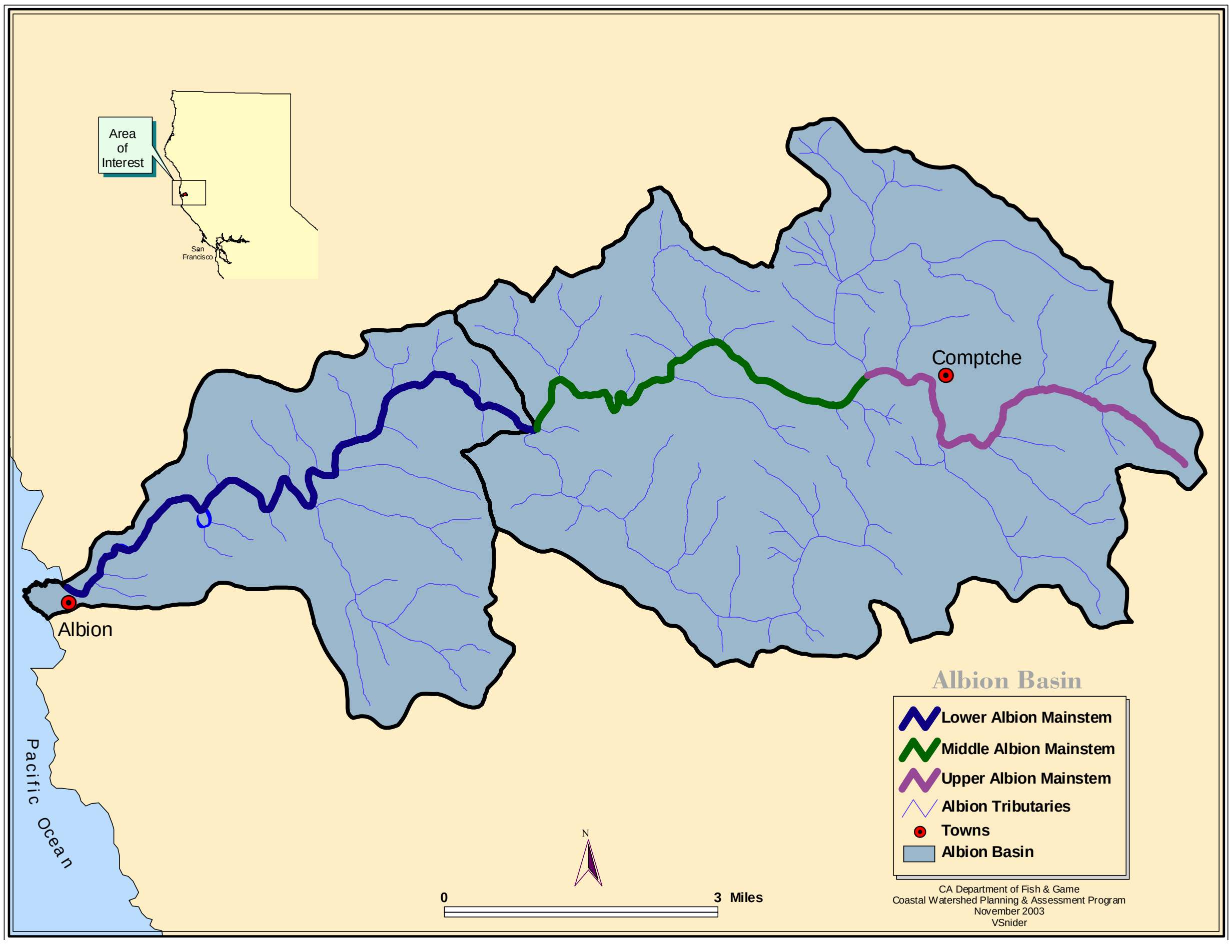


Figure 11. Albion River Basin, subbasins, and lower, middle, and upper mainstem.

Albion Subbasin Scale

For the purpose of this assessment, the Albion Basin has been divided into two subbasins based on four distinct planning watersheds as defined by CalWater 2.2a (Figure 11). The subbasins were designated based on geography, geology, climate patterns, and land use.

- The Coastal Subbasin is 13 square miles and contains the area downstream of the confluence with the South Fork and mainstem Albion. The estuary drains the Albion River to the Pacific Ocean.
- The Inland Subbasin is located from the confluence of the mainstem with the South Fork to the headwaters. It drains 30 square miles. Most of the subbasin is under private ownership and managed for timber harvest, ranching and rural residential. The predominant vegetation type is second growth redwood and Douglas fir.

The summary of the Albion Basin and subbasin characteristics includes area, type of land ownership, geology, vegetation, rainfall, range of elevation, fish habitat conditions, and known fish species (Table 8).

Table 8. Albion Basin and subbasin characteristics.

Category of Attribute	Coastal	Inland	Total
Square Miles	13	30	43
Acreage, Total	8,320	19,200	27,520
Private Land (Acres)	8,106	18,792	26,898
Public Land (Acres)	214	408	622
Principal Communities	Albion	Comptche	2
Predominant Geology	Coastal Franciscan	Coastal Franciscan	
Predominant Vegetation	Redwood/Douglas Fir	Redwood/Douglas Fir	
Predominant Land Use	Timber Production Rural Residential	Timber Production, Ranching, Rural Residential	
Rainfall (Inches)	~40	~50-55	~40-55
Miles of Blue Line Stream	8	21	29
Low Elevation (Feet)	Sea Level	40	0-40
High Elevation (Feet)	900	1,030	900-1030
Fish Habitat Condition	Possible unsuitable summer temps; Lack of cover;	Suitable water temps; Good canopy; lack of cover and spawning substrate;	
Fish Species	*Coho salmon* *Steelhead trout* *Chinook salmon* *Pink salmon* *Pacific lamprey* *Coast Range sculpin* *Prickly sculpin* *Threespine stickleback* *Arrow goby* *Bay pipefish* *Cabezon* *Rockfish species-juvenile* *English sole* *Jack smelt* *Monkeyface prickleback* *Northern anchovy* *Pacific herring* *Pacific sardine*	*Coho salmon* *Steelhead trout* *Chinook salmon* *Pink salmon* *Coast Range sculpin* *Prickly sculpin* *Threespine stickleback* *Pacific lamprey*	

	Pacific staghorn sculpin *Penpoint gunnel* *Pile surfperch* *Plainfin midshipman* *Rainbow surfperch* *Rubberlip surfperch* *Shiner surfperch* *Silverspot sculpin* *Speckled sanddab* *Starry flounder* *Surf smelt* *Striped surfperch* *Topsmelt* *Walleye surfperch*		

Climate

The Albion Basin has a Mediterranean climate characterized by a pattern of low-intensity rainfall in the winter and cool, dry summers with coastal fog. Mean annual precipitation is about 40 inches at Fort Bragg near the western margin of the basin and about 50-55 inches at Willits to the east. About 90% of the precipitation in this area falls between October and April, with the highest average precipitation in January. Snowfall in this basin is very rare and hydrologically insignificant.

Hydrology

The Albion River is a relatively small coastal river with a catchment area of approximately 43 square miles. The mainstem becomes a third order stream downstream from the confluence with Railroad Gulch in the Coastal Subbasin and all of the tributaries are first order and intermittent (Figure 12).

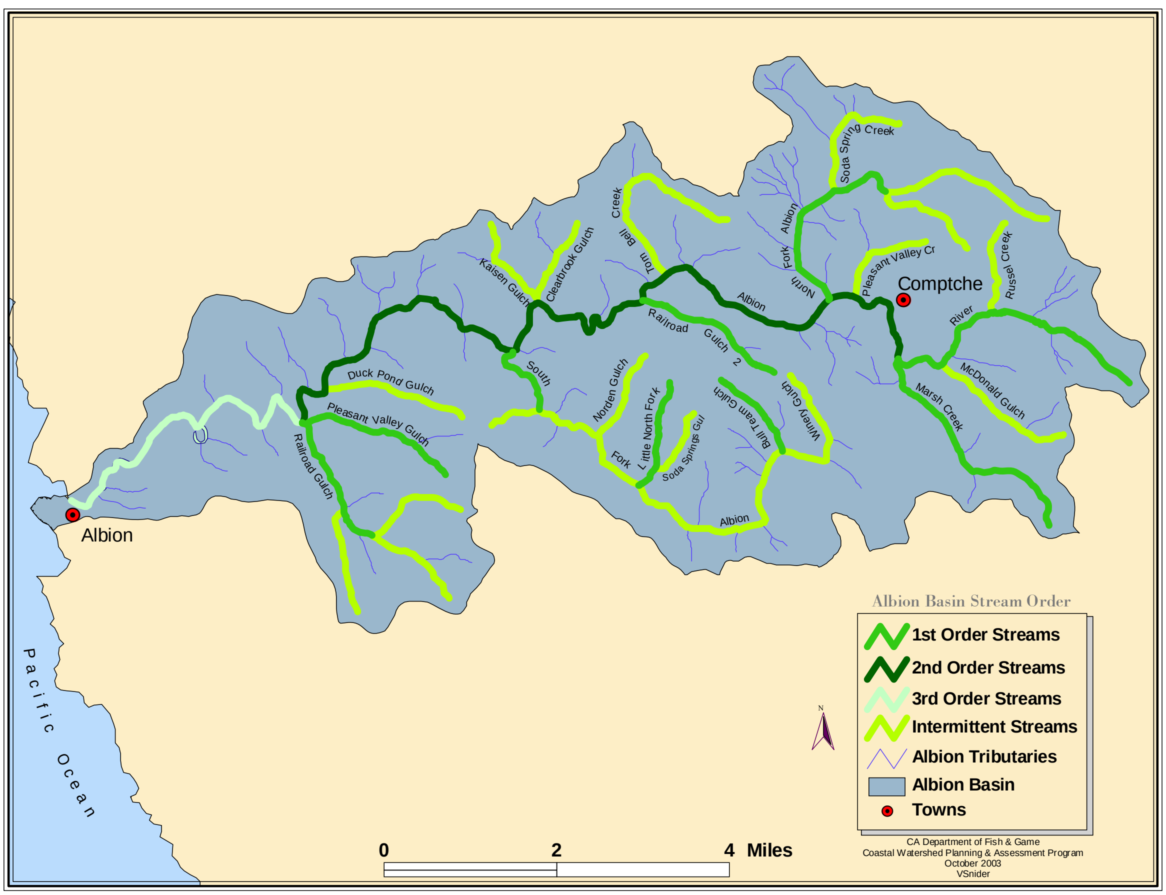


Figure 12. Stream order in the Albion Basin.

Mean Daily Discharge

Data from the middle reach of the Albion River (RM 9.2 to RM 15.2) show that high flows during storms are of very short duration, generally lasting only one to two days. Flows rapidly return to typical winter base flow within one week after peaks unless additional rain falls. Most significant runoff events occur in December and January with relatively few events occurring in November or March (GMA 2001).

Flow Duration

Analyses indicate that the Albion River at the USGS gage only exceeds 173 cubic feet per second (cfs) 10% of the time, or 36 days per year on average, while 50% of the time flows are below 13 cfs. Flows exceed 1045 cfs in the Albion River only 1% of the time, or 3.6 days per year on average. Relatively little bedload transport probably occurs below 400 cfs, thus most of the geomorphic work accomplished by the river occurs in less than 5% of the time, with most concentrated in the top 1% of the flows.

Flow conditions in the Albion Basin are surprisingly low. Almost 30% of the time, flow at the USGS gage site during the period of record was below 1 cfs, while about 5% of the time there was zero flow. Thus, for about 3 and 4 months out of every year, flows are less than 1 cfs in the upper portions of the basin.

A brief review of water rights permits indicates that diversions are currently permitted for at least 0.5 cfs in areas upstream of the site of the former USGS gage, mostly in the vicinity of Comptche and with a few diversions in the North Fork SW. Diversion purposes include irrigation and domestic uses. Low-flows may be a limiting factor in salmonid production in this upper portion of the watershed (GMA 2001). During summer months, naturally low flows may be further reduced by these diversions and may limit juvenile salmonid production in the upper portion of the watershed (GMA 2001).

Annual Runoff

The mean annual runoff for the 1952-1997 period was 16,316 acre-feet. Large volumes of runoff are often associated with both large flood years, and years with high annual precipitation. The two largest annual runoff years were 1983 and 1974, almost 20% larger than the 3rd largest runoff year, 1958 (Table 9). Three particularly dry periods stand out from the cumulative departure analysis, 1959-1964, 1976-1981, and 1987-1992 (GMA 2001).

Table 9. Mainstem Albion River downstream from Comptche annual runoff and cumulative departure from mean (after GMA 2001)

Ordered Annual Runoff and Cumulative Departure Analysis				**Ranked Annual Runoff**		
Water Year	Annual Runoff (ac-ft)	Cumulative Departure (ac-ft)		Rank	Water Year	(ac-ft)
1952	25,890	9,574		1	1983	38,083
1953	25,093	18,351		2	1974	38,033
1954	19,075	21,110		3	1958	31,195
1955	7,828	12,622		4	1982	27,777
1956	27,418	23,723		5	1995	27,549
1957	11,330	18,737		6	1956	27,418
1958	31,195	33,616		7	1952	25,890
1959	9,894	27,194		8	1993	25,233
1960	11,977	22,856		9	1953	25,093
1961	13,240	19,780		10	1969	24,711
1962	10,550	14,014		11	1986	21,828
1963	14,106	11,803		12	1996	20,870
1964	8,110	3,597		13	1997	20,702
1965	20,104	7,385		14	1971	20,592
1966	13,256	4,325		15	1970	20,494
1967	16,242	4,251		16	1975	20,259
1968	8,833	(3,233)		17	1965	20,104
1969	24,711	5,162		18	1954	19,075
1970	20,494	9,340		19	1978	18,793
1971	20,592	13,616		20	1973	18,155
1972	8,941	6,241		21	1984	17,418
1973	18,155	8,080		22	1967	16,242
1974	38,033	29,796		23	1980	16,129
1975	20,259	33,739		24	1963	14,106
1976	6,795	24,218		25	1989	13,593
1977	861	8,763		26	1966	13,256
1978	18,793	11,239		27	1961	13,240
1979	8,422	3,346		28	1960	11,977
1980	16,129	3,158		29	1957	11,330

Ordered Annual Runoff and Cumulative Departure Analysis				Ranked Annual Runoff		
Water Year	Annual Runoff (ac-ft)	Cumulative Departure (ac-ft)		Rank	Water Year	(ac-ft)
1981	7,317	(5,841)		30	1985	10,905
1982	27,777	5,620		31	1962	10,550
1983	38,083	27,387		32	1959	9,894
1984	17,418	28,489		33	1990	9,124
1985	10,905	23,077		34	1972	8,941
1986	21,828	28,589		35	1987	8,844
1987	8,844	21,117		36	1968	8,833
1988	8,517	13,318		37	1988	8,517
1989	13,593	10,595		38	1979	8,422
1990	9,124	3,403		39	1964	8,110
1991	4,722	(8,191)		40	1955	7,828
1992	6,227	(18,280)		41	1981	7,317
1993	25,233	(9,364)		42	1976	6,795
1994	5,514	(20,166)		43	1992	6,227
1995	27,549	(8,933)		44	1994	5,514
1996	20,870	(4,378)		45	1991	4,722
1997	20,702	7		46	1977	861

Mean 16316 Maximum 38083 Minimum 861

Notes: Annual runoff data derived from synthetic data except for Water Year 1962-1969.

Peak Discharge

The largest recorded peak discharge for the Albion River, according to USGS records occurred in January 1974, when the river crested at 4,430 cfs. Surprisingly, a major flood event that occurred in December 1964 across much of Northern California was not a very significant of event in the Albion Basin, where it ranked seventh out of 48.

Significant storm flows in the extended (synthetic and recorded) period of record occurred in the months of December and January (Table 10). The relationship between peak discharge and mean daily discharge on the day of the peak flow averaged 1.91 for the 8 years of record, with a range of 1.35-2.93, indicating the peak flow hydrographs are very sharp (GMA 2001).

Table 10. Mainstem Albion River downstream from Comptche former USGS gage #11468070 peak discharges and annual maximums ranked with computed recurrence intervals based on the Weibull formula (historic and synthetic data) (after GMA 2001).

Rank	Water Year*	Peak Discharge (cfs)	Probability	Recurrence Interval (Years)
1	1974	4430	0.020	49.00
2	1993	3336	0.041	24.50
3	1956	3174	0.061	16.33
4	1966	2390	0.082	12.25
5	1952	2294	0.102	9.80
6	1986	2236	0.122	8.17
7	1965	2050	0.143	7.00
8	1953	1856	0.163	6.13
9	1995	1740	0.184	5.44
10	1960	1711	0.204	4.90
11	1954	1667	0.224	4.45
12	1971	1650	0.245	4.08
13	1969	1620	0.265	3.77
14	1983	1588	0.286	3.50
15	1997	1588	0.306	3.27
16	1970	1500	0.327	3.06
17	1982	1464	0.347	2.88
18	1962	1310	0.387	2.72
19	1996	1207	0.388	2.58
20	1958	1165	0.408	2.45
21	1980	1146	0.429	2.33
22	1973	1140	0.449	2.23
23	1964	1090	0.489	2.13
24	1978	1010	0.490	2.04
25	1963	934	0.510	1.96
26	1967	840	0.531	1.88
27	1975	840	0.551	1.81

Rank	Water Year*	Peak Discharge (cfs)	Probability	Recurrence Interval (Years)
28	1998	837	0.571	1.75
29	1990	704	0.592	1.69
30	1985	672	0.612	1.63
31	1968	615	0.633	1.58
32	1959	598	0.653	1.53
33	1989	584	0.673	1.48
34	1961	558	0.694	1.44
35	1984	548	0.714	1.40
36	1957	517	0.735	1.36
37	1955	513	0.755	1.32
38	1988	496	0.776	1.29
39	1981	420	0.796	1.26
40	2001	352	0.816	1.23
41	1994	341	0.837	1.20
42	1972	340	0.857	1.17
43	1987	337	0.878	1.14
44	1979	330	0.898	1.11
45	1992	291	0.918	1.09
46	1991	216	0.939	1.07
47	1976	168	0.959	1.04
48	1977	18	0.980	1.02

*Historic USGS Data
GMA (2001) Data and Synthetic Data from peak correlation with Noyo River

Flood Frequency

A flood frequency analysis for available data in the Albion Basin indicated that the January 1974 (4430 cfs) flood would be about a 75-year event, while flows similar to December 1964 (2050 cfs) would be smaller than a 10-year event. The 2-year event is about 935 cfs (Table 11).

Table 11. Mainstream Albion River downstream from Comptche 3-parameter log-normal flood frequency analysis for the combined historic and synthetic 1952-2001 period of record (After GMA 2001).

Return Period (Years)	Computed Annual Maximum Peak Discharge (cfs)
2	935
5	1745
10	2375
20	3050
50	4010
100	4800

Historic Floods

Although the Albion Basin has a relatively short period of streamflow records, GMA (2001) was able to infer the dates of significant floods with regional data. Known large flood events in the region, many of which would also have occurred in the Albion Basin, have occurred in Water Years 1861, 1881, 1890, 1906, 1914, 1938, 1952, 1956, 1965, 1966, 1974, 1986, and 1993. The largest of these were likely to have been the 1861 and 1890 events, followed by the 1914, 1938, 1965, and 1974 events (not necessarily in that order by magnitude).

During the period of available historic and synthetic streamflow records, 1974 stands out as a year with a high peak flow and a long duration of these flows (Table 12). This is similar to the adjacent Noyo and Caspar Creek basins, but considerably different from the Ten Mile basin and most coastal watersheds farther north. In the Albion River basin, the January 1974 event appears to have been the most significant in the past 50, and perhaps 100, years (GMA 2001).

Table 12. Albion River sediment source analysis data for assessing event magnitude. Data sources sorted and ranked with top 20 values listed.

Annual Runoff			Peak Discharge			Annual Precipitation				1-Day Precipitation Intensity				
Albion River near Comptche			Albion River near Comptche			Willits (NCDC * gage 1 NE)		Fort Bragg (NCDC gage 5N)		Willits (NCDC gage 1 NE)			Fort Bragg (NCDC gage 5N)	
Rank	Water Year	Annual Runoff (ac-ft)	Rank	Water Year	Peak Discharge (cfs)	Water Year	Annual Precipitation (inches)	Water Year	Annual Precipitation (inches)	Rank	Water Year	1-Day Precipitation (Inches)	Water Year	1-Day Precipitation (Inches)
1	1983	38,083	1	1974	4,430	1958	92.82	1998	77.31	1	1965	8.80	1953	4.15
2	1974	38,033	2	1993	3,336	1904	89.30	1983	62.47	2	1938	7.61	1939	4.05
3	1958	31,195	3	1956	3,174	1938	87.62	1941	60.32	3	1906	7.07	1995	3.84
4	1982	27,777	4	1966	2,390	1983	86.48	1995	58.61	4	1914	6.50	1979	3.78
5	1995	27,549	5	1952	2,294	1879	85.46	1909	58.52	5	1947	6.50	1990	3.78
6	1956	27,418	6	1986	2,236	1890	84.51	1958	58.02	6	1960	6.46	1938	3.70
7	1952	25,890	7	1965	2,050	1974	76.39	1915	55.85	7	1974	5.90	1937	3.62
8	1993	25,233	8	1953	1,856	1998	75.93	1974	54.84	8	1952	5.87	1969	3.58
9	1953	25,093	9	1995	1,740	1995	74.44	1938	53.29	9	1943	5.78	1958	3.52
10	1969	24,711	10	1960	1.711	1956	72.71	1914	52.61	10	1951	5.50	1966	3.52
11	1986	21,828	11	1954	1,667	1982	72.33	1993	51.54	11	1986	5.50	1965	3.49
12	1996	20,870	12	1971	1,650	1941	71.88	1969	50.62	12	1963	5.40	1915	3.42
13	1997	20,702	13	1969	1,620	1909	71.13	1942	50.53	13	1956	5.33	1996	3.30
14	1971	20,592	14	1983	1,566	1895	70.28	1921	50.52	14	1969	5.21	1998	3.30
15	1970	20,494	15	1997	1,566	1894	68.57	1904	50.43	15	1940	5.20	1971	3.23
16	1975	20,259	16	1970	1,500	1925	66.23	1925	49.78	16	1990	5.20	1993	3.23
17	1965	20,104	17	1982	1,464	1942	65.99	1997	49.71	17	1913	5.13	1913	3.10
18	1954	19,075	18	1962	1,310	1969	65.69	1953	48.36	18	1966	5.10	1956	3.07
19	1978	18,793	19	1996	1,207	1986	65.61	1978	47.95	19	1979	5.06	1994	3.06
20	1973	18,155	20	1958	1,165	1978	65.56	1956	47.41	20	1932	5.05	1997	3.06

After GMA 2001. **Notes**: Annual runoff data is synthetic for all years except Water Year 1962-1969.
Peak discharge was obtained by correlation analysis except Water Years 1962-1969. Annual precipitation and intensity data from Goodridge (1999).
** NCDC = National Climatic Data Center*

Geology and Fluvial Geomorphology

The rocks of the Coastal Belt of the Franciscan Complex comprise the bedrock of the majority of the Albion Basin. These rocks are primarily composed of a sequence of slightly metamorphosed, interbedded, arkosic sandstone and interbedded siltstone and shale with minor pebble conglomerate and greenstone. The Coastal Belt Franciscan is typically a broken formation, characterized by shear zones, tight folding, faulting, and zones of relatively coherent bedded sections. The Coastal Belt Franciscan has been interpreted as trench and trench-slope deposits that accumulated in an east-dipping subduction zone along the western margin of North America during latest Cretaceous and early Tertiary time.

Fossils collected from Coastal Terrane rocks between Fort Bragg and Willits are Paleocene and Eocene in age (about 33 to 65 million years old). However, Late Cretaceous fossils (over 65 million years old) and fossils as young as Miocene (less than 23 million years old) have been found in the unit in other areas (Blake and Jones 1974; Ochard 1978).

Uplift of the Coast Ranges in central Mendocino County began about 8 million years ago when the East Pacific Rise migrated to the subduction zone, forming the San Andreas Fault System (Engebretson et al. 1985; McLaughlin et al. 1994). During advances of Pleistocene glaciers, beginning about 2 million years ago, ocean levels dropped. The falling level of the sea, combined with mountain uplift formed steep coastal bluffs, resulting in topographic steps.

During interglacial periods when sea level was rising, broad expanses of quartz sand and small amounts of gravel accumulated in the surf zone on wave cut platforms. This interaction of tectonic uplift and fluctuating sea level developed a sequence of at least seven marine terraces along the Mendocino County coast (Kilbourne 1986; Lajoie 1986). Poor fertility, an iron-rich hardpan layer and associated soil wetness restricts vegetation growth and has created pygmy forests in some areas with marine terrace deposits.

During the late Wisconsin glaciation, 15,000 years ago, the sea level was about 400 feet (120 meters) lower than it is today (Grove and Niemi 1999). River gradients were greatly steepened from the combined effects of the low sea level and the concurrent uplift. This resulted in deep incisions of river canyons through marine terraces and underlying Coastal Terrane bedrock. The rise in sea level, resulting from the melting of the continental glaciers, flooded the mouths of the coastal rivers and formed estuaries (such as the Albion River estuary). These areas are now zones of deposition and have slowed the rate of river downcutting. The effects of this are most pronounced near the ocean where the flooding has occurred. Farther inland, the rise in sea level has had less effect on stream channel incision.

Sedimentary sequences, for the most part, represent turbidite and other mass-flow type deposits. In the western portion of the watershed, volcanic rocks form several northwest/southeast trending lenses that are aligned with a regional structural grain of the northern Coast Ranges. The volcanic rocks are predominantly composed of greenstone. Some of the sediments that accumulated in the Quaternary remain as terrace and alluvial deposits perched atop the Coastal Belt bedrock.

Physiographically, the watershed can be divided into three sub-regions; a western, central, and eastern (Figure 13). These sub-regions are elongate and oriented northwesterly along the general structural grain of the northern Coast Ranges. In the western sub-region, marine terraces are distinctive. In the central sub-region, large relic landslides are distinctive. In the eastern sub-region, broad areas of older Quaternary alluvium are distinctive.

The watershed has experienced a variety of natural disturbances and land uses that have likely impacted sediment conditions in the stream channels. This suite of natural disturbances has occurred over the last century and includes earthquakes, flooding, droughts, and decadal climate shifts.

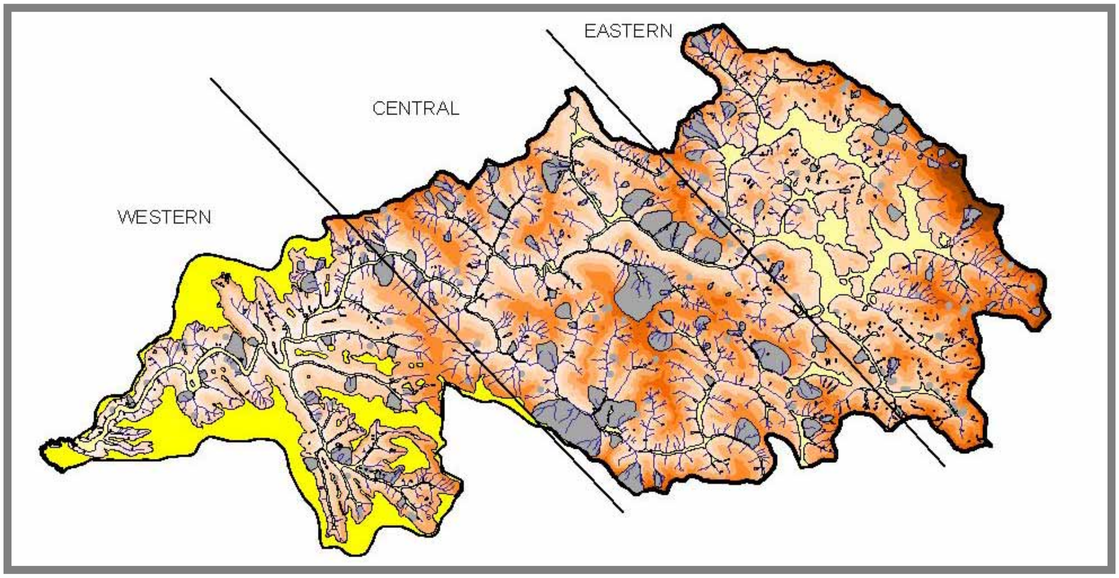


Figure 13. Geologic sub-regions of the Albion Basin.

The western sub-region consists largely of broad marine terraces and associated deposits (yellow areas) that have been deeply incised. In the central sub-region, very large dormant landslides (gray areas) are prominent features formed along a northwest oriented structural grain. In the eastern sub-region, older unconsolidated alluvium (pale yellow areas) forms broad low lying areas. The shades of orange denote elevation. Darker shades indicate higher elevations.

Western Subregion

The western sub-region consists of a series of marine terraces formed at various times during the Pleistocene (11,000- 1,100,000 years ago) when the land was periodically uplifted above sea level. Marine terrace deposits make up approximately 40% of the land surface. The oldest recognized and uppermost marine terrace is the broadest, extending inland from the coast at least five miles.

The elevation of the terrace ranges approximately between 550 and 600 feet (Schoenherr, 1992; Kilbourne, 1986). Much of the watershed lies below this elevation. The sea level dropped over 400 feet worldwide during the Wisconsin Glaciation (approximately 15,000 years ago). In response to the fall of base level, the lower Albion River and its tributaries incised deep, steep canyons with inner gorges into the emergent terraces. Largely due to the steepness of canyon walls, these areas have been a locus of historically active landsliding. The sea level rose again at the end of the Wisconsin Glaciation and drowned the lower Albion River.

The mainstem Albion River throughout this sub-region is exclusively estuarine, flanked with intertidal mudflats and saltwater marshes (Figure 14). In 1964, a tsunami consisting of four or five surges reportedly roared over a mile upriver and scoured out the river mouth (Lander et al. 1993).

Aerial photo interpretation of fluvial features in 1984 and 2000 imagery found little change in the estuary geomorphology. Bars and sediment deposits mapped from year 2000 imagery are mainly those lying at or slightly above high tide and are covered with grasses, reeds, and salt tolerant vegetation.

Mapping of fluvial features in the estuary from 1984 imagery identified a greater number of bars and areas of sediment deposition due primarily to their exposure at low tide. These lower channel features were observed during reconnaissance field studies in June 2003; they typically lack significant vegetation and are characteristic of tidal mud flats. At low tide, the lower Albion is reduced to a central channel thread that appears to be fairly stable, varying little from 1984 to 2000 and is in a similar location in 1936 imagery (Figure 15).

The main low-flow channel is mostly Rosgen type E5 and E6 channels with occasional sections of type C where the channel shallows. Submerged logs are typically in these shallower sections and may trap sediment. Remnants of the abandoned Albion railroad pilings and mill piers are common in the estuary. Occasionally, buried sections of railroad works are visible in the channel banks. Tributaries to the estuary typically have a broad flood plain deposit of fine sediment and E-type channels join with the mainstem after meandering through marshy areas.

Figure 14. Mud flats and salt tolerant grasses are typical along the lower river.

Figure 15. Low tide exposes a single thread channel flanked by mud flats.

Figure 16. Estuarine vegetation seems to effectively stabilize some of the stored sediment in the lower river.

Central Subregion

The central sub-region consists of steep ground that includes highly dissected debris slide slopes and inner gorges. This sub-region lacks the well-defined marine terraces; however many of the ridgelines are flat topped at approximately the same elevation (600 feet) of the uppermost marine terrace. Most of the sub-region lies below that elevation.

A northwest oriented zone of structural deformation extending from Cloverdale to Fort Bragg transects the watershed and defines this roughly seven-mile wide sub-region. Within this zone, bedrock has been tightly folded and faulted. During the mid to late 1800's, a moderate earthquake (estimated magnitude of M5 to 6) originated from within this zone about two miles south of the Albion Basin. In 1898, a strong earthquake (M 6.7) originated near Fort Bragg (Toppozada et al. 2000) and damaged railroad tracks in the Albion Basin. Those nearby earthquakes and the distant San Francisco earthquake in 1906 triggered landsliding throughout the watershed.

The largest (hundreds of acres) dormant rockslides of the watershed are abundant in this sub-region flanking mainly the northwest oriented slopes above the North and South Forks of the Albion River. Large deep-seated landslides comprise approximately 15% of the land surface. Historically active landsliding has occurred more frequently in the vicinity of the large dormant rockslides than in other portions of the watershed.

The river transects variably silty, sandy, and gravelly deposits formed on older river (strath) terraces. However, much of the stream substrate is either bedrock or relatively thin accumulations of sediment. Occasional coarse gravelly substrate is observed, particularly adjacent to relict gravel terrace deposits and toes of deep-seated landslides. A notable area of gravel and cobble deposits is found on the South Fork Albion at the confluence with the mainstem. For approximately 4.5 miles upstream from the confluence, channel substrate is noticeably coarser than in the mainstem. The source of this sediment may be the both the remnant channel terraces and/or the deep-seated landslides that bound the lower channel.

Much of the riparian area in this sub-region consists of closed canopies that in aerial photos masked fluvial features. Estimates of Rosgen channel type for the blueline streams were made from topography and aerial photo mapping. However, reconnaissance field studies as well as more detailed fluvial studies by Mendocino Redwood Company suggest that the extent of Rosgen F, G, and E type channels is underestimated by our reconnaissance channel typing.

Photo mapping of channel fluvial features suggesting sediment sources or depositions showed a reduction in the number and total length of mapped features (such as sediment bars) from 1984 to 2000. From the 1984 imagery, 49 channel reaches in the blueline channels above the estuary were mapped with total length of approximately 4.3 miles. In the year 2000, only 16 channel features were mapped above the estuary with a total length of approximately 1.4 miles. This represents an approximate 57% reduction in length of mapped channel showing features suggesting sediment sources or sediment deposition. This probably indicates a net loss of sediment. However, a portion of the apparent reduction may be due in part to decreased detection because of an increase in channel canopy cover. More detailed discussion of channel conditions is given in Mendocino Redwood Company's assessment of their Albion holdings.

Figure 17. Coarse spawning gravels at the mouth of the South Fork Albion.

Figure 18. Closed canopy in the South Fork Albion.

The nearly closed canopy above this reach of the South Fork is typical in the Central sub-region and likely reduced the effectiveness of aerial photo based mapping to detect sediment bars such as these.

Eastern Subregion

The eastern sub-region consists of more mature (low relief and rounded) terrain with rolling grasslands. Large blocks of relatively resistant Franciscan greenstone underlie the divide and form steep slopes.

Elevations along the watershed divide range from 1,000 to 1,400 feet; however, most of the sub-region lies below the elevation of 600 feet and consists of unconsolidated Quaternary sediments, probably bay or estuarine deposits (Kilbourne 1983c).

The Quaternary sediments comprise approximately 15% of the land surface. Streams are moderately incised. Largely due to the steepness of the slopes along the divide, those slopes have been the locus of historically active landsliding.

Most of the channel features mapped from aerial photos that lie outside of the estuary were found in the eastern sub-region. In 1984, approximately one-half of the 4.4 miles of fluvial features mapped outside the estuary were in the eastern sub-region. In 2000, the total length of fluvial features mapped outside of the estuary was significantly reduced to approximately 1.4 miles. Approximately 83 % of these features were in the eastern sub-region. In the eastern sub-region, these mapped stream features occur primarily within the older alluvial unit, Qoal. This may be due, in part, to better detection of the incised and wide channel features in the grassland versus timberland.

Quaternary uplift and the lack of cementation of this unit are also likely contributors to its erodability. Mapped fluvial features in both 1984 and 2000 were found mostly in two reaches; the upper 8,000 feet of Tom Bell Creek and an unnamed, 1.5 mile long tributary draining northwest into the North Fork Albion at approximately one third mile upstream from Soda Spring.

Figure 19. Eastern sub-region low relief landscape.

This area is typical of the low relief landscape that formed atop a perched older alluvium in the eastern sub-region.

Vegetation

Current Vegetation

Prior to European settlement, mostly old growth redwood and coniferous forests dominated the Albion Basin. Maps of the area were created in the early 1860s by the Department of the Interior General Lands Office (GLO). The GLO maps are not well detailed. However, they offer descriptions of the terrain and vegetation. The Coastal Subbasin is designated as "coastal prairie with the remainder generally designated as mountainous and unfit for cultivation." The Inland Subbasin area is labeled "broken and hilly with redwood and fir timber, and unfit for cultivation with a few small prairies" while within this area the South Fork is labeled "rolling land and well timbered."

GLO maps also detailed routes, buildings, and splash dams located in the Albion Basin. The Albion Mill, a few roads (one near the present Albion Ridge Road), a wagon road to the Little River Camp, and "Heezer's Trail from Mendocino to Ukiah" are shown. These routes have changed little in 143 years.

Across the entire watershed, conifer forest covers 59% of the watershed, mixed conifer and hardwood forestland occupy 30% of the watershed, and hardwood forests occupy 4%. Annual grasslands occupy 6% of the watershed. All other vegetation types occupy the remainder of the watershed (Table 13). Comparison of 1993 and 2000 data show that shrub vegetation type is a result of re-colonization of harvested areas. Some changes in vegetation composition and distribution have occurred since timber harvest began in the mid 1800s.

Table 13. Albion vegetation types.

Albion Basin Vegetation Types		
Vegetation Type	**Total Acreage**	**Percent of Total Area (%)**
Conifer	16,137	59
Mixed Forest	8,152	30
Grasslands	1,614	6
Hardwood	1,215	4
Shrub	147	1
Barren	81	<1
Agricultural	27	<1
Water	117	<1

Sixty-one percent of the watershed is covered by trees that have an average size of 12-24 inches diameter at breast height (DBH) (

Figure 20, Table 14). Stands that average greater than 24-inch DBH trees cover 25% of the area, pole-sized trees cover another 3% 6-11 inches DBH, and sapling-sized trees 1-6 DBH. The accuracy assessment indicates that overall accuracy is about 69% but that average tree size is overestimated.

Table 14. Albion Basin tree size.

Albion Basin Tree Sizes		
Tree Size	**Total Acreage**	**Percent of Total Area (%)**
Sapling (1-6 inches)	874	3
Pole (6-11 inches)	866	3
Small Tree (11-24 inches)	16,837	61
Medium/Large Tree (>24 inches)	6,927	25
Other	1,997	7

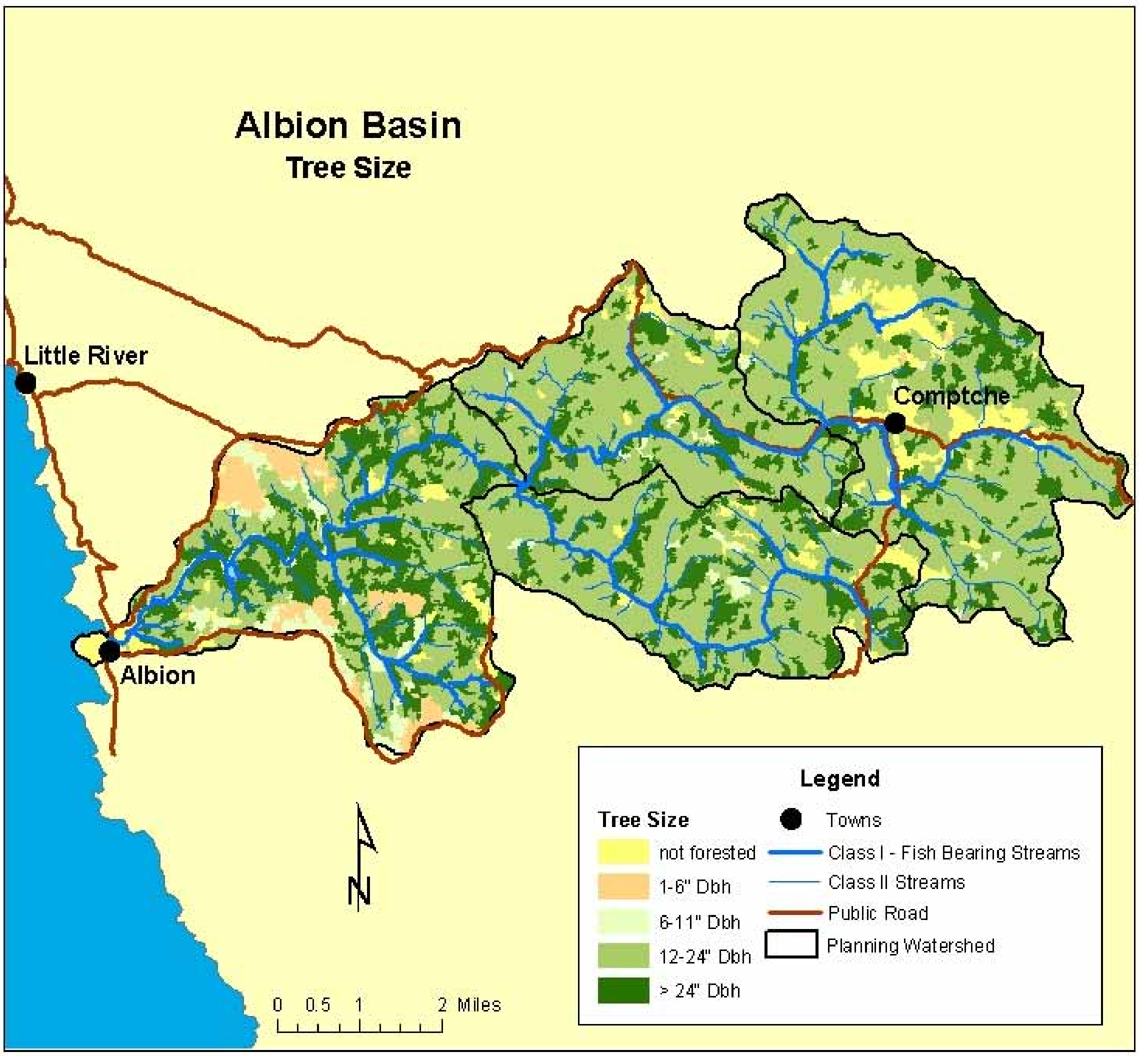


Figure 20. Tree size in the Albion Basin.

Fire History

Native Americans used fire as a land management tool. Specific practices and fire history is not known in the Albion Basin but information is available from research on State property twenty miles to the north. Fire history data reported for Jackson Demonstration State Forest (JDSF) indicate that redwood forests on the Mendocino Coast had a fire frequency of about 6 to 20 years during the previous two to four hundred years prior to European settlement (Brown 1999). Including surface fires, this burning interval is higher than previously reported in some studies, in part because of the tendency of redwood to obscure fire scarring. There was no clear trend of increasing fire frequency or intensity with increased distance inland from the coast. Most fires occurred during the late season of September through November when coastal fog generally dissipates and forest conditions are driest. These fires are thought to have been primarily started by Native Americans as a land management tool, clearing brush and providing a desirable landscape for their activities. As in the Albion Basin, JDSF wildfire activity ceased in the 1930's following the establishment of well-organized fire suppression forces.

The only wildfire in CDF records is the 1931 Comptche wildfire. Apparently ignited from slash piles and driven by high temperatures, low relative humidity, and strong northerly winds, the fire swept across the eastern half of the watershed. There were actually several heads of the fire as residents frantically set back fires to protect their property and families (Escola, pers. Comm.). Totaling about 29,600 acres, the fire destroyed homes and livelihoods, incinerated standing timber, the remains of the old log dams, railroad ties, trestles, and abandoned logging camps. Approximately 28,850 acres or 39% of the Albion basin was burned (Figure 21).

Current vegetation is the result of fire history in addition to timber harvesting and grazing. As noted earlier, fire was a natural and frequent visitor to the Albion watershed. Interviews of Albion Basin residents indicated that many ranchers burned the same areas every two or three years to keep the poison oak and brush down and logging slash was routinely burned after the original harvests. Management plans submitted by private landowners often state that range burning ceased in the 1960s.

Fire severity and hazard models generated by the California Department of Forestry and Fire Protection indicate that fires have the ability to burn through large acreages and to severely damage both upslope and riparian areas. The fire hazard map is strongly influenced by the current vegetation and proximity of residential housing. The towns of Albion and Comptche have active volunteer fire departments.

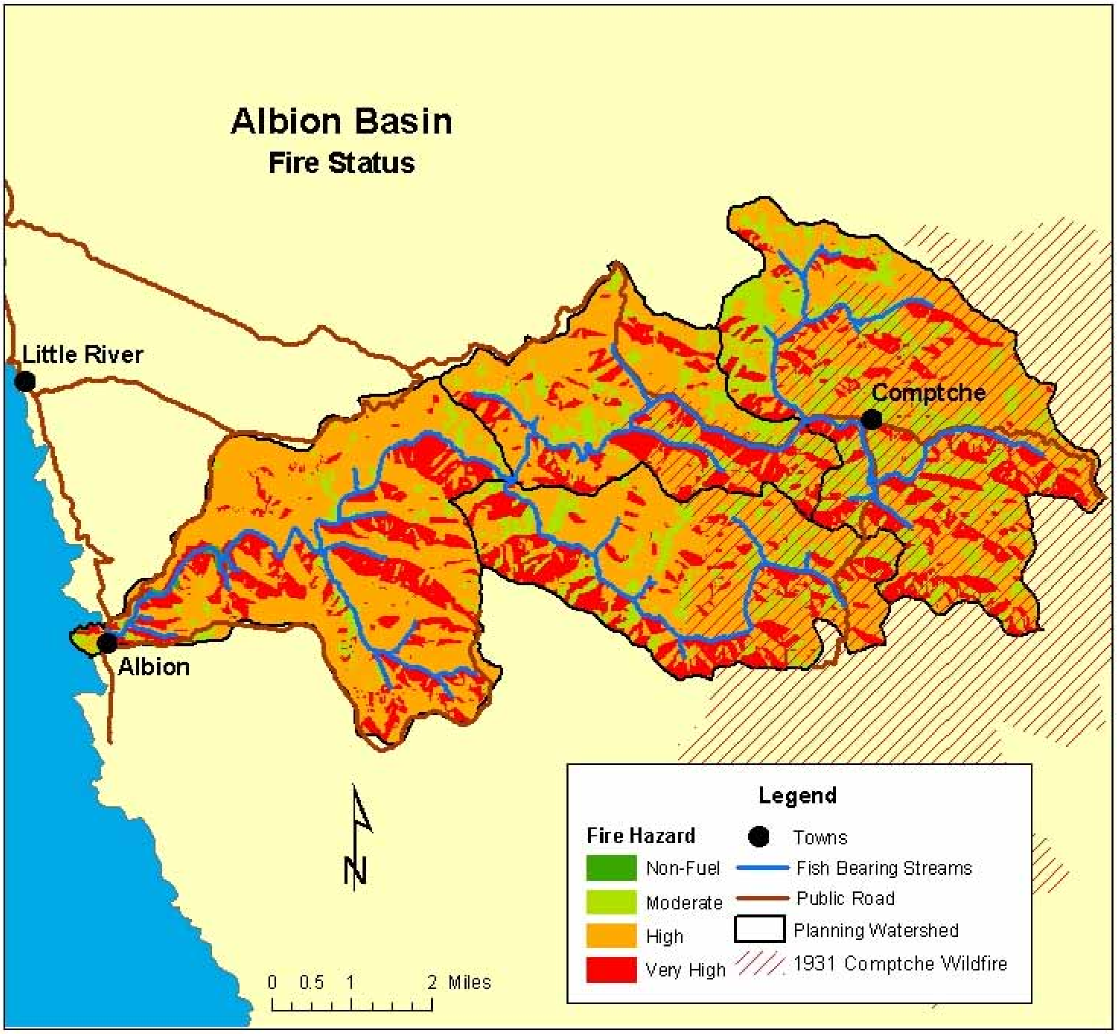


Figure 21. Albion Basin fire status.

Population

There are two post office towns in the Albion Basin: Comptche near the headwaters and Albion near the mouth. The total Albion Basin resident population in the year 2000 census was estimated at about 912 people. The Coastal Subbasin is inhabited by 612 people, with the remainder residing in the Inland Subbasin.

Land Use

Land use from 1840 to 1923

The Albion Basin was occupied by Pomo Native Americans when the first European settlers arrived in the early 1840s. Fire was used extensively for better access to native vegetation, such as oak trees, which provided acorns, a major food source. Fire also reduced oak pests, allowed for the growth of nutritious forage for game, and provided better visibility and mobility for hunting and gathering.

The Pomo had two villages located near present day Comptche and an extensive trail system which linked Ukiah and the coast. The terrain and general routes in and out of the Albion Basin have changed little since the Pomo inhabited the area.

Logging in the Albion Basin began in 1852, about the same time as in adjacent streams along the Mendocino Coast. Early logging endeavors used water to transport logs to mills along rivers that had enough water at high tide to allow flat-bottomed schooners capable of hauling 80-150,000 feet of lumber to load directly at mill docks. Larger schooners remained in the small harbor and were loaded by barges.

The first recorded Mill in the Albion Basin was constructed in 1852. This mill was a tidal-powered redwood mill located in the area of the oxbow lagoon at the confluence of lower Railroad Gulch. Fills were built to power this mill, although it is not know if the fills were extended across the oxbow lagoon or the mainstem of the Albion River. This mill was destroyed the winter after it was first constructed (MCHS 1978).

In 1854, new owners purchased the remains of the mill and timber and built a steam-powered mill at the mouth of the Albion River. This mill produced around 4,000 board feet of lumber a day, but the following year an additional saw increased production to 15,000 board feet a day – the equivalent of one large old-growth tree. Logs from large trees were dropped into the river and floated down to the millpond, which was formed by a simply constructed wooden structure.

By 1864, timber harvest had moved slowly eastward into the Inland Subbasin. Logs had to be transported to the mill with water impounded by splash dams (Figure 22). Families that settled in the Comptche area described five splash dams located in the Inland Subbasin. However, maps show only two: one located on the South Fork, just downstream of the Little North Fork, and a second one located on the North Fork, about one quart of a mile above the confluence with the mainstem Albion River (GLO 1867).

Figure 22. Example of a splash dam with water being released on the neighboring Big River.

In 1867, a newly constructed mill had a production rate of 35,000 board feet of lumber a day (Figure 23). Between 1881 and 1891, a railroad was constructed linking the lower estuary with Comptche and Keene's Summit, and also the ridge between the South Fork Albion and North Fork Navarro. Railroad building was very expensive, as all the tools had to be shipped to Albion via the transcontinental railroad and then delivered by horse drawn carriage, or shipped by sailing vessel around Cape Horn. Investing in and completing such a venture supports the idea that timber production seemed endless and lucrative, especially when looking north to the Big River and south to the Navarro River Basins.

Harvesting moved Inland with the construction of the railroad (Figure 24). The historic towns of Melbourne and Gunari were settled in the 1870s and 80s and both grew during the early logging boom into logging camps for the hundreds of men working in the woods and hundreds of families in the late 1890s and early 1900s (Thompson 1973). These towns flourishing during the boom days have long disappeared with some remaining as locations on USGS topographic maps. The South Fork area was cleared by 1900 after the construction of the railroad up to Keene's Summit.

In 1907, the Southern Pacific Railroad purchased the Albion Lumber Company in order to produce redwood ties for the construction of the Southern Pacific Railroad of Mexico. The purchase included mills, stores, cabins and houses, rail lines, rail rolling stock, land and timber. The 20,622 acres of land, obtained with the purchase, included parts of the Big, Navarro, and Albion Basins. The entire purchase included an estimated 374,521,000 board feet of standing timber, averaging 18,000 board feet per acre.

Figure 23. The Albion flats circa early 1900s.

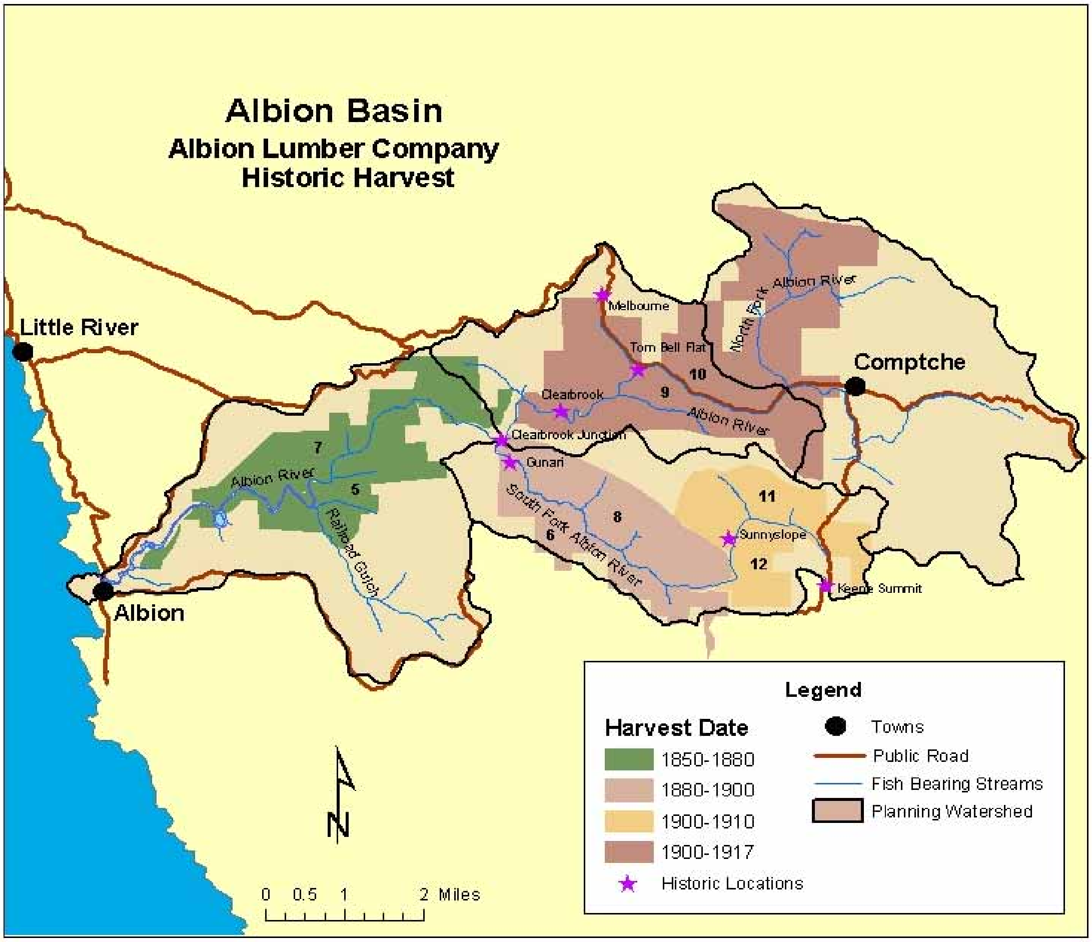


Figure 24. Early logging history of the Albion Basin.

1923 to the Present

By 1923, almost all of the remaining timber in the Albion had been harvested. Thus logging related activities in the Albion Basin ceased as the remaining timber was probably too small to be profitable. The "Albion Lumber Company, Survey of Second Growth Map" (1923) shows the number of trees varied from a low of just over one per acre to a high of about eight trees per acre. A large proportion of the Basin had been clear-cut logged and burned. By 1928, the last log was cut at the Albion Mill. When it closed, Albion became a ghost town (Levene 1977). In 1931, the timberlands were transferred to the Southern Pacific Land Company.

After timber harvest ended, the Albion Lumber Company/Southern Pacific Land Company tried to create cattle grazing land by burning brushy hillsides immediately after logging and later sowing with rye grass. Agricultural activities, including ranching, were not particularly profitable and denuded lands were difficult to be made profitable. The Coastal Subbasin was used to graze cattle, managed for future second growth, protected from fire and other damage, with the plan to achieve perpetual yield.

When prices for scrap metal increased in 1937, the tracks along the mainline, spurs, sidings, and other tracks were dismantled and the rolling stock sold (Borden 1961). Little evidence remains of the extensive railroad which transported timber for almost fifty years.

Masonite Corporation bought the land from Southern Pacific Land Company in 1948. In 1982, the Albion lands were placed into a Masonite liquidation company called the Timber Realization Company, and sold to Louisiana-Pacific Corporation (L-P) in 1986. In 1998, the Mendocino Redwoods Company, LLC bought all of L-P's holdings in Mendocino and Sonoma Counties lying west of Highway 101. The acquisition consisted of 235,000 acres that included the Albion Basin properties.

Aerial photographs were examined from 1936 through 2000. The 1936 photos show regeneration of the cleared areas to forests that were harvested between 1850 and 1927. By 1947, the area burnt by the Comptche fire in 1931 was regenerating and covered by blue blossom (*Ceanothus sp.*). A few small logging sites are also visible and some areas were re-burned by ranchers to keep pasturelands from reverting to shrub and forestland. More recent aerial photos show increasing road density and canopy recovery in most riparian areas with time.

From 1952- 2002, almost 25,000 of the 27,520 total acres in the Basin were re-harvested (Table 15 and Figure 25). Silviculture methods included clear-cut, seed tree, selection, and alternative prescription. Yarding was accomplished via tractor, cable, and helicopter.

Table 15. Timber harvest activities recorded from 1952-1989 in the Albion Basin.

Year Harvested	Acres clear-cut and seed tree seed step	Acres Prep step, removal step, or alternative prescriptions	Acres Selection or Commercial thinned	Total Acres harvested	Percent of Basin Harvested	Percentage cable or helicopter yarded
~1952	2,023	0	0	2,023	7	0
1973-1987	596	1,004	3,459	5,059	18	29
1987-1989	521	1,132	273	1,926	7	49
1990-1999	1,307	4,263	4,744	10,314	37	43
2000-2002	309	783	3,288	4,380	16	40
Open 2002	0	403	3048	3451	13	36
Total by System	2,733	7,585	14,512	24,830	90	

Figure 25. Recent timber harvesting locations in the Albion Basin.

As of March 2003, about 2,900 acres of the Albion Basin are in approved Non-Industrial Timber Management Plans (NTMP) and another 886 acres are pending approval, for a total of about 14% of the land base. There are over 20 separate NTMPs approved, some involving more than one land owner. Many of the NTMPs have not had any operations yet because of a drop in redwood prices.

Current land ownership consists of a few large landowners actively practicing timber management and numerous small landowners who intermittently practice timber management and/or live on their property (Figure 26).

The largest landowner is the MRC, nearly 54% of the basin. MRC completed a Watershed Analysis (1999) for their land using the Washington State methodology, followed by annual updates detailing monitoring results and road improvement activities. MRC is presently in consultation with various Federal and State agencies in the process of developing a draft Habitat Conservation Plan.

The next two largest landowners are both timber companies that own about 600 acres each. The seventh largest landowner, California State Parks, recently acquired almost 400 acres as part of the Big River State Park purchase from the Hawthorne Timber Company.

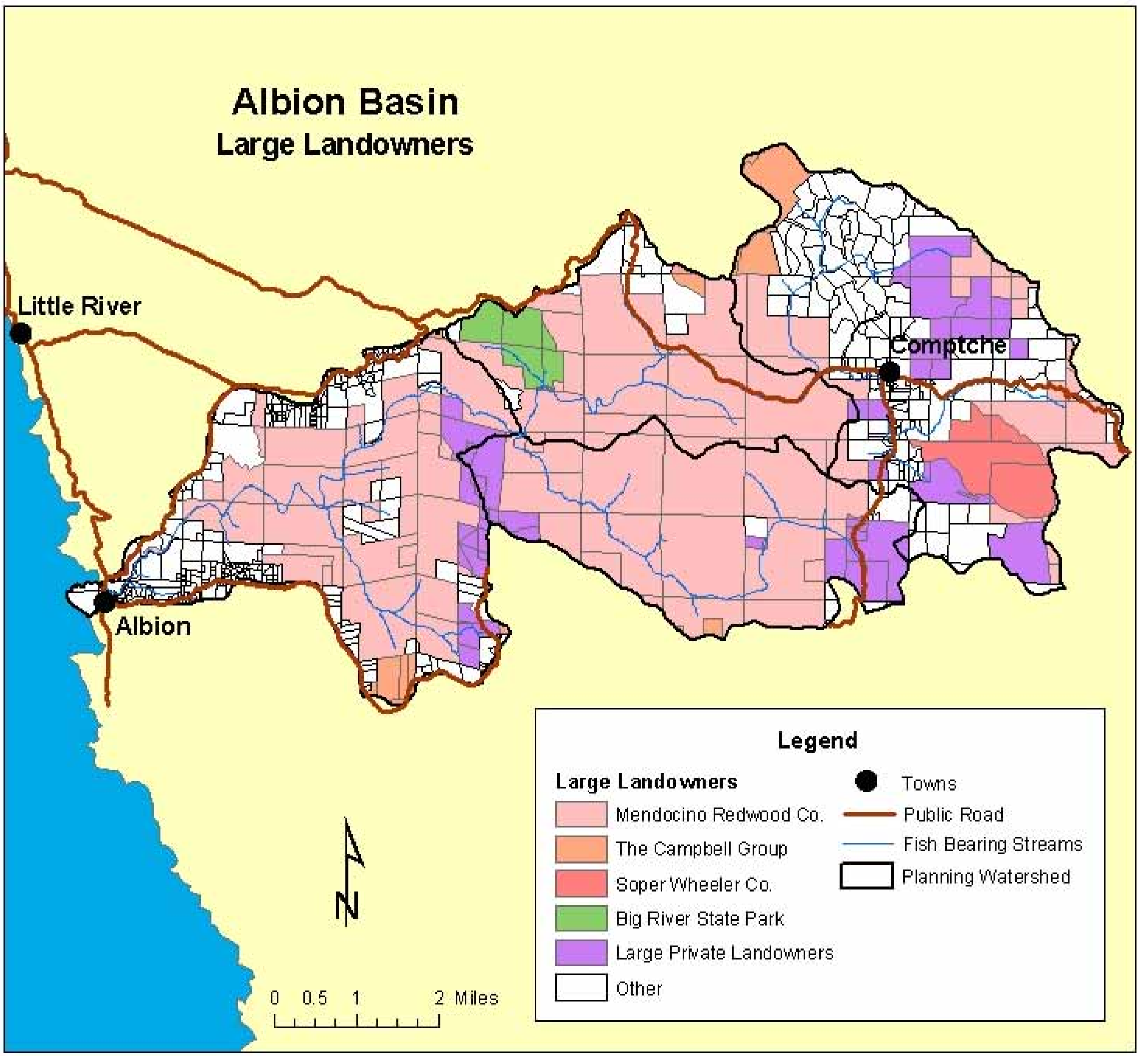


Figure 26. Ownership pattern of the Albion Basin.

Due to limitations in the available database, land ownership in the basin was divided into five categories: timber production zone, other forestland, rangeland, public/non-profit, and residential/miscellaneous (Table 16). The public/non-profit category consists predominately of California State Parks (398 acres) and the Nature Conservancy (188 acres). Conservation and maintenance or establishment of pre-European vegetation is the primary objective and recreation is a secondary objective of these public landowners. Another 36 acres are held by the County, school and fire districts, and the Comptche Grange.

Table 16. General ownership categories in 2002 in the Albion Basin.

Subbasin	Timber Production Zone	Other Forestland	Range-land	Public/ Non-Profit	Residential and Miscellaneous	Total
Coastal	5,575	455	184	214	1,637	8,065
Inland	14,686	1,522	558	408	2,277	19,451
Basin wide:	20,261	1,977	742	622	3,914	27,516

Within the entire basin, Timber Production Zone (TPZ) land occupies 69% of the total acreage, other forestland 13%, rangeland 4%, public ownership 3%, and 11% in the residential and miscellaneous category. Industrial timberland owners collectively own about 56% of the acres.

Roads

The first roads were originally wagon transportation routes following the Pomo Native American Indian trails that evolved to become modern day County roads. Most new roads where built near and/or in streams, on top of old railroad beds which accessed timber and rural housing with little regard to the geology. Road density in the Albion is in the high range when compared to other North Coast Basins (Table 17 and Figure 27).

Table 17. Road mileage and density in the Albion Basin.

Subbasin	Miles of road	$Miles^2$ of land	Road Density miles per $mile^2$
Coastal	123	12.61	9.8
Inland	273	30.37	9.0
Albion Basin	396	42.98	9.2

Figure 27. Roads in the Albion Basin.

The Albion Total Maximum Daily Load (TMDL) lists roads as a major source of human-related sediment (EPA 2001). The development and later abandonment of roads and skid trails coupled with the highly unstable geology of the North Coast are known to contribute sediment to streams. It appears that less skid trails were developed in the Albion compared to other basins in the area because most of the basin's trees were not yet large enough to be re-harvested when the tractor-yarding era began in Mendocino County.

Many North Coast Basins have programs underway to evaluate and properly repair and/or abandon roads and to educate landowners on effective ways to maintain their driveways. Mendocino County is currently engaged in a road program that is assessing, evaluating, and implementing projects that include re-aligning drainage-structures to reduce road-related erosion, and replacing culverts that cause barriers to fish migration. MRC (1999) mapped active and abandoned roads visible in the 1987 and 1996 aerial photos. Additional mapping and field surveys of mass wasting locations and sediment delivery to streams associated with individual road segments were quantified. Surface erosion estimates were also generated based on both field observations and local adjustment to standardized equations.

Based on the results of this analysis, road locations have been specified as high priority for maintenance/abandonment and remedial actions are prescribed for both existing and new road construction. The active road management program undertaken by the MRC, the large percentage of small landowners with NTMPs that require long-term analysis and mitigation of road problems, and the number of THPs incorporating road improvements in recent years are all helping to improve road standards throughout the basin. Many of the residential landowners and others have improved or expressed an interest in improving their roads.

Slope classes in relation to stream class can assist landowners in determining suitability for new road construction, locating road areas of concern, and pinpointing roads for decommissioning (Figure 28).

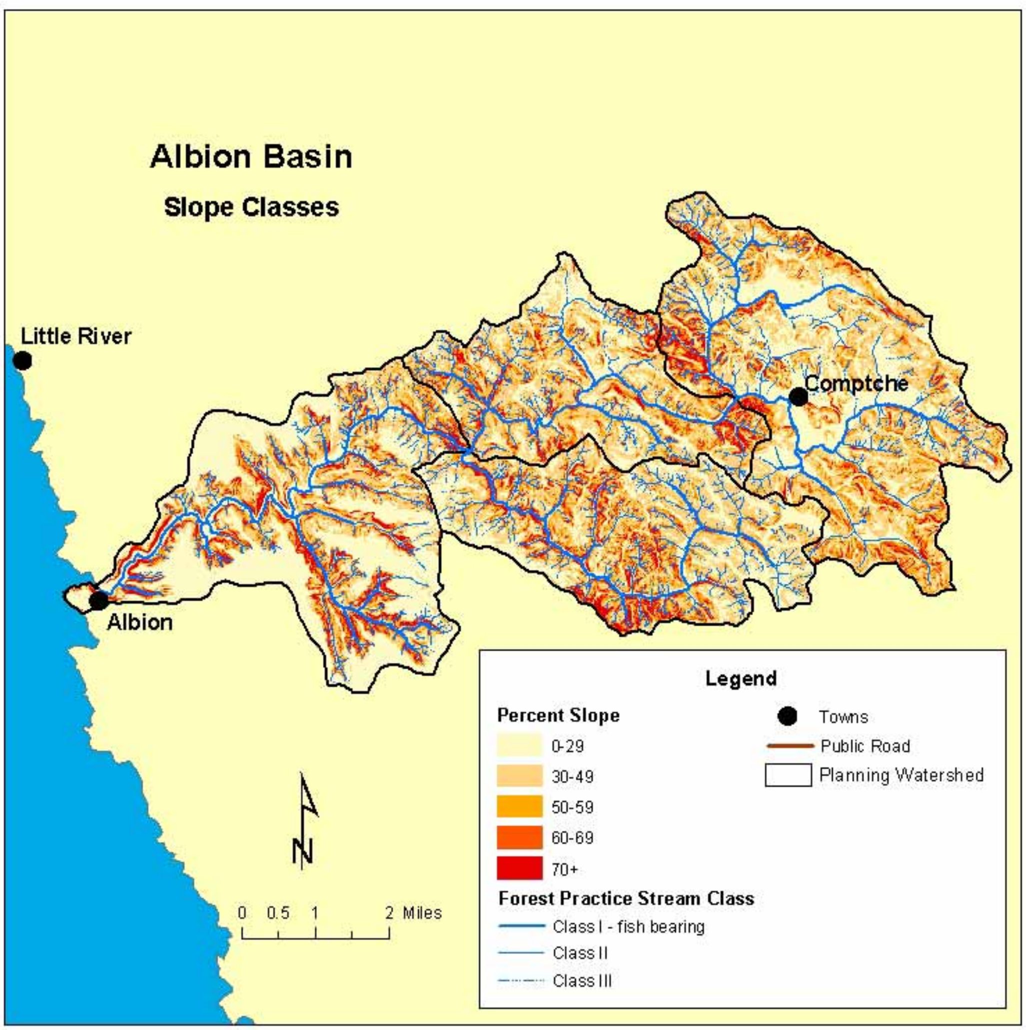


Figure 28. Slope classes integrated with stream class, Albion Basin.

Areas where roads cross slopes over 60% and where roads cross or are within 5 feet of the stream are shown in Figure 29. The road/stream intersections are areas of relatively high risk of sediment delivery to streams although the actual condition of the crossings is not implied here. Since these locations are based on data that is mapped at a scale of 1:24,000, one should regard them as an approximation of the general conditions in the basin. In addition, all roads mapped from 1936-2000 aerial photographs are included. Miles of road as a function of slope in each subbasin are shown in

Table 18.

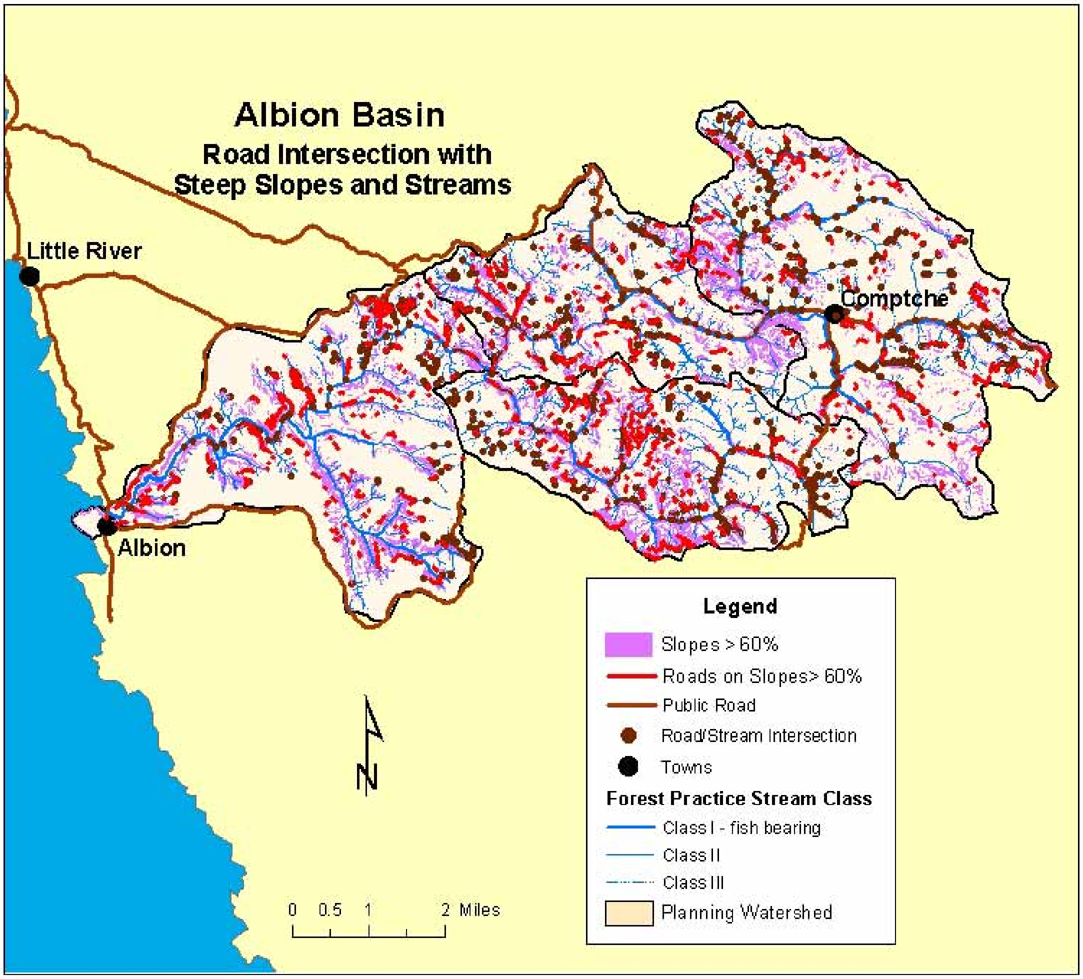


Figure 29. Road crossings on slopes over 60%.

Table 18: Acres and road miles as a function of slope in the Albion Basin.

Area	Slope Classes	Number of Acres	Miles of Road
Albion Basin	0 - 29%	10,885	235.9
	30 - 49%	9,604	108.1
	50 - 59%	3,439	27.7
	60 - 69%	1,922	13.3
	>70%	1,660	10.6
Total		**27,509**	**395.5**
Coastal	0 - 29%	4,142	84.3
	30 - 49%	1,986	23.6
	50 - 59%	809	7.2
	60 - 69%	534	4.2
	>70%	600	3.6
Total		8,070	122.9
Inland	0 - 29%	6,743	151.5
	30 - 49%	7,618	23.8
	50 - 59%	2,631	84.6
	60 - 69%	1,388	9.1
	>70%	1,059	7.0
Total		19,439	273

Human disturbance and land-use practices increases sediment delivered to streams above non-disturbance background levels. The actual quantities of sediment delivered to stream systems and the relative importance of various inputs is subject to much professional hypotheses and modeling efforts. Research in the Caspar watershed in Jackson Demonstration State Forest in Mendocino County and in Redwood National Park in Humboldt County are two of the few long-term data collection and analysis efforts in the coastal redwood forest type (CDF Appendix).

The MRC (1999) watershed analysis on their property, attributed road-associated mass wasting to 37% of the total mass-wasting sediments delivered to streams over the last 20 years (190 tons/sq. mile/yr.). MRC attributed surface erosion from roads to be 116 tons/sq. mile/year and surface erosion from skid trails to range from 6 to 45 tons/sq. mile/year. Graham Matthews & Associates (U.S. EPA 2001) performed a preliminary sediment budget for EPA and found land use related sediment production during the time period from 1921-2000 in excess of calculated natural background levels. GMA also explicitly noted differences in results with MRC arising from differences in methodology (CDF Appendix).

Water Quality

The Albion River is on a list of water bodies for impairment or the threat of impairment by sediment as required by Section 303(d) of the Clean Water Act. The 303(d) list describes water bodies that do not fully support all beneficial uses or are not meeting water quality objectives, and the pollutants for each water body that impair water quality. Because of the listing of the Albion River, the US EPA has developed numeric targets for sediment and established sediment allocations expressed as a total maximum daily load (TMDL) in tons of sediment per square mile per year. At the time of this assessment, the Regional Water Board is developing an implementation plan for the Albion River TMDL for sediment.

At the time of the listing, sediment was judged to be affecting the cold (COLD) water fishery and associated beneficial uses as described in the Basin Plan (RWQCB 2001). Nearly all aspects of the cold-water fishery are affected by sediment pollution, including the migration, spawning and reproduction, and early development of cold-water fish such as coho and Chinook salmon, and steelhead trout.

Other beneficial uses of water in the Basin Plan for the Albion River include municipal, industrial, ground water recharge, water contact and non-contact recreation, commercial and sport fishing, wildlife habitat and those plant and animal populations associated with terrestrial ecosystems, as well as similar attributes in estuarine ecosystems. Aquaculture in the Albion River is also considered a potential beneficial use in the Basin Plan.

The Basin Plan also describes specific water quality objectives for the Albion River that include limitations for dissolved oxygen and pH or hydrogen ion concentration. If exceedences to specific water quality objectives are discovered during data gathering, collection, and analysis, they will be elucidated and addressed in pertinent report sections.

Key Regional Water Board findings for the Albion River and some of its tributaries are summarized below. Refer to the Water Quality Appendix for a more detailed discussion.

Water Temperature

Water temperatures at monitoring locations in the Albion Basin are generally supportive of salmonids with the exception of the reach of the lower mainstem Albion River in the estuary below Railroad Gulch, and possibly other areas in the estuary. Temperature data from the estuary, tributaries in the Inland subbasin, and the upper mainstem Albion above Marsh Creek are limited.

The team proposed suitability-unsuitability ranges for maximum weekly average temperatures (MWATs), and a single value for maximum temperature, referred to in the following discussions, as affecting salmonid viability, growth, and habitat fitness.

MWATs at mainstem Albion River monitoring sites ranged from fully suitable to somewhat suitable, with the exception of the reach below Railroad Gulch in the estuary, and one year of data samples just above Duck Pond Gulch that were unsuitable (Table 19). MWATs at monitoring locations on the tributaries ranged from fully suitable to moderately suitable. Seasonal maximum temperatures at mainstem Albion sites were generally below the 75°F lethal threshold for salmonids, with the exception of two years of data from the mainstem below Railroad Gulch in the estuary, and one year on the mainstem above the South Fork which were unsuitable. Monitoring locations on tributaries in this basin all had fully suitable seasonal maximum temperatures.

Table 19. MWATs and seasonal maximum temperature in the Albion Basin.

Watercourse	Number of Sites	Number of Samples	Period of Record	MWAT Range (°F)	Seasonal Maximum Range (°F)
Coastal Subbasin					
Mainstem Albion River	3	11	1994-2001	59-74	60-77
Tributaries	7	11	2000-2002	55-62	57-71
Inland Subbasin					
Mainstem Albion River	3	17	1992-2002	59-63	62-75
Tributaries	7	21	1992-2002	56	57-67

MWATs: fully suitable (50-60°F), moderately suitable (61-62°F), somewhat suitable (63°F), undetermined (between somewhat suitable and somewhat unsuitable) (64°F), somewhat unsuitable (65-66°F), moderately unsuitable (67°F), unsuitable (>68°F). Seasonal Maximum Temperature: >75°F lethal.

Estuary grab sample temperature profiles conducted in 1997 from ten sample sites yielded water temperatures ranging from 44-75°F (Maahs and Cannata 1998). With such limited data, it is difficult to determine whether estuary conditions are suitable for salmonids. Water temperatures of 65°F or greater have been determined to be unsuitable to some degree for salmonids, with temperatures over 75°F being lethal without escape to cooler locations. The water temperatures at all 10 stations monitored include readings over 65°F. When these grab samples are viewed in conjunction with continuous data from the estuary site below Railroad Gulch, it appears that summer temperature conditions in estuary are in the unsuitable range for salmonids. Further monitoring should be performed to fully evaluate the impact of water temperatures on salmonids.

Sediment

Instream substrate data were limited in this basin. Sites were generally monitored for one or two years, precluding any analysis of temporal trends in sediment size, movement, and accumulation (

Table 20).

Table 20. Summary of in-stream sediment related parameters in the Albion Basin.

Parameter	Number of Sites	Period of Record	Sample Range (Min-Max)	Notes
Coastal Subbasin				
Mainstem Albion River				
D50 (mm)	4	1998, 2000-2001	9-28	Some cross-sections were not necessarily located on riffles in the streambed. Three different methods were used to collect data (Water Quality Appendix).
Bulk Sediment Sample Median Percent <0.85 mm (%)	2	1998 & 2001	7-9	Samples were dry-sieved and the percentage of sediment was calculated on a by-weight basis.
Bulk Sediment Sample Median Percent <6.3/6.4 mm (%)	2	1998 & 2001	30-31	Samples were dry-sieved and the percentage of sediment was calculated on a by-weight basis.
Bulk Sediment Sample 50th percentile of particles (mm)	2	1998 & 2001	11.8-21.8	25th percentile ranged from 3.6-5.1. 75th percentile ranged from 22.6-66.
Median Streambed Gravel Permeability (cm/hr)	1	1998 & 2000	4656.5-27174.5	Median percent survival associated with these permeabilities are 42% to 68%, per McBain and Trush (2000).
Tributaries				
D50 (mm)	6	1998	10-20	Some cross-sections were not necessarily located on riffles in the streambed. Three different methods were used to collect data (Water Quality Appendix).
Inland Subbasin				
Mainstem Albion River				
D50 (mm)	6	1998, 2000-2001	8-55	Some cross-sections were not necessarily located on riffles in the streambed. Three different methods were used to collect data (Water Quality Appendix).
Bulk Sediment Sample Median Percent <0.85 mm (%)	5	1998 & 2001	1-11	Samples were dry-sieved and the percentage of sediment was calculated on a by-weight basis.
Bulk Sediment Sample Median Percent <6.3/6.4 mm (%)	5	1998 & 2001	4.5-59.8	Samples were dry-sieved and the percentage of sediment was calculated on a by-weight basis.
Bulk Sediment Sample 50th percentile of particles (mm)	5	1998 & 2001	3.7-39.7	25th percentile ranged from 1.8-22.4. 75th percentile ranged from 19.1-75.4.
Median Streambed Gravel Permeability (cm/hr)	2	1998 & 2000	1017-17519.5	Median percent survival associated with these permeabilities are 20% to 62%, per McBain and Trush (2000).
Tributaries				
D50 (mm)	10	1998, 2000-2001	7-55	Some cross-sections were not necessarily located on riffles in the streambed. Three different methods were used to collect data (Water Quality Appendix).
Bulk Sediment Sample Median Percent <0.85 mm (%)	3	1998 & 2001	6.5-8	Samples were dry-sieved and the percentage of sediment was calculated on a by-weight basis.
Bulk Sediment Sample Median Percent <6.3/6.4 mm (%)	3	1998 & 2001	23.3-31.5	Samples were dry-sieved and the percentage of sediment was calculated on a by-weight basis.
Bulk Sediment Sample 50th percentile of particles (mm)	3	1998 & 2001	15.3-33.3	25th percentile ranged from 4.4-7.4. 75th percentile ranged from 46.7-80.6.
V*	1	2001	0.2	V* was determined from sampling one pool within the reach.
Median Streambed Gravel Permeability (cm/hr)	1	1998 & 2000	121-796	Median percent survival associated with these permeabilities are 0% to 17%, per McBain and Trush (2000).

Results from instream substrate conditions at monitoring sites in the Albion Basin showed:

- The median percent of fine sediment at pool-tailouts (from McNeil data) in the mainstem and tributary locations monitored were below TMDL targets for fine sediment of <0.85mm, and therefore suitability cannot be determined at the present time. However, the median percent of fine sediment of <6.3/6.4mm ranged from below to well above the target value. Exceedences of the target for fines of <6.4mm (unsuitable) occurred in samples taken from:
    - The mainstem below the South Fork Albion in 1998 and 2001;
    - The mainstem below East Railroad Gulch in 1998;
    - The mainstem below the North Fork Albion in 2001;
    - The mainstem above the South Fork;
    - The South Fork above the mainstem confluence in 1998.
- Levels of fines at these last two sites were under target values in 2001. According to the Water Quality Appendix, the targets for fine sediment of <0.85mm and <6.4mm in the Albion River TMDL are for volumetric (wet sieved) data, and therefore are not directly comparable to these

gravimetric (dry sieved) data. However, when material is wet sieved, water retained on the particles (particularly those <4mm) becomes significant (Shirazi, Seim, and Lewis 1979). Therefore, the percent finer than values calculated from dry sieved data would be lower than the values from wet sieved material. As a result, dry sieve data results that are equal to or above the TMDL target are unsuitable. Data that are below TMDL targets are stated as such, although no conclusive determination can be made about their suitability for salmonids. A wet to dry conversion factor is needed for the Albion River Basin so that these data may be directly compared to the targets laid forth in the Albion River TMDL.

- The percent of residual fine sediment in the pool monitored on the South Fork Albion (V*) was suitable for salmonids.
- The median size of particles in riffles (D50) was small to moderate at monitoring locations in this basin.
- Generally, at bulk sediment sampling locations, 50% of the particles were in the lower quarter of the 6-102 mm range utilized by salmonids for spawning. An exception was the lower North Fork and mainstem above the North Fork, where approximately 50% of the particles were in the lower third of the range. This indicates a lack of larger particles at these locations.
- Median substrate permeabilities at monitoring locations on the mainstem Albion ranged from 1017-27174.5 cm/hr and as a result, the calculated median percent of fry surviving to emergence per McBain and Trush (2000) ranged from 42-68%. Median permeabilities at the South Fork Albion site were much lower, ranging from 121-796 cm/hr. The associated median percent survival to emergence from these permeability values were, 0-17%. These quality ratings reflect the conditions at pool-tailouts before a spawning fish has worked the gravels into a redd.

  Survival of salmonid eggs within a redd is dependent upon multiple factors including temperature, dissolved oxygen, flow, fine sediment, and permeability. Additionally not all eggs laid in a redd are viable, and some will naturally die and disintegrate. If the survival to emergence value calculated from permeability is low, this is an indication that even if the other factors affecting survival of eggs and embryos are suitable there may still be low emergence. Conversely, if estimated survival values based on permeabilities are high, it indicates permeability is suitable although the other factors influencing survival may affect actual emergence values.

Water Chemistry

Comparison of historic versus present conditions in the Albion basin was limited by the lack of data (Table 21).

Historic data from the Regional Water Board were available from the estuary and lower portion of the mainstem Albion River in the Coastal Subbasin. Conditions at these sites appear to have been suitable for salmonids with respect to pH and specific conductance, although dissolved oxygen in the mainstem Albion River above the estuary may have been an issue. Additionally, other parameters violated various human health and freshwater standards, although no marine aquatic life standards were violated.

Current data from the Regional Water Board and Maahs and Cannata (1998) allow for the assumption that conditions at present monitoring locations are suitable with respect to specific conductance and pH, although dissolved oxygen could be an issue in the upper Estuary and the North Fork Albion. These assumptions are by no means conclusive and are based on information that is limited both spatially and temporally.

Table 21. Water chemistry parameters in the Albion Basin.

Parameter Name	Total Number Samples	Number Detect Samples	Period of Record	Detect Samples, Range (Min-Max)	Criteria	Number Samples Violating Criteria	Criteria Source
Coastal Subbasin							
Mainstem Albion River1							
Dissolved Oxygen (mg/L)	37	37	1976, 1977, 1985, 1988, 1997, 2001	2.3-12.0	≥7.0	21 (14H)	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
pH (Standard Units)	34	34	1976, 1977,	6.7-8.0	6.5-8.5	0	Basin Plan, Table 3-1, p 3-7.00

Parameter Name	Total Number Samples	Number Detect Samples	Period of Record	Detect Samples, Range (Min-Max)	Criteria	Number Samples Violating Criteria	Criteria Source
			1985- 1988, 2001				(RWQCB 2001)
Specific Conductance (umhos/cm)	33	33	1976, 1977, 1985- 1988, 2001	160-74000	none	-	-
Boron, Total (ug/L as B)	6	6	1987-1988	530-3600	630	5	US EPA IRIS one-in-a-million incremental cancer risk estimate for drinking water. See Marshack (2000).
Chloride, Total in Water (mg/L)	9	9	1985-1988	3000-19000	250	9	California Secondary MCL for drinking water. See Marshack (2000).
Iron, Total (ug/L as Fe)	11	10	1976, 1977, 1987, 1988, 2001	30-1400	300	5, (3H)	California Secondary MCL for drinking water. See Marshack (2000).
					1000	2 (H)	US EPA National Recommended Ambient Water Quality Criteria for Freshwater Aquatic Life Protection. See Marshack (2000).
Sodium, Total (mg/L as Na)	6	6	1987-1988	1800-9800	2	6	US EPA Drinking Water Health Advisory or SNARL. See Marshack (2000).
Sulfate, Total (mg/L as SO4)	9	9	1985-1988	380-2900	250	9	California Secondary MCL for drinking water. See Marshack (2000).
Inland Subbasin							
Mainstem Albion River[2]							
Dissolved Oxygen (mg/L)	3	3	2001	9.4-11.3	≥7.0	0	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
pH (Standard Units)	3	3	2001	7.1-8.2	6.5-8.5	0	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
Specific Conductance (umhos/cm)	3	3	2001	175-319	none	-	-
Tributaries[2,3]							
Dissolved Oxygen, Datalogger (mg/L)	263	263	2001	6.8-7.6	≥7.0	13	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
pH, Datalogger (Standard Units)	263	263	2001	7.9-8.1	6.5-8.5	0	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
Specific Conductance, Datalogger (umhos/cm)	263	263	2001	601-606	none	-	-

H = Historic
[1]Samples were collected at four sites for each parameter except dissolved oxygen, which was collected at seven site.
[2]Samples were collected at one site.
[3]Samples taken at one site every 15 minutes for a period of three days with a continuous datalogger.

Aquatic/Riparian Conditions

Riparian vegetation across the entire Albion Basin (Table 22) can be broadly described within the context of Calveg2000 data. Stream classifications are based on Forest Practice Rules applicable to timber harvesting activities. Class I streams contain fish at least seasonally, while Class II streams contain non-fish species such as frogs and aquatic salamanders as well as insects that could drift and provide food for fish. Class III streams are considered transport streams that deliver beneficial uses, such as cool, clear water to Class IIs or Class Is. Likewise, a Class III could also transport or deliver substances that would degrade downstream beneficial uses such as sediment, chemicals, or if it flowed late in the season, unnaturally and undesirably warm water. The riparian widths used in Table 22 correspond to the standard Watercourse and Lake Protection Zone (WLPZ) widths defined in the Forest Practice rules. These zones have specific regulatory prescriptions, including silvicultural and yarding method practices, intended to protect the beneficial uses of streams and to provide late seral wildlife habitat on land managed for commercial timber production.

Class I stream length is estimated at about 44 miles. Riparian vegetation acreage is based on a WLPZ width of 150 feet on each side of the stream. The resulting 1,641 acres is about 6% of the total watershed acreage. There are a higher percentage of conifers in this near-stream area and 5% more tree type vegetation than in the overall basin. The water designation is all within the estuary. About 20% of the herbaceous category is in the estuary WLPZ and the remainder is in the upper third of the basin. A larger percentage (34%) of the Class I WLPZ zone contains stands that average 24" diameter trees than in the watershed as a whole (25%).

Class II stream length is estimated at 63 miles. In recent years, many streams previously classified as Class IIIs are now considered Class IIs. The length of Class II streams in the Albion watershed is an underestimate but the large percentage of the watershed under plan in the last 10 years probably minimizes the discrepancy. Riparian vegetation acreage is based on a WLPZ width of 75 feet on each side of the stream. The resulting 1,087 acres is about 4% of the total watershed acreage. There are a higher percentage of conifers in this near-stream area and 5% more tree type vegetation than in the overall watershed. A larger percentage (32%) of the Class II WLPZ zone contains stands that average 24" diameter trees than in the watershed as a whole (25%).

Class III streams have a total length of about 146 miles. Current protection measures for these streams consist of equipment exclusion zones except where approved on a site-specific basis. Vegetation types and sizes are based on land use practices that do not treat Class IIIs differently than the surrounding area.

Table 22. Riparian vegetation characteristics of the Albion Basin.

Class I Stream Vegetation	Total Acreage	Percent of Total Area
Conifer	1,114	68
Mixed Forest	25	2
Grassland	75	5
Hardwood	362	22
Shrub	9	>1
Urban	5	>1
Water	52	3
Total	**1,642**	**100**
Class I Stream Tree Size	**Total Acreage**	**Percent of Total Area**
Sapling (1-6")	6	>1
Pole (6-11")	20	1
Small Tree (11-24")	917	56
Medium/Large Tree (>24")	558	34
Other	141	9
Class II Stream Vegetation	**Total Acreage**	**Percent of Total Area**
Conifer	714	66
Mixed Forest	50	5
Grassland	34	3
Hardwood	285	26
Shrub	4	>1
Other	>1	>1
Total	**1087**	**100**
Class II Stream Tree Size	**Total Acreage**	**Percent of Total Area**
Sapling (1-6")	5	>1
Pole (6-11")	23	2
Small Tree (11-24")	669	62
Medium/Large Tree (>24")	351	32
Other	39	4

Fish Habitat Relationships

Coho salmon and steelhead trout are the predominant anadromous fish using the waterways of the Albion River, incidental Chinook salmon and pink salmon also use the river. Habitat requirements of salmon and steelhead in the freshwater environment vary to some degree for each species but are generally similar. These species specific needs are in the CDFG Appendix.

Historic Conditions

In 1961, 1962, 1966, and 1979, CDFG conducted stream surveys on various tributaries in the Albion Basin. Coho salmon and steelhead trout were present, with coho recorded as most abundant. However, differences in behavior and habitat preference between steelhead and coho make the latter more easily observed. The results of the historic stream surveys are not quantitative and cannot be used in comparative analyses with current habitat inventories. The data from these stream surveys provide a snapshot of the conditions at the time of the survey (Table 23). Terms such as excellent, good, fair, and poor were based upon the opinion of the biologist or scientific aide conducting the survey.

Table 23. Summary of stream surveys conducted in the Albion Basin in the 1960s.

Tributary	Date Surveyed	General Comments	Fish Comments	Habitat Comments	Barrier Comments	Management Recommendations
Albion River	5,6,9 and 10 Oct.1961	Appears to be a fair to poor spawning and nursery area	Coho salmon, steelhead trout, and rainbow trout present	Approximately 10-30% spawning area, primarily in the headwaters and in isolated areas throughout of the drainage; Pool: Riffle ratio 5:1; Shelter considered adequate	One natural bedrock falls; 98 log jams recorded	Manage as a steelhead trout and/ coho salmon spawning and nursery stream. Remove jams and barriers.
	8 July 1966	Water diversions at Comptche are a contributing to salmon being stranded due to low or lack of flows.	Coho salmon and steelhead trout observed	Spawning gravels poor above Comptche and good below	34 log jams; 2 major log jams	Maintain for coho salmon and steelhead trout spawning and nursery;
	Jan. & Feb. 1979	None	Coho salmon spawners 100+	Spawning areas in the upper South Fork in good condition	Several log jams	
Kaisen Gulch	27 Aug. 1962	None	Steelhead trout	Spawning areas below the forks, none above the forks; Pool: Riffle ratio 10:90; Good shelter	No barriers observed	Manage as a steelhead trout spawning and nursery stream; Remove jam and slash.
Morrison Gulch	9 Oct. 1961	No flow in the stream; This stream has received extensive damage from logging and fire in the past	No fish observed	Spawning areas considered almost non-existent; No pool development due to lack of flow; Shelter is considered abundant	No barriers	Decide if should be restored
Railroad Gulch	6 Oct. 1961	Entire stream dry except for isolated pools	No fish observed	Spawning areas poor; Shelter good,	No passage barriers; 10 log jams recorded	Check to see if used for spawning
South Fork Albion River	3 & 4 Oct. 1961	Considerable damage from logging in 1850s-1950s	Few steelhead trout	Spawning areas poor in the upper sections, good in the lower section; Pool development poor throughout; Fair to good shelter	Very few barriers observed; 1 culvert with a 10 foot drop	Clear the log jams and miscellaneous slash and debris
	15 July 1966	Intermittent in some places	Coho salmon and steelhead trout	Excellent spawning grounds; fair nursery grounds	4 large log jams below the Little North Fork; 16 small jams on tributaries and headwaters	Clear large jams

In response to management recommendations, logging debris, log jams, and other woody material were cleared from the streams by the CDFG in 1966, and the Center of Education and Manpower Resources (CEMR) and the New Growth Forestry from 1978-1987.

Current Conditions

Sixteen habitat inventory surveys were conducted by Louisiana Pacific (1994), the Coastal Land Trust (1996) and the CDFG (1998, 2001, 2002, and 2003) on a total of 13 streams (Table 24). All streams surveyed met the target values for canopy cover. The target value for pool depth/frequency was met on the middle mainstem in 2003, but was not met for any of the other streams surveyed. Pool shelter cover did not meet target values on the streams surveyed except on the Little North Fork in 1998.

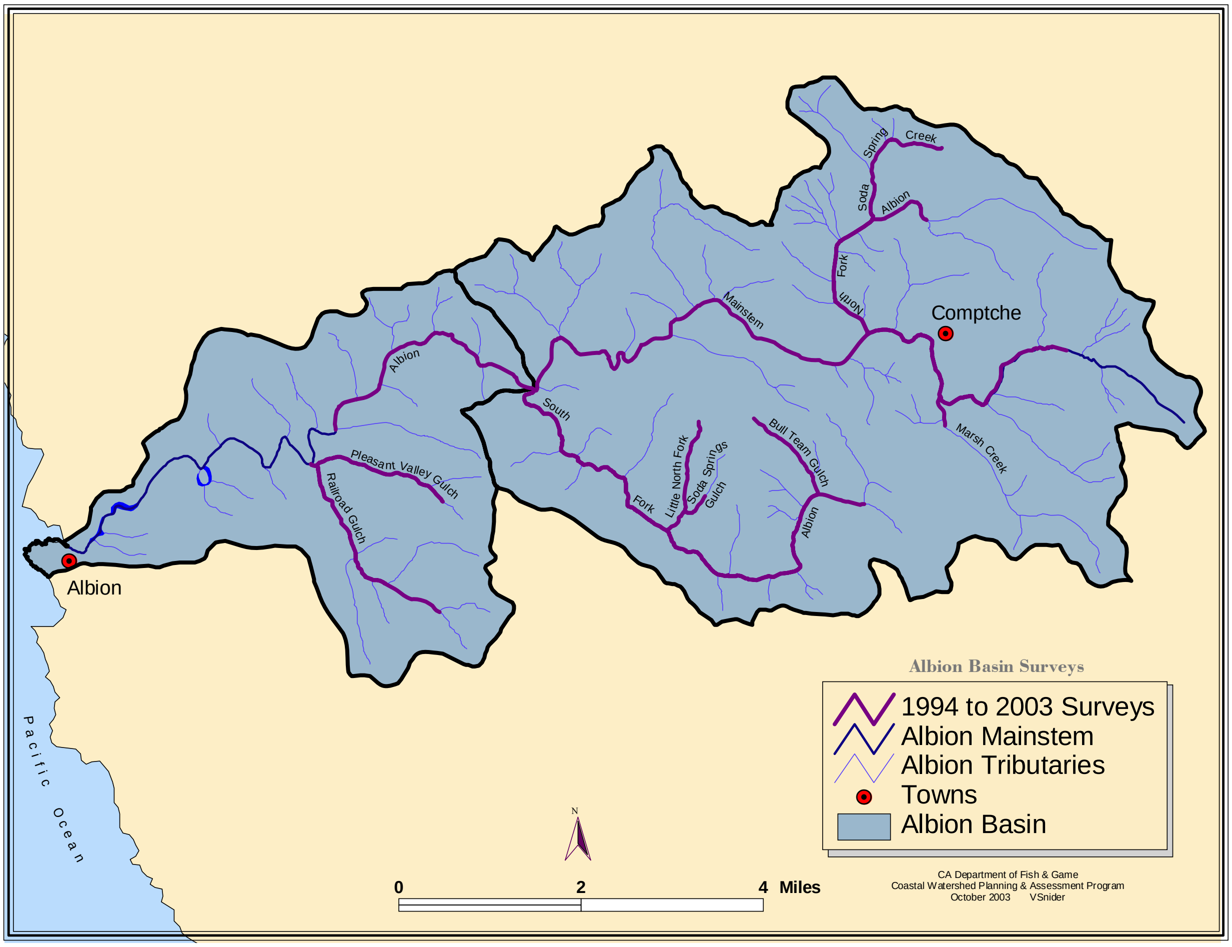


Figure 30. Habitat inventory surveys from 1994, 1996, 1998, 2001, 2002, and 2003 in the Albion Basin.

Table 24. Summary of current (1994-2003) fish habitat conditions in the Albion Basin.

Habitat Element Stream Name	Year Surveyed	Surveyed Length (feet).	% Canopy Density Cover	% Embeddedness	% Primary Pool Depth/Frequency	Shelter Cover Ratings
Target Values (Flosi et al 1998)			**>80**	**>50 in Category 1 <25 Embedded)**	**>40**	**>80**
Railroad Gulch	1994	10,432	81%	72%	44%	31
Railroad Gulch	2003	16,602	82%	2%	14%	40
Pleasant Valley Gulch	1994	3,342	88%	63%	41%	60
Pleasant Valley Gulch	2003	8,762	84%	0%	4%	43
Lower Mainstem Albion River	1994	13,402	90%	93%	57%	57
South Fork	1998	37,414	91%	4%	32%	29
Soda Springs Creek	2002	4,418	97%	0%	30%	23
Unnamed Right Bank Tributary	1998	1,509	97%	0%	24%	22
Bull Team Gulch	1998	3886	94%	0%	22%	56
Little North Fork of the SF	1998	2,000	95%	0%	4%	128

Habitat Element Stream Name	Year Surveyed	Surveyed Length (feet).	% Canopy Density Cover	% Embeddedness	% Primary Pool Depth/Frequency	Shelter Cover Ratings
Target Values (Flosi et al 1998)			**>80**	**>50 in Category 1 <25 Embedded)**	**>40**	**>80**
Middle Mainstem Albion River	2003	28,436	90%	1%	43%	30
North Fork	2002	11,663	93%	1%	27%	15
Upper Mainstem Albion River	1996	12,590	93%	1%	23%	36
Upper Mainstem Albion	2002	10,410	97%	13%	9%	24
Marsh Creek	2001	2,510	90%	0%	15%	18
Soda Springs Gulch	1998	444	94%	0%	32%	41

Fish Passage Barriers

Stream Crossings

Two stream crossings were surveyed in the Albion Basin as a part of the coastal Mendocino County culvert inventory and fish passage evaluation conducted by Ross Taylor and Associates (2001). Priority ranking of 24 culverts in coastal Mendocino County, for treatment to provide unimpeded salmonid passage to spawning and rearing habitat placed the culvert on the Albion River at rank one, and the culvert on Marsh Creek at rank four (Table 25).

Table 25. Definitions of barrier types and their potential impacts to salmonid in the Albion Basin.

Stream	Road	Priority Rank	Barrier Status	Upstream Habitat	Treatment
Albion River	Flynn Creek Road	1	Total barrier. A barrier for adult Coho salmon and steelhead trout and all age classes of juveniles due to excessive velocities over the smooth concrete lining, a lack of depth at lower migration flows, and the leap required to enter the culvert.	Approximately 4.6 miles of good salmonid habitat.	In progress
Marsh Creek	Flynn Creek Road	4	Total barrier. A barrier for all age classes of juveniles due to excessive velocities over the smooth concrete lining.	Approximately 0.7 miles of fair salmonid habitat to an old mill pond; and approximately 1.7 additional miles of fair salmonid habitat upstream from the pond.	In progress
Marsh Creek	Instream Dam	———	Total barrier.	Approximately 1/7 miles of fair habitat.	———

Culvert repair, upgrade, and improvement are an important part of stream restoration projects. In the Albion Basin, the CDFG North Coast Watershed Improvement Program includes culverts as a part of stream restoration and improvement efforts. They were able to supply information on recent culvert assessment and treatment contracts. Typically, following assessments like those done by Ross Taylor and Associates, the County or landowner follows up with improvement proposals to CDFG for funding support to implement recommendations. In the Albion Basin, some of the recommended treatments are currently proposed or being implemented.

Dry Channel

CDFG stream inventories were conducted for 30.8 miles on 30 reaches of 13 tributaries in the Albion Basin and dry channels were found on six streams.

Although the habitat typing survey only records the dry channel present at the time when the survey was conducted, this measure of dry channel can give an indication of summer passage barriers to juvenile salmonids. Dry channel conditions in the Albion River Basin generally occur from late July through early September. Therefore, CDFG stream surveys conducted outside this period are less likely to encounter dry channel.

The amount of dry channel reported in surveyed stream reaches in the Albion Basin is 5.2% of the total length of streams surveyed. This dry channel was found in six streams of the Inland Subbasin. Dry habitat units occurred at the upper reaches in all six tributaries. No dry channel was recorded in CDFG Stream Surveys in the Coastal Subbasin.

Fish History and Status

Documented fishery resources of the Albion Basin include coho salmon and winter-run steelhead trout. Infrequent reports and anecdotal information also record Chinook and pink salmon. Other fish include sculpin and stickleback in the freshwater habitat and a diversity of marine species in the lower estuary (Table 8, page 43).

Similar to most coastal streams, salmonid population data are limited for the Albion Basin. Anecdotal evidence and local opinion provide a case that coho salmon and steelhead trout were plentiful in the Albion Basin and experienced a decrease like other salmonid populations along the coast of California. These sources contend that salmonid populations in the Albion Basin may not have decreased as much as other nearby larger basins. These factors are suggested as possible reasons:

- The cooling coastal influence that allow water temperatures to remain cool in much of the basin;
- A large and open year round estuary;
- Suitable canopy over the streams;
- Low human population density;
- Improved timber harvest methods consistent with Forest Practices Act;
- Early timber harvest allowing for recovery.

Distribution relates to a species given range at the time information is collected. Changes in fish distribution result from changes in water and habitat conditions caused by natural and human impacts on localized and global scales. A record of fish absence does not preclude the possibility that salmonids were present, just as a record of presence does not necessarily mean that a population is persistent or viable. Historic coho salmon and steelhead distribution for the Albion Basin were estimated based on 1960s and 1970s stream surveys via visual observation (Figure 31 andFigure 32).

With the publication of the *California Salmonid Stream Habitat Restoration Manual* in 1991, stream survey methodologies used by CDFG became standardized and more quantitative. Twelve habitat inventory reports were completed between 1994 and 2003. During these surveys, biological inventories were conducted on three streams and visual observations were recorded on all streams. Coho salmon and steelhead trout were detected in all of the streams surveyed. More details about CDFG stream surveys and inventories are in the analyses and results by subbasin sections of this report and the CDFG Appendix.

The MRC and its predecessor L-P have conducted extensive biological surveys of juvenile salmonids in the Albion Basin within its land holdings. These studies have documented the presence of coho salmon and steelhead trout in most of the major tributaries. The most widely available data on juvenile salmonid abundance has been collected during electrofishing and more recently from snorkel surveys. Biological surveys and visual observations from CDFG, L-P, and MRC have been used to estimate current salmonid ranges. Current coho salmon and steelhead trout distribution were estimated based on CDFG observations and L-P/MRC biological surveys (Figure 33 andFigure 34).

In assessing salmonid populations, data are collected through various methods: spawning surveys, mark and recapture creel census, juvenile trapping, and electrofishing. The data are then analyzed to arrive at a population estimate backed by statistical confidence intervals. Accurate and credible population estimates include some enumeration of the whole or selected portion of the population. Population estimates made without data or by relating one basin's precipitation, latitude and longitude, and comparing it with better-studied streams of similar size are not accurate or credible and should not be used to establish trends. NMFS (2001) asserts that "trend analysis should be conducted at the same location using consistent methods, so that at least two complete life cycles (six years) can be used to indicate the size of a population".

NMFS (2001) analyzed data from six MRC index sites from 1988 to 1996. The data suggest that there was a general downward trend in juvenile coho salmon and steelhead in 1993 after a peak abundance in 1992. Numbers of juvenile salmonids have remained constant from1993 to 1996. As with most other sites in the ESU, the 1996-year class was the strongest. See the CDFG Appendix for further details.

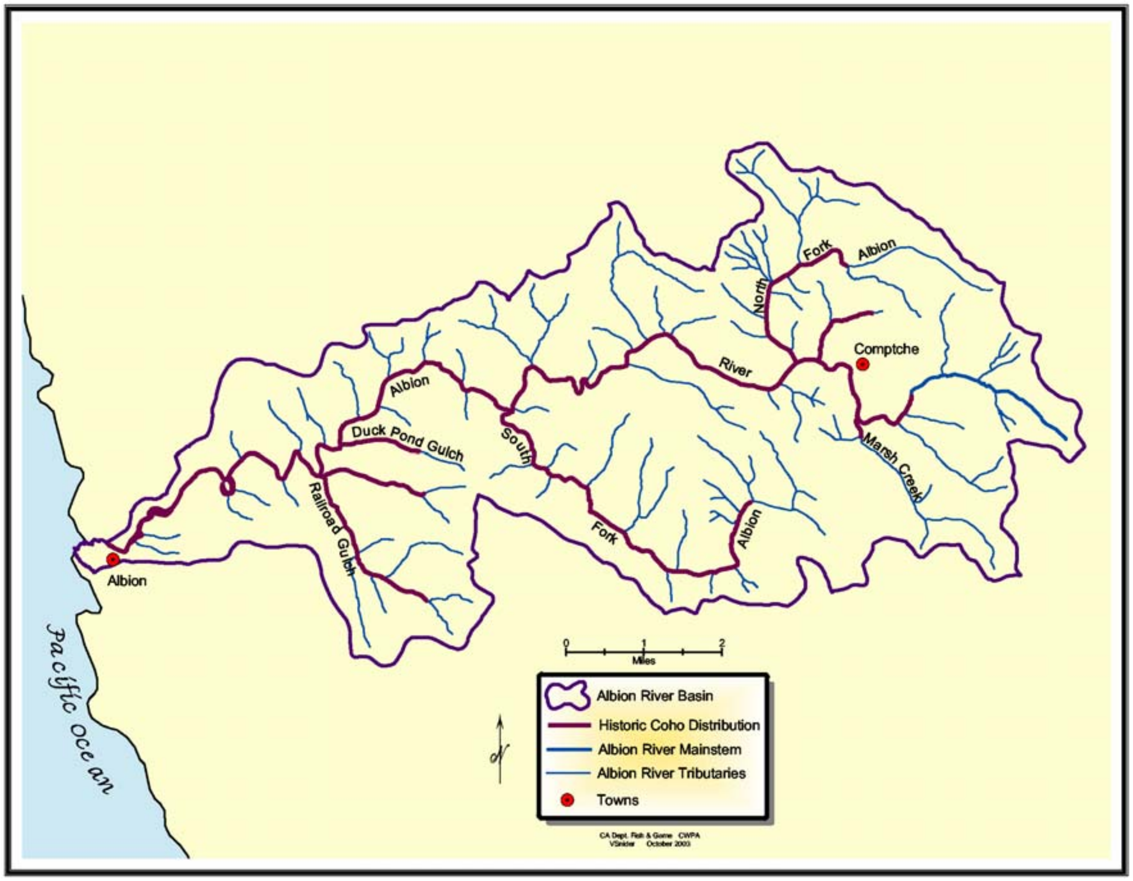


Figure 31. Estimated historical range of coho in the Albion River Basin.

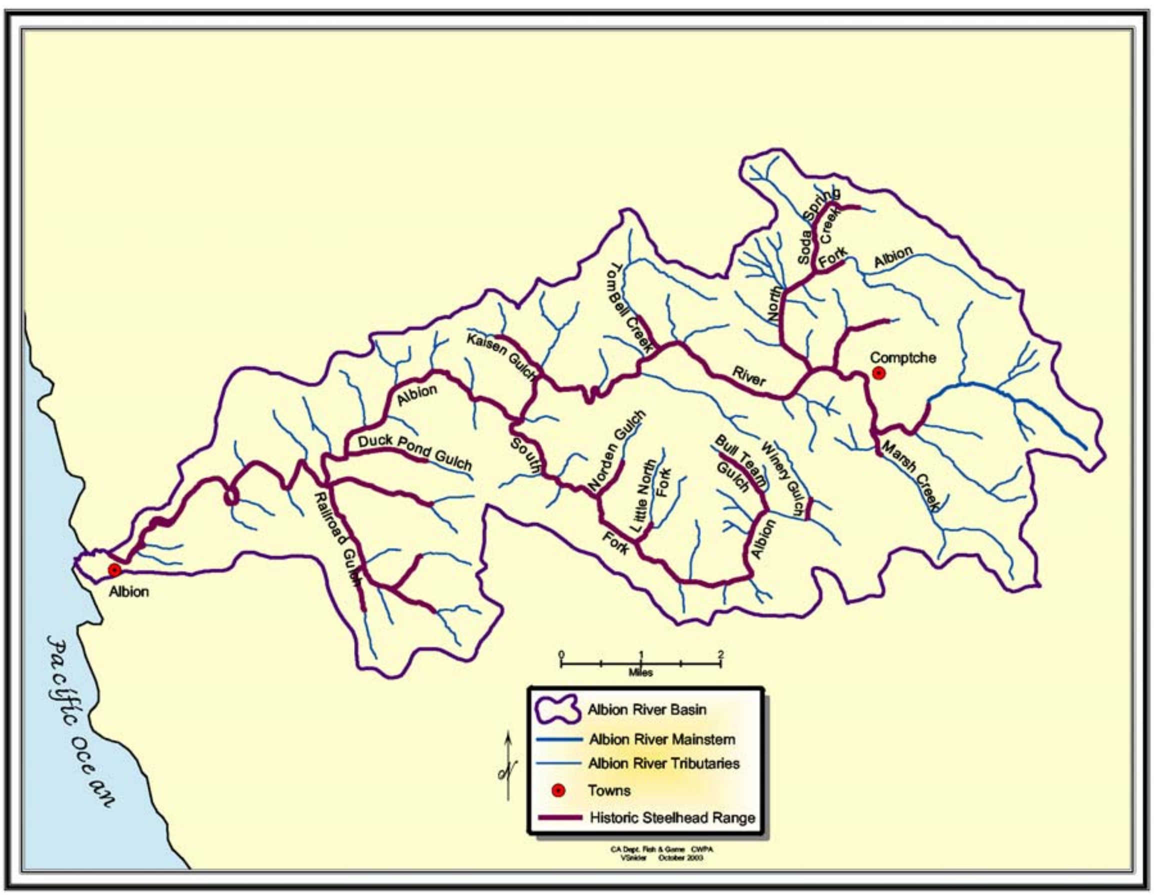


Figure 32. Estimated historical range of steelhead in the Albion Basin.

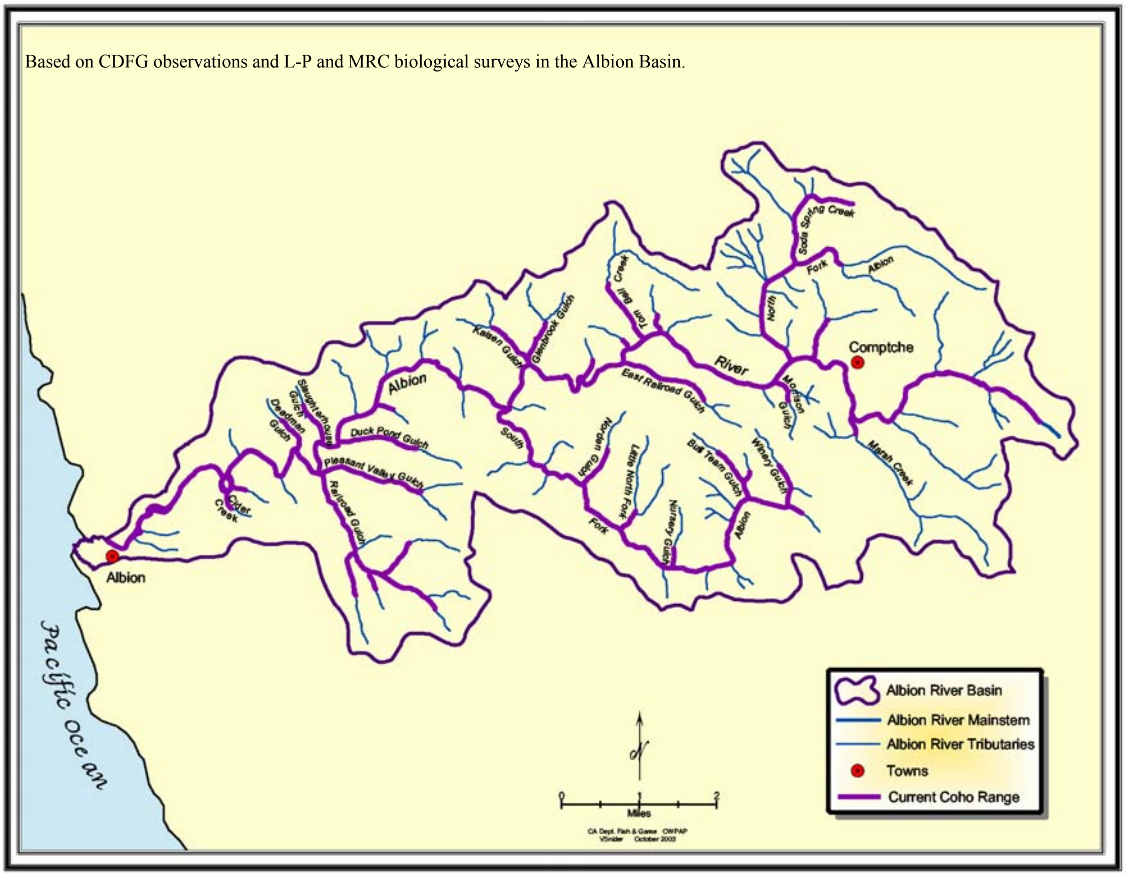


Figure 33. Estimated current coho range.

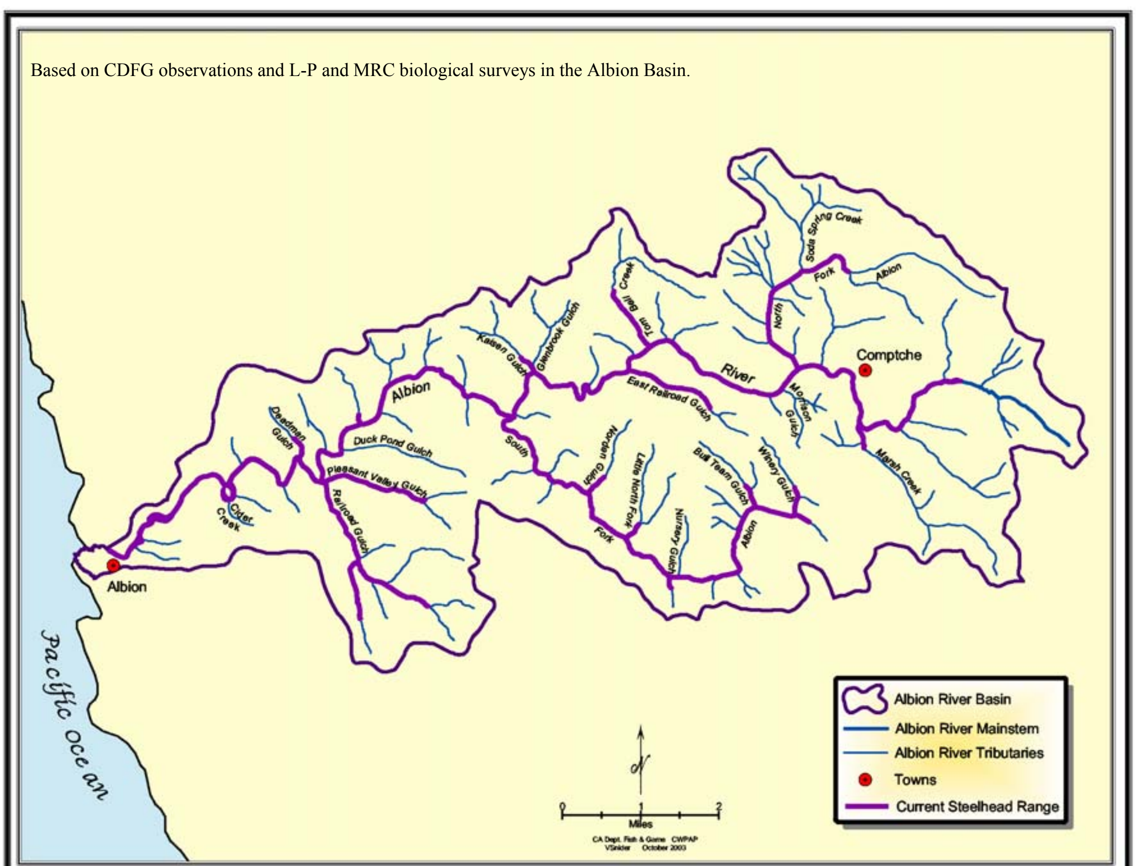


Figure 34. Estimated current steelhead trout range.

In an attempt to assess current salmonid populations of the Albion Basin, spawning and carcass surveys were conducted on the mainstem and the South Fork Albion. Survey sites were chosen to repeat earlier L-P and MRC surveys in hopes of collecting sufficient data to make a viable population estimate. A maximum of three surveys were conducted on several of the reaches. Even though this was the most complete set of surveys to date, the surveys were not continued throughout the spawning season due to flow conditions and low staffing. According to NMFS (2001), at least six years of comprehensive surveys conducted throughout the spawning season will be needed to establish baseline adult spawner populations (Table 26). The 2001-02 surveys yielded a population estimate of 720 coho spawners with a range of 386-1,753 with a 95% *confidence* interval (CDFG 2002). These surveys and observations are subject to substantial variability and multiple years of data over generations is needed to make well-supported estimates.

Table 26. MRC coho spawner population estimates using the Petersen model for the 1998-99 and 2001-02 seasons.

Year	Population Estimate	Number of Carcasses	Total Number of Carcasses Tagged	Number Recovered Tags
1998-99	52	33	29	17
2001-02	720	96	60	8

Fishing Interests and Constituents

Historically, sport fishing for salmon and steelhead has drawn local anglers to the Albion River during the winter months to a few locations where there is public assess. The threatened status of Chinook, coho and steelhead trout restricts river sport fishing on Albion Basin. The steelhead fishery of the Albion River (no salmon fishing at this time) is managed as a catch and release fishery from November 1 to March 31. Only barbless hooks may be used. For up to date fishing regulations contact Department of Fish and Game Central Coast Region in Yountville, CA 95501 (707) 944-5500 or visit the CDFG website at www.dfg.ca.gov.

Fish Restoration Programs

Fish Population Enhancement Programs

A total of 60,000 coho salmon were planted between 1969 and 1970 to enhance declining stocks and to provide sport-fishing opportunities. Between 1979 and 1985, 6,142 steelhead trout were planted in Marsh Creek (Table 27). The stocking of steelhead trout was aimed at mitigating the effects of the Marsh Creek dam that eliminated historic steelhead spawning habitat. All of the stocked fish originated from the Mad and Russian River hatcheries.

Table 27. DFG stocking records from 1960-1985 in the Albion Basin.

YEAR	LOCATION	SPECIES	NUMBER STOCKED
1969	Mainstem	Coho	30,000
1970	Mainstem	Coho	30,000
1979	Marsh Creek	Steelhead	1,200
1980	Marsh Creek	Steelhead	1,248
1981	Marsh Creek	Steelhead	1,196
1983	Marsh Creek	Steelhead	1,295
1985	Marsh Creek	Steelhead	1,203

Fish Habitat Improvement Work in the Albion River WAU, 1999-2000 (MRC 1999)

Many streams in the Albion Basin were identified as LWD deficient in the Albion River Watershed Analysis (MRC 1999). In this analysis, both the mainstem and the South Fork were identified as needing LWD to improve fish habitat conditions.

Between 1994 and 2000, CDFG carried out several stream enhancement projects within MRC ownership (

Table 28). For more information about the extent of restoration projects throughout the Albion Basin, see the CDFG Appendix.

Table 28. Stream habitat restoration projects in the Albion Basin

Stream Restoration Projects				
Stream	**Date**	**Project Location**	**Project Type**	**Project Scope**
Middle Mainstem	October 1994	Below Tom Bell Flat	LWD introduction	15 sites
South Fork	October 1994	Upper Section	Barrier modification Removal of one jam	2 sites
South Fork	1999-2000	6000 feet of lower section	Stream enhancement structures	18 sites

Special Status Species

Several plant and animal species in the Albion Basin have been found to have declining populations across their ranges and thus warrant special concern (Table 29). Species with declining populations are eligible to be listed under the Federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA) for special attention. Detailed explanations of federal and state listings criteria are in the CDFG Appendix.

Table 29. Special status species of the Albion Basin.

Common Name	Scientific Name	Federal Listing	State Listing
Plants			
Pygmy manzanita	Arctostaphylos mendocinoensis		Special plant
Humboldt milk vetch	Astragalus agnicidus		Endangered
Small groundcone	Boschniakia hookeri		Special plant
Thurber's reed grass	Calamagrostis crassiglumis	Species of concern	Special plant
Coastal bluff morning glory	Calystegia purpurata ssp. saxicola	Species of concern	Special plant
Swamp harebell	Campanula californica	Species of concern	Special plant
Northern clustered sedge	Carex arcta		Special plant
California sedge	Carex californica		Special plant
Livid sedge	Carex livida	Species of concern	Special plant
Lyngbye's sedge	Carex lyngbyei		Special plant
Deceiving sedge	Carex saliniformis	Species of concern	Special plant
Green sedge	Carex virdula var. virdula		Special plant
Oregon coast indian paintbrush	Castilleja affinis ssp. littoralis		Special plant
Mendocino coast indian paintbrush	Castilleja mendocinensis	Species of concern	Special plant
Whitney's farewell to spring	Clarkia amoena ssp. whitneyi	Species of concern	Special plant
Pygmy cypress	Cupressus goveniana ssp. pigmaea	Species of concern	Special plant
Streamside daisy	Erigeron biolettii		Special plant
Supple daisy	Erigeron supplex	Species of concern	Special plant
Coast fawn lily	Erythronium revolutum		Special plant
Roderick's fritillary	Fritillaria roderickii	Species of concern	Endangered
Pacific gilia	Gilia capitata ssp. pacifica		Special plant
American manna grass	Glyceria grandis		Special plant
Hayfield tarplant	Hemizonia congesta ssp. leucocephala		Special plant
Point Reyes horkelia	Horkelia marinensis	Species of concern	Special plant
Hair-leaved rush	Juncus supiniformis		Special plant
Baker’s goldfields	Lasthenia macrantha spp. bakeri	Species of concern	Special plant
Perennial goldfields	Lasthenia macrantha spp. macrantha	Species of concern	Special plant
Coast lily	Lilium maritimum	Species of concern	Special plant
Running-pine	Lycopodium clavatum		Special plant
Northern microseris	Microseris borealis		Special plant
Leafy-stemmed mitrewort	Mitella caulescens		Special plant
Robust monardella	Monardella vilosa ssp. globosa	Species of concern	Special plant
Bolander’s beach pine	Pinua contorta spp. bolanderi	Species of concern	Special plant
North Coast semaphore grass	Pleuropogon hooverianus	Species of concern	Threatened
White beaked rush	Rhynchospora alba		Special plant
Great burnet	Sanguisorba officinalis		Special plant
Seacoast ragwort	Senecio bolanderi var. bolanderi		Special plant
Point Reyes checkerbloom	Sidalcea calycosa ssp. rhizomata	Species of concern	Special plant
Maple-leaved checkerbloom	Sidalcea malachroides	Species of concern	Special plant
Purple-stemmed checkerbloom	Sidalcea malviflora ssp. purpurea	Species of concern	Special plant
Beaked tracyina	Tracyina rostrata	Species of concern	Special plant

Common Name	Scientific Name	Federal Listing	State Listing
Cylindrical trichodon	Trichodon cylindricus (moss)		Special plant
Coastal triquetrella	Triquetrella californica		Special plant
Long-bear lichen	Usnea longissima		Special plant
Marsh violet	Viola palustris		Special plant
Fish			
Coho salmon	Oncorhynchus kisutch	Threatened	Endangered
Chinook salmon	Oncorhynchus tshawytscha	Threatened	
Steelhead Trout	Oncorhynchus mykiss	Threatened	
Amphibians			
Foothill yellow legged frog	Rana boylii		Species of special concern
Northern red legged Frog	Rana aurora aurora	Species of concern	Species of special concern
Reptiles			
Northwestern pond turtle	Clemmys marmorata marmorata	Species of concern	Species of special concern
Birds			
Northern spotted owl	Strix occidentalis caurina	Threatened	

In addition to special status species, the Albion Basin provides habitat for other aquatic and terrestrial organisms (Table 30).

Table 30. Aquatic and terrestrial animals documented during various stream surveys in the Albion Basin.

Common Name	Scientific Name
Invertebrates	
Soft shelled or sand gaper clam	Mya arenaria*
Dungeness crab	Cancer magister
Purple shore crab	Hemigrapsus nudus
Lined shore crab	Pachygrapsus crassipes
Mudflat crab	Hemigrapsus oregonensis
Signal crayfish	Pacifastacus leniusculus
Amphibians	
California toad	Bufo boreas halophilus
Pacific giant salamander	Dicamptodon ensatus
Bullfrog	Rana catesbeiana*
Newt	Taricha spp.
Pacific tree frog	Hyla regilla
Reptiles	
Western pond turtle	Emys marmorata
Western fence lizard	Sceloporus occidentalis
Alligator lizard	Elgaria spp.
Gopher snake	Pituophis catenifer
Garter snake	Thamnophis spp.
Birds	
Western grebe	Aechmophorus occidentalis
Loon	Gavia spp.
Common merganser	Mergus merganser
Belted kingfisher	Ceryle alcyon
Great blue heron	Ardea herodias
Osprey	Pandion haliaetus
Mallard duck	Anas platyrhynchos
Northern pintail duck	Anas acuta
Mammals	
Blacktail deer	Odocoileus columbianus
Bobcat	Lynx rufus
Gray fox	Urocyon cinereoargenteus
Raccoon	Procyon lotor
Striped skunk	Mephitis mephitis
American mink	Mustela vison
Northern river otter	Lontra canadensis
Mountain lion	Puma concolor
Black bear	Ursus americanus

* Non-native

Albion Basin General Issues

Public scoping meetings with Albion Basin residents and constituents and initial analyses of available data by watershed experts developed this working list of general issues and/or concerns:

- Low stream flow in the late summer and fall are exacerbated by water extraction and diversions in the Inland Subbasin;
- Water temperatures and well mixed, dissolved oxygen in the mainstem estuary may be unsuitable for salmonids;
- Dissolved oxygen levels may be unsuitable in the North Fork Albion;
- Excessive fine sediment generated by surface erosion from residential winter road use;
- Sediment from poorly maintained and undersized county road culverts;
- Levels of fine sediment in some areas of the basin <6.4mm are unsuitable and therefore impact instream conditions;
- There is evidence of streambank erosion caused by livestock grazing within the riparian zone in some areas of the basin;
- There have been negative impacts to streams and fish habitat from legacy timber harvest practices;
- Instream substrate particle size (D50) is generally small throughout the basin;
- Permeability samples at the South Fork Albion sample site were low;
- High road density throughout the watershed, both current and legacy;
- Large Woody Debris (LWD) recruitment potential is generally poor;
- There is a shortage of instream LWD in most stream reaches;
- Inadequate spawning habitat due to limited recruitment, sorting, and retention of cobble size substrate;
- Some fish passage barriers related to Mendocino County road stream crossings have been identified in the basin;
- Rural subdivision and development in the estuary and Albion Ridge areas;
- There is limited information on salmonid populations;
- California sea lion predation impacts on fish populations;
- Lack of ground truthing by agency staff of privately collected data and/or data based on remote sensing;
- The estuary may be more shallow now than in the past and it currently lacks channel complexity;
- An earthen dam on Marsh Creek is an impassable barrier to salmon.

Integrated Analyses

The following analyses provide a dynamic, spatial picture of the basin conditions for the freshwater life stages of salmonids. Comments are presented on the impacts of these conditions on the stream or fishery. Especially at the tributary and subbasin levels, the dynamic, spatial nature of these processes provides a synthesis of the basin condition and indicates the quantity and quality of the freshwater habitat for salmon and steelhead. In-depth analyses of watershed processes were only conducted for water quality and instream habitat for the Albion Basin due to budgetary constraints.

Water Quality

The following Water Quality summary (Table 31 to Table 33) for the Albion River basin attempts to compile and condense spatially and temporally varying data and information from the subbasins into a more readily accessible format. The information in the tables below is a summary of the water quality data that was presented earlier in this section, with additional information about the significance of each of the parameters.

MWAT and seasonal maximum temperature data from continuous monitoring locations have a consistent and reliable history of information gathering over time. Therefore, conclusions can be formulated about the relative conditions affecting salmonids and other aquatic species proximate to monitored locations. Where grab sample data are available, continuous monitoring is necessary to decisively determine the suitability of temperatures for salmonids.

Instream sediment related parameters were generally available for one or two years, and therefore temporal trends in sediment size, movement, and accumulation were impossible. The sediment information available is useful to provide a picture of conditions for salmonids at monitoring locations in the years data were available.

Almost all of the water chemistry data were sporadically and inconsistently collected and analyzed, making it difficult to detect trends.

Table 31. .Water temperature summary table, Albion Basin.

<table>
<tr><th colspan="5">TEMPERATURE</th></tr>
<tr><th colspan="5">Significance-MWATs</th></tr>
<tr><td colspan="5">The maximum weekly average temperature (MWAT) is the maximum value of a seven day moving average of the daily average temperatures. The MWAT range for "fully suitable conditions" of 50-60°F was developed as an average of the needs of several cold water fish species, including coho salmon and steelhead trout. As such, it may not represent fully suitable conditions for the most sensitive cold-water species (usually considered to be coho). Temperatures between 61-62°F are considered "moderately suitable," while a temperature of 63°F is considered "somewhat suitable." The suitability of a 64°F temperature is considered "undetermined." Temperatures of 65°F and above are within the ranges considered "unsuitable" for salmonids (Refer to EMDS Appendix).</td></tr>
<tr><th colspan="5">Significance-Seasonal Maximum Temperatures</th></tr>
<tr><td colspan="5">The seasonal maximum temperature is the highest value of the maximum daily water temperatures during a calendar year. Through extensive literature research it has been determined that once the threshold of 75°F is exceeded salmonids experience high levels of mortality if cold water refugia is unavailable (Sullivan et al. 2000). Therefore, seasonal maximum temperatures below 75°F are considered "suitable", while temperatures above this thresholds are "unsuitable" for salmonids.</td></tr>
<tr><th colspan="2">MWATs</th><th colspan="2">Seasonal Maximum Temperatures</th><th>Discussion-MWATs</th></tr>
<tr><th colspan="4">Coastal Subbasin</th><td rowspan="8">The majority of mainstem Albion River monitoring locations ranged from fully to somewhat suitable. One record on the mainstem Albion River above Duck Pond Gulch, and all records below Railroad Gulch in the estuary were unsuitable. Tributary monitoring locations were all fully to moderately suitable.</td></tr>
<tr><th colspan="4">Mainstem Albion River[1]</th></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>6</td><td>5</td><td>9</td><td>2</td></tr>
<tr><th colspan="4">Tributaries[2]</th></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>11</td><td>0</td><td>11</td><td>0</td></tr>
<tr><td colspan="4"></td></tr>
<tr><th colspan="4">Inland Subbasin</th><th>Discussion-Seasonal Maximum Temperatures</th></tr>
<tr><th colspan="4">Mainstem Albion River[3]</th><td rowspan="7">The majority of mainstem Albion River records were fully suitable. One record on the mainstem above the South Fork, and two records below Railroad Gulch in the estuary were unsuitable. All tributary locations monitored were fully suitable for salmonids.</td></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>17</td><td>0</td><td>16</td><td>1</td></tr>
<tr><th colspan="4">Tributaries[4]</th></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>21</td><td>0</td><td>21</td><td>0</td></tr>
</table>

Data: MRC & MCWA

[1] Samples at three sites in various years from 1994-2001.

[2] Samples at seven sites in various years from 2001 & 2002.

[3] Samples at three sites in various years from 1992-2002.

[4] Samples at seven sites in various years from 1992-2002.

In general, water temperature conditions at monitoring locations in the Albion River basin are supportive of salmonids, with the exception of the lower mainstem Albion River below Railroad Gulch in the estuary. All but two mainstem locations monitored in the estuary were grab samples from Maahs and Cannata (1998) and MWATs and seasonal maximum temperatures could not be calculated from these data. Water temperatures at all 10 grab sample locations include readings over 65°F (45-77°F). When these grab samples are viewed in conjunction with continuous data from the lower mainstem estuary site below Railroad Gulch, it appears that temperature conditions in areas the estuary are in the unsuitable range for salmonids. Further monitoring should be performed to fully evaluate the impact of water temperatures on salmonids.

Table 32. Sediment summary table, Albion Basin.

<table>
<tr><th colspan="3">SEDIMENT</th></tr>
<tr><th colspan="3">Significance-D50s</th></tr>
<tr><td colspan="3">Pebble counts to determine the median particle size, or D50, of the streambed are used to characterize streambed substrate particle size distributions. Pebble counts are usually performed in the riffles of wadeable, gravel-bed streams. This simple and rapid method may help in determining if land use activities or natural land disturbances are introducing fine sediment into streams.</td></tr>
<tr><th colspan="2">D50 (mm)</th><th>Discussion-D50</th></tr>
<tr><th colspan="2">Coastal Subbasin</th><td rowspan="13">D50s at monitoring locations were small to moderate, ranging from fine to very coarse gravel (Rosgen 1996). Mainstem Albion D50s ranged from 8-55 mm, while tributary sites had D50s from 7-55 mm.

Note: Three different methods were used to collect data. Some cross-sections were not necessarily located on riffles in the streambed.</td></tr>
<tr><th colspan="2">Mainstem Albion River1</th></tr>
<tr><td>9</td><td>28</td></tr>
<tr><th colspan="2">Tributaries2</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>10</td><td>20</td></tr>
<tr><th colspan="2">Inland Subbasin</th></tr>
<tr><th colspan="2">Mainstem Albion River3</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>8</td><td>55</td></tr>
<tr><th colspan="2">Tributaries4</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>7</td><td>55</td></tr>
<tr><th colspan="3">Significance-Bulk Sediment Samples</th></tr>
<tr><td colspan="3">The suitability of spawning gravels depends on the size of the fish, therefore a range of particle sizes (6 mm to 102 mm) are necessary to accommodate all sizes of salmonids (Bjorn and Reiser 1991). The instream substrate needs to be distributed over this range of sizes because of variations in salmonid size and their selection of spawning gravels. If all the particles were in the lower or upper part of this range it would limit the usefulness of these particles for salmonids. Bulk sediment samples are used to assess the amount of fine sediment and size of particles at pool tail-outs deemed suitable for spawning. Fine material <0.85 mm can affect embryo survival by blocking the interstitial spaces between particles. This can decrease dissolved oxygen levels in the streambed, and prevent metabolic wastes from being carried away. Fine material <6.4 mm have been known to impact salmonids during the emergence stage. Particles of this size can block the emergence of fry depending on the angularity of particles, and are inversely related to the size of emerging fry (Chapman 1988). The TMDL target values for fine sediment <0.85 mm and <6.4 mm (<14% and <30% respectively) are not directly comparable to the data due to different collection methodologies. However, it can be determined that fine sediment levels which exceed these targets are unsuitable for salmonids, while values below the targets are of unknown suitability (see Water Quality Appendix for additional detail).</td></tr>
<tr><th colspan="2">Fine Sediment</th><th>Discussion-Bulk Sediment (fine sediment)</th></tr>
<tr><th>Median % <0.85 mm</th><th>Median % <6.3/6.4 mm</th><td rowspan="15">Median values for fine sediment <0.85 mm at monitoring locations were below TMDL target values (suitability undetermined), while median values for fines <6.3/6.4 mm ranged from below to well above the target (undetermined to suitable). Exceedances of the target for fines <6.4 mm (unsuitable) occurred on the mainstem below the South Fork in 1998 and 2001, the mainstem below East Railroad Gulch in 1998, the mainstem below the North Fork in 2001, and the mainstem above the South Fork and South Fork above the mainstem in 1998 (although levels at these two sites were below target values in 2001). <u>Note:</u> Samples were dry-sieved and the percentage of sediment was calculated on a by-weight basis.</td></tr>
<tr><th colspan="2">Coastal Subbasin</th></tr>
<tr><th colspan="2">Mainstem Albion River5</th></tr>
<tr><td>Minimum-Maximum</td><td>Minimum-Maximum</td></tr>
<tr><td>7-9</td><td>30-31</td></tr>
<tr><th colspan="2">Tributaries</th></tr>
<tr><td colspan="2">None</td></tr>
<tr><th colspan="2">Inland Subbasin</th></tr>
<tr><th colspan="2">Mainstem Albion River6</th></tr>
<tr><td>Minimum-Maximum</td><td>Minimum-Maximum</td></tr>
<tr><td>1-11</td><td>4.5-59.8</td></tr>
<tr><th colspan="2">Tributaries7</th></tr>
<tr><td>Minimum-Maximum</td><td>Minimum-Maximum</td></tr>
<tr><td>6.5-8</td><td>23.3-31.5</td></tr>
<tr><th colspan="2">50th percentile of particles (mm)</th><th>Discussion- Bulk Sediment (particle distribution)</th></tr>
<tr><th colspan="2">Coastal Subbasin</th><td rowspan="6">Generally, 50% of the particles at bulk sediment sampling sites were in the lower quarter of the 6-102 mm range, with the exception of the lower North Fork and mainstem above the North Fork where approximately 50% of the particles were in the lower third of the range. This indicates a lack of larger particles at sampling locations in this basin, which could limit their usefulness to salmonids. (Note: 75^{th} percentile of particles ranged from 19.1-80.6 mm, and the 25^{th} percentile of particles ranged from 1.8-22.4 mm).</td></tr>
<tr><th colspan="2">Mainstem Albion River[5]</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>11.8</td><td>21.8</td></tr>
<tr><th colspan="2">Tributaries</th></tr>
<tr><td colspan="2">None</td></tr>
</table>

Inland Subbasin		
Mainstem Albion River[6]		
Minimum	*Maximum*	
3.7	39.7	
Tributaries[7]		
Minimum	*Maximum*	
15.3	33.3	

Significance-V*

V* (V-Star) measures the percent of a pool's volume filled with fine sediment. Low V* values indicate relatively low basin disturbances. The following V* ranges, derived from Knopp (1993), are meant as reference markers and should not be construed as regulatory targets: V* $\leq$ 0.30 = low pool filling; correlates well with low upslope disturbance, V* > 0.30 and $\leq$ 0.40 = moderate pool filling; correlates well with moderate upslope disturbance, V* > 0.40 = high pool filling, correlates well with high upslope disturbance. The Albion River TMDL (US EPA 2001) set a numeric mean target value of <0.21 for the Albion Basin.

V*	Discussion-V*
Inland Subbasin	A V* value of 0.20 is suitable and indicates low pool filling. This value is comparable to the Albion River TMDL numeric mean target value. **Note:** This value was from one pool within the reach.
South Fork Albion River8	
0.20	

Significance-Thalweg/Cross-sections

Stream transects, or cross-sections provide a bottom profile of the streambed along a transect perpendicular to the direction of the flow. Thalweg measurements help develop a picture of the profile of the stream by measuring the elevation (depth) of the stream along a longitudinal transect. Multiple year data sets can reveal whether a location is aggrading (accumulating sediment), degrading (losing stored sediment), undergoing channel shifts (changes within an established floodplain), or channel migration (changes beyond established floodplains).

Thalweg/Cross-sections	Discussion-Thalweg/Cross-sections
Coastal Subbasin	Limited Thalweg data did not allow for trend analysis. Cross-sections showed mostly channel shifts within the established floodplain. Aggradation, degradation, and shifts in the thalweg are apparent at some sites from year to year. Sediment volumes were not calculated. (Water Quality Appendix).
Mainstem Albion River9	
1998, 2000, & 2001	
Tributaries	
None	
Inland Subbasin	
Mainstem Albion River[10]	
1998, 2000, & 2001	
Tributaries[11]	
1998, 2000, & 2001	

Significance-Streambed Permeability

The survival of salmonid eggs depends on the flow of water through the gravels. This serves to deliver oxygen to the incubating eggs and remove metabolic wastes from the egg pocket. The intrusion of fine sediment can reduce intergravel flow by reducing permeability, thus oxygen availability decreases and metabolic wastes build up (McBain and Trush 2000). Additional factors such as high temperature and egg disintegration can also affect embryo survival. An equation which uses permeability to calculate the estimated percent survival to emergence was used to assess conditions for salmonid embryos (Water Quality Appendix).

Streambed Permeability		Discussion-Permeability and Percent Survival
Median Permeability (cm/hr)	**Median Survival (%)**	Median permeabilities at Mainstem Albion sampling locations were higher than those measured on the South Fork Albion River. Median permeabilities and the calculated median percent survival to emergence values decreased on the mainstem from 1998 to 2000, although they increased on the South Fork. These quality ratings reflect the conditions before a spawning fish has worked the gravels into a redd, and therefore it would be assumed that permeability would improve to some degree through the creation of the redd.
Coastal Subbasin		
Mainstem Albion River12		
Minimum-Maximum	*Minimum-Maximum*	
4656.5-27174.5	42-68%	
Tributaries		
None		
Inland Subbasin		
Mainstem Albion River[13]		
Minimum-Maximum	*Minimum-Maximum*	
1017-17519.5	20-62%	
Tributaries[12]		
Minimum-Maximum	*Minimum-Maximum*	
121-796	0-17%	

Significance-Suspended Sediment vs. Turbidity

Turbidity occurs when suspended and dissolved materials in the water cause light to be scattered and absorbed, rather than transmitted through the water column. A relationship can be developed between turbidity and suspended sediment for a waterbody that enables turbidity to be used as a reasonable estimator of suspended sediment. Increases in turbidity can have negative effects of salmonids and other aquatic species. Varying degrees of turbidity can result in the following: decreased production and abundance of plant material, decreased abundance of fish food organisms, decreased production and abundance of fish, decreased feeding rates, and altered normal behavior patterns, as well as other effects.

Suspended Sediment vs. Turbidity	Discussion-Suspended Sediment vs. Turbidity
Inland Subbasin	Suspended sediment and turbidity data were collected sporadically, and data are insufficient to assess the impacts to salmonids. The data provide a preliminary look at the relationship between turbidity and suspended sediment in the Albion Basin (Water Quality Appendix).
Mainstem Albion River11	
WY 2000-2001	
Tributaries14	
WY 2000-2001	

Data: MRC, GMA, & RWQCB [1] Nine samples at four sites in 1998, 2000, & 2001. [2] Six samples at six sites in 1998. [3] Fifteen samples at six sites in 1998, 2000, & 2001 [4] Twenty-one samples at ten sites in 1998, 2000, & 2001. [5] Two samples at two sites in 1998 & 2001. [6] Five samples at five sites in 1998 & 2001. [7] Three samples at three sites in 1998 & 2001. [8] One sample at one site in 2001. [9] Sample at one site. [10] Samples at two sites. [11] Samples at three sites. [12] Two samples at one site in 1998 & 2000. [13] Four samples at two sites in 1998 & 2000. [14] Samples at four sites.

Sediment data from the basin are inconclusive when attempting to extrapolate the limited results to long term trend analysis. The median particle size of the streambeds (D50) were small to moderate at sampling locations. Fine sediment levels in the pools monitored were suitable. At pool tail-outs, the median percent of fines <0.85 mm were below the TMDL target value, while the median percent of fine sediment <6.3/6.4 mm ranged from below to well above the target value. Fines equal to or above target values are unsuitable for salmonids. At least half of the particles available to spawning salmonids at monitoring sites were in the lower quarter to third of the 6-102 mm range. Instream median permeabilities and the resulting estimated median percent survivals were higher in the mainstem than on the South Fork. Median permeabilities and their associated calculated median percent survival to emergence decreased from 1998 to 2000 on the mainstem Albion, although they increased on the South Fork.

Table 33. Water chemistry summary table, Albion Basin.

<table>
<tr><th colspan="3">WATER CHEMISTRY</th></tr>
<tr><th colspan="3">Significance-Dissolved Oxygen (D.O.)</th></tr>
<tr><td colspan="3">Dissolved oxygen enters the water by photosynthesis of aquatic biota and by the transfer of oxygen across the air-water interface. The Basin Plan (RWQCB 2001) requires a minimum level of 7.0 mg/L be maintained to protect beneficial uses in the Albion River, including salmonids.</td></tr>
<tr><th colspan="3">Significance-pH</th></tr>
<tr><td colspan="3">The Basin Plan (RWQCB 2001) requires that pH be within the range from 6.5-8.5 to protect the beneficial uses in the Albion River, including salmonids. These pH levels help control/regulate the chemical state of nutrients such as CO2, phosphates, ammonia, and some heavy metals.</td></tr>
<tr><th colspan="3">Significance-Specific Conductance (S.C.)</th></tr>
<tr><td colspan="3">Specific conductance is the measure of ionic and dissolved constituents in aquatic systems. The quantity and quality of dissolved solids-ions can determine the abundance, variety and distribution of plant/animals in the aquatic environment. Osmoregulation efficiency is largely dependent on salinity gradients. Estuary salinity is essential to outmigrant smoltification.</td></tr>
<tr><th colspan="2">Coastal Subbasin</th><th rowspan="2">Discussion-D.O., pH, S.C.</th></tr>
<tr><th colspan="2">Mainstem Albion River</th></tr>
<tr><th colspan="2">Dissolved Oxygen (mg/L)1</th><td rowspan="22">Historically, pH and S.C. and D.O. were suitable at monitoring sites in mainstem Albion River, with the possible exception of D.O. in the lower Albion River. Recent mainstem data at monitoring locations are suitable for all three parameters, with the possible exception of D.O. in the estuary (Maahs and Cannata 1998). Further sampling should be performed to conclusively determine current mainstem and estuary conditions for salmonids.

Limited water chemistry data are available from one tributary site in the basin on the North Fork Albion River. D.O. levels at this monitoring location were below suitable levels at times, pH levels were within the suitable range, and S.C. was higher than normal for freshwater streams. The monitoring location is below Soda Springs Creek, which is fed mostly from spring water. This may account for the elevated S.C. levels.

The lack of water quality information in this basin does not allow for a conclusive suitability analysis. Additional sampling efforts throughout the basin should be conducted for conclusive results.

<u>Note:</u> All samples are limited both spatially and temporally.</td></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>2.3</td><td>12.0</td></tr>
<tr><th colspan="2">pH (Standard Units)2</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>6.7</td><td>8.0</td></tr>
<tr><th colspan="2">Specific Conductance3</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>160</td><td>74000</td></tr>
<tr><th colspan="2">Tributaries</th></tr>
<tr><td colspan="2">None</td></tr>
<tr><th colspan="2">Inland Subbasin</th></tr>
<tr><th colspan="2">Mainstem Albion River4</th></tr>
<tr><th colspan="2">Dissolved Oxygen (mg/L)</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>9.4</td><td>11.3</td></tr>
<tr><th colspan="2">pH (Standard Units)</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>7.1</td><td>8.2</td></tr>
<tr><th colspan="2">Specific Conductance</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>175</td><td>319</td></tr>
</table>

Tributaries5		
Dissolved Oxygen (mg/L)		
Minimum	*Maximum*	
6.8	7.6	
pH (Standard Units)		
Minimum	*Maximum*	
7.9	8.1	
Specific Conductance		
Minimum	*Maximum*	
601	606	

Significance-Other Chemistry/Nutrients

Quality and quantity of natural and introduced chemical/nutrient constituents in the aquatic environment can be toxic, beneficial, or neutral to organisms. Chemical composition can be influenced by rainfall, erosion and sedimentation, evaporation, and introduction of chemicals/nutrients through human and animal interactions.

Coastal Subbasin		**Discussion-Chemistry/Nutrients**
Mainstem Albion River		
Boron, Total6		Historic data for estuary sites exceeded various human health standards for drinking water. Where marine aquatic life standards existed for these parameters, they were not exceeded. At one historic non-estuary site in the freshwater portion of the Coastal Subbasin, iron violated various human health and freshwater aquatic life standards. Current data from sampling locations did not violate any human health, marine aquatic life, or freshwater aquatic life standards. **Note:** Grab samples were collected sporadically, and further data collection should be performed for conclusive results.
Minimum	*Maximum*	
530	3600	
Chloride, Total in Water (mg/L)7		
Minimum	*Maximum*	
3000	19000	
Iron, Total (ug/L as Fe)8		
Minimum	*Maximum*	
30	1400	
Sodium, Total (mg/L as N)6		
Minimum	*Maximum*	
1800	9800	
Sulfate, Total (mg/L as SO4)7		
Minimum	*Maximum*	
110	2900	
Tributaries		
None		

Data: STORET, RWQCB
[1]Thirty-seven samples from seven sites in 1976, 1977, 1985, 1988, 1997, & 2001.
[2]Thirty-four samples from four sites in 1976, 1977, 1985-1988, & 2001.
[3]Thirty-three samples from four sites in 1976, 1977, 1985-1988, & 2001.
[4] Three samples from one site in 2001.
[5] Samples taken at one site in 2001, every 15 minutes for a period of three days (263 samples total) using a data logger.
[6] Six samples from two sites in 1987 & 1988.
[7] Nine samples from two sites in 1985-1988.
[8] Eleven samples from three sites in 1976, 1977, 1987, 1988 & 2001.

Long-term water chemistry data are insufficient for any significant conclusions to be drawn about these parameters. Historic data from monitoring locations were suitable for pH and specific conductance. Historically, dissolved oxygen may have been unsuitable above the estuary in the Lower mainstem. Other parameters measured exceeded various human health and freshwater standards on some occasions, although no marine aquatic life standards were violated. Limited current data from monitoring sites for pH and specific conductance are within suitable levels for salmonids, although further study should be performed to determine if dissolved oxygen is limiting in the estuary and North Fork.

Instream Habitat

Introduction

The products and effects of the watershed delivery processes are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Albion Basin are presented in the CDFG Instream Habitat Integrated Analysis. Instream habitat data presented here were compiled from stream inventories, an estuary study, and fish passage barrier removal project. Details of these reports are presented in the CDFG Appendix.

Pool Quantity and Quality

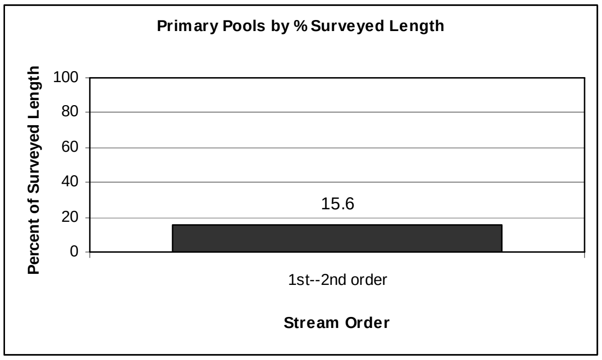


Figure 35. Primary pools in the Albion Basin.

Pools greater than 2.5 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30 – 55% of its length in primary pools to be suitable for salmonids.

Comments: The percent of primary pools by length in the Albion Basin is generally below target values for salmonids.

Spawning Gravel Quality

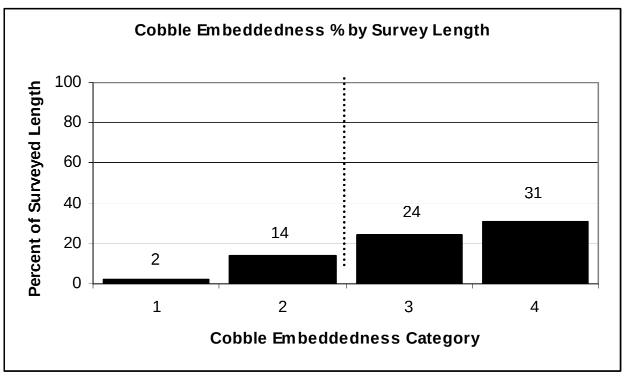


Figure 36. Cobble embeddedness in the Albion Basin.

Cobble Embeddedness will not always sum to 100% because Category 5 (not suitable for spawning) is not included.

Significance: Salmonids cannot successfully reproduce when forced to spawn in streambeds with a lack of suitably or excessive silt, clays, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded, and category 4 is 76-100% embedded. Cobble embeddedness categories 3 and 4 are not within the fully supported range for successful use by salmonids.

Comments: More than one half of the surveyed stream lengths within the Albion Basin have cobble embeddedness in excess of 50% in categories 3 and 4, which does not meet spawning gravel target values for salmonids. Suitably sized spawning substrate is not well distributed in most streams reaches. Many areas are dominated by bedrock substrate.

Shade Canopy

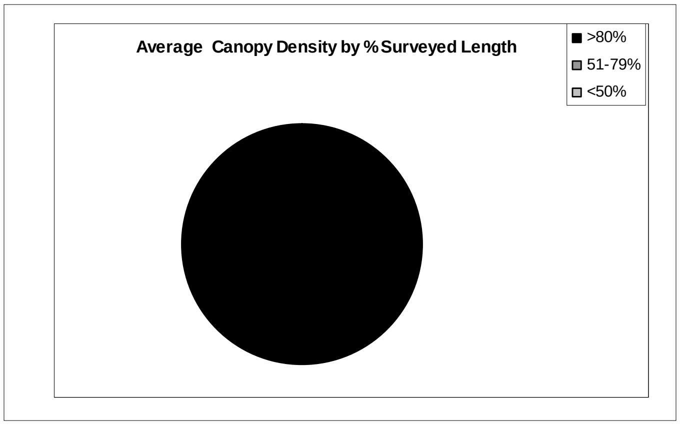


Figure 37. Canopy density in the Albion Basin.

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is below target values and greater than 85% fully meets target values.

Comments: All of the surveyed stream lengths within the Albion Basin have canopy densities greater than 80% and all but two of the surveyed lengths had canopy densities greater than 85%. This is above the canopy density target values for salmonids. The dense canopy is dominated by conifers and helps to support the suitable water temperatures recorded through out the basin.

Fish Passage

Figure 38. Salmonid habitat artificially obstructed for fish passage in the Albion Basin.

Feature/Function		Significance	Comments
Type of Barrier	% of Estimated Current Coho Salmon Habitat Currently Inaccessible Due to Artificial Passage Barriers	Free movement in streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt fish passage. Partial barriers exclude certain species and lifestages from portions of a watershed and temporary barriers delay salmonid movement beyond the barrier for some period of time. Total barriers exclude all species from portions of a watershed	Two culverts on county roads currently block 13% of estimated historic coho salmon habitat by length in the Albion Basin. Replacement is scheduled for 2005. Mendocino County Transportation Department has submitted culvert replacement plans to NMFS.
Total Barrier	13%		
Partial and Temporary Barriers	0		
All Barriers N=3*	13%		

*(N=3 -- 2 Culverts and Marsh Creek Dam) in the Albion Basin (1998-2000 Ross Taylor and Associates Inventories and Fish Passage Evaluations of Culverts within the Humboldt County and the Coastal Mendocino County Road Systems).

Figure 39. Juvenile salmonid passage in the Albion Basin (1998-2003 CDFG stream surveys, CDFG Appendix).

Feature/Function		Significance	Comments
Juvenile Summer Passage:	Juvenile Winter Refugia:	Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems.	Dry channel recorded in CDFG stream inventories in the Albion Basin has the potential to disconnect tributaries from the mainstem Albion River and disrupt the ability of juvenile salmonids to forage and escape predation. This condition is most common in streams in the Albion headwaters in the upper areas of the Inland Subbasin. Juvenile salmonids seek refuge from high winter flows, flood events, and cold temperatures in the winter. Intermittent side pools, back channels, and other areas of relatively still water that become flooded by high flows provide valuable winter refugia.
1.6 Miles of Surveyed Channel Dry	No Data		
5.2% of Surveyed Channel Dry			

Large Woody Debris

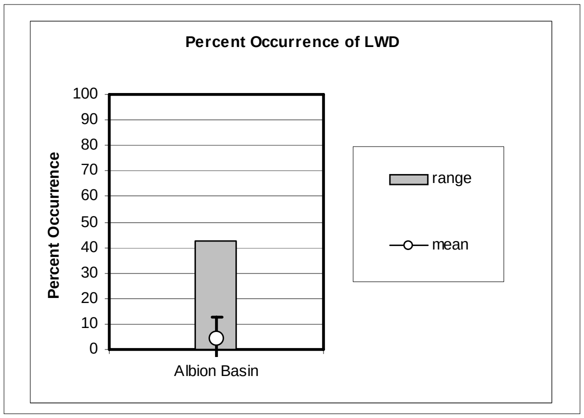


Figure 40. Large woody debris (LWD) in the Albion Basin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described in CDFG surveys. The dominant shelter type is determined and then the percentage of a stream reach in which the dominant shelter type is provided by organic debris is calculated.

Significance: Large woody debris shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids. There are currently no target values established for the % occurrence of LWD.

Comments: The average percent occurrence of LWD for the Albion Basin is 16%, as the dominant shelter type recorded in most stream reaches was undercut banks. According to CDFG records, this average percent occurrence of LWD is higher than that found in surveys in the Gualala River (average = 11.3 ± 13.6) and

Discussion

Although instream habitat conditions for salmonids vary across the 43 square mile Albion Basin, several generalities can be made. Canopy density was generally greater than 85% across the basin. Additionally, 1.6 miles of surveyed stream (5.2%) were dry and 13% of historic coho habitat was inaccessible due to artificial passage barriers. Throughout the Albion Basin, the percent of primary pools by survey length were below the target values found in CDFGs *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998) and calculated by the EMDS modeling system except in the middle mainstem Albion River which fully met the target value. Embeddedness values were also below target values in all survey reaches except part of the middle mainstem Albion River.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the conditions for salmonids in a stream reach based on water temperature, riparian vegetation, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG Stream Inventories. Currently, data exist in the Albion Basin to evaluate overall reach, water temperature, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS functions are in the EMDS Appendix. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual survey. Tributary EMDS results are presented in the subbasin sections.

EMDS stream reach scores were weighted by stream length to obtain overall scores for subbasins and the entire Albion Basin. Weighted average reach conditions on surveyed streams in the Albion Basin as evaluated by the EMDS are somewhat unsuitable for salmonids, although suitable conditions exist for canopy in the Coastal and the Inland subbasins (Table 34).

Table 34. Summarized EMDS anadromous reach condition model results for the Albion Basin.

Subbasin	Reach	Water Temperature	Canopy	Stream Flow	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Coastal	-	++	+++	U	--	---	--	---
Inland	--	+++	+++	U	---	--	---	---
Albion Basin	--	+++	+++	U	---	--	---	---

Analysis of Tributary Recommendations

In order to compare the frequency with which recommendations were made within the two subbasins in the Albion Basin, the three top ranking recommendations for each tributary were compiled. Each tributary was originally assigned anywhere from zero to ten recommendations, which were ranked in order of importance. Complete tributary recommendations for each subbasin can be found in each of the two subbasin sections of this report.

The top three improvement recommendations in each tributary were summed for each subbasin (Table 35). In terms of the most frequently given recommendations in each subbasin, the Coastal Subbasin had Bank, Roads, Pool, Cover, Spawning Gravel, and Fish Passage recommendations for two out of four tributaries surveyed. The Inland Subbasin had a Pool recommendation for 10 out of 10 tributaries surveyed, Cover recommendations for 9 out of 10 tributaries surveyed, and Spawning Gravel recommendations for 8 out of 10 tributaries surveyed. The top three recommendations for the entire basin in order of importance were Pool, Cover, and then Spawning Gravel.

Table 35. Occurrence of improvement recommendations in first three ranks in surveyed streams in the Albion Basin.

Subbasin	# of Surveyed Tributaries	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Live-stock	Fish Passage
Coastal	4	8.3	2	2			2	2	2		1	2
Inland	10	16.5	5	5			10	9	8	2	3	1
Albion Basin	14	24.8	7	7			12	11	10	2	4	3

In order to further examine subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 36). When examining recommendation categories by number of tributaries, the most important Recommendation Category in both the Coastal and Inland subbasins was Instream Habitat and Erosion/Sediment (Table 37).

Table 36. How improvement recommendations were collapsed into recommendation categories in the Albion Basin.

Tributary Report Recommendations	Basin Wide Recommendation Category
Bank/Roads	Erosion/Sediment
Canopy/Temp	Riparian/Water Temp
Pool/Cover	Instream Habitat
Spawning Gravel/LDA	Gravel/Substrate
Livestock/Barrier	Other

Table 37. Distribution of basin-wide recommendation categories in the Albion subbasins.

Subbasin	Erosion/Sediment	Riparian/Water Temperature	Instream Habitat	Gravel/Substrate	Other
Coastal	4	0	4	2	3
Inland	10	0	19	8	4
Albion Basin	14	0	23	10	7

However, comparing recommendation categories between subbasins could be confounded by the differences in the number of tributaries and the number of stream miles surveyed in each subbasin. Of the 14 tributaries evaluated in the Albion Basin, 16 stream miles were in the Inland Subbasin and eight in the Coastal Subbasin. Therefore, the percentage of stream miles in each subbasin assigned to the various recommendation categories was calculated for each subbasin. The percentage of the total stream length in each subbasin assigned to each subbasin recommendation category was then calculated to compare between subbasins.

Instream Habitat is the most important recommendation category in both the Coastal and Inland subbasins (Figure 41). In the Albion Basin as a whole, the most important recommendation category is Instream Habitat, followed by Erosion/Sediment, Gravel/Substrate and Other. No Riparian/Water Temperature recommendations were necessary. Therefore, the number one priority rankings remained the same for Estuary and Inland subbasins, whether assessed by the number of tributaries or the percentage of stream miles. Additionally, the overall rankings of Recommendation Categories in the Albion Basin as a whole remained the same in both analyses.

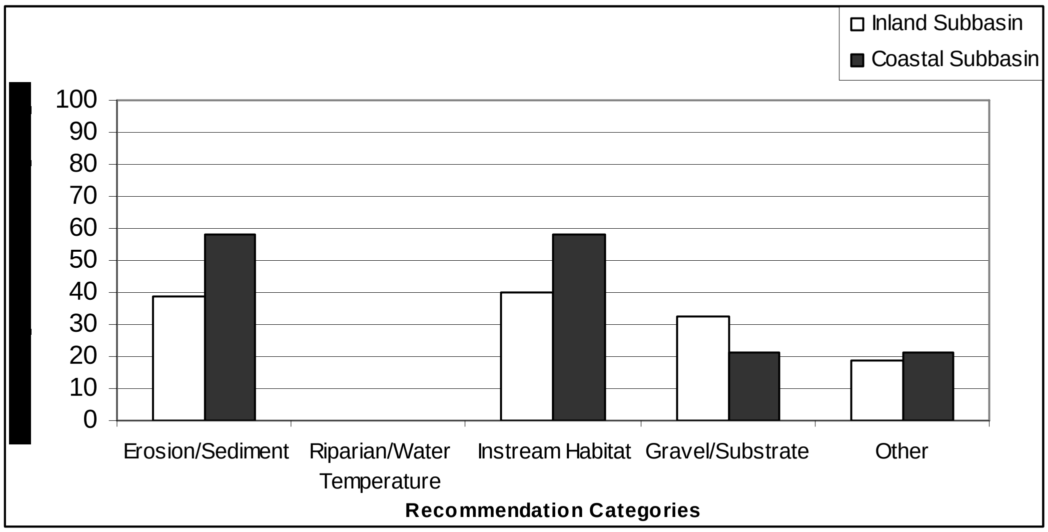


Figure 41. Frequency of recommendation categories in surveyed streams of the Albion Basin.

The high number of Instream Habitat and Erosion/Sediment Recommendations across the Albion Basin indicates that high priority should be given to restoration projects emphasizing pools, cover, and sediment reduction. The Gravel/Substrate Recommendation reflects the lack of suitable spawning substrate and the opportunity to implement both retention and addition of gravel where appropriate.

Refugia Areas

The interdisciplinary team identified and characterized refugia habitat in the Albion Basin (Figure 42) by using expert professional judgment and criteria developed for North Coast basins. The criteria included measures of basin and stream ecosystem processes, the presence and status of fishery resources, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by EMDS at the stream reach and planning watershed and subbasin scales.

The most complete data available in the Albion Basin were for tributaries surveyed by CDFG and long term monitoring sites from MRC. However, many of these areas were still lacking data for some factors considered by the team.

Salmonid habitat conditions in the Albion Basin are generally somewhat better in the Inland Subbasin than in the Coastal Subbasin. The following refugia area rating table summarizes subbasin salmonid refugia conditions:

Table 38. Subbasin salmonid refugia area ratings in the Albion Basin.

Subbasin	Refugia Categories:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Coastal			X			X	X
Inland			X			X	X

Albion River Tributaries by Refugia Category:

High Quality Habitat, High Quality Refugia Tributaries:

None

High Potential Refugia Tributaries:

Inland Subbasin
Middle Mainstem Albion

Medium Potential Refugia Tributaries:

Coastal Subbasin
Pleasant Valley Gulch
Railroad Gulch
Lower Mainstem
(above tidal influence)

Inland Subbasin
East Railroad Gulch
North Fork
Bull Team Gulch
South Fork
Little North Fork
Upper Mainstem

Low Quality Habitat, Low Potential Refugia Tributaries:

Coastal Subbasin
Lower Mainstem
(within tidal influence)

Inland Subbasin
Soda Springs Creek
Marsh Creek
Soda Springs Gulch
South Fork, Tributary #1

Data Limited and Critical Contributing Area

Occasionally, individual streams were missing data that would have provided a more complete picture for use in the refugia analysis. In these cases, only one or two of the factors used in the rating process were missing and this did not prevent refugia determination from being estimated. Where there was not enough data to give a stream a refugia rating, the site may have been listed as a critical contributing area based on the suitability of the habitat according to available data. All streams are lacking desired data.

<u>Other Related Refugia Component Categories:</u>

Potential Future Refugia (Non-anadromous)

None Identified

Critical Contributing Area:

Upper Mainstem
Lower Mainstem (within tidal influence)
Deadman Gulch
Slaughterhouse Gulch
Duck Pond Gulch
Unnamed Tributary
Anderson Gulch
Winery Gulch

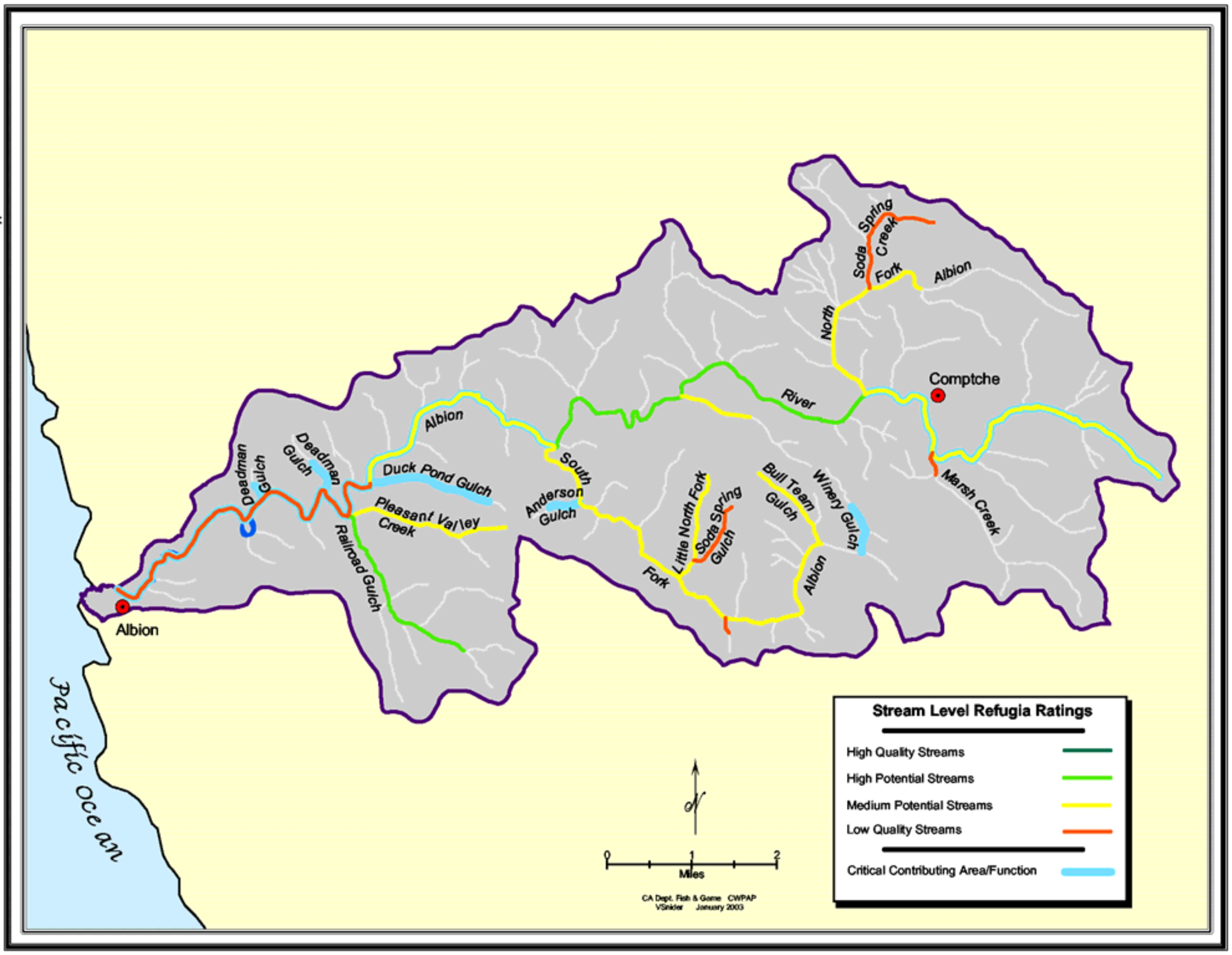


Figure 42. Stream Refugia in the Albion Basin.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Albion Basin?

<u>**Findings and Conclusions:**</u>

- Historic accounts and stream surveys conducted in the 1960s by CDFG indicate that the Albion Basin supported coho salmon and steelhead trout;
- Current data indicate that the Albion Basin continues to maintain steelhead and coho populations. Not enough data exists to comment on status or trends of these populations. Presence surveys since the 1960s indicate that the range of coho salmon and steelhead trout has not changed in that period;
- Mendocino Redwood Company (MRC) has conducted fishery surveys throughout their Albion ownership for the past ten years. These stream surveys indicate the presence of coho salmon and steelhead trout throughout their sample area;
- The National Marine Fisheries Service (NMFS 2001) analyzed data from six MRC index sites from 1988 to 1996. The data suggest that during the analyzed period there was a general downward trend in juvenile coho salmon and steelhead from a peak abundance 1992-1993. Following the observed peak abundance in 1993, numbers of juvenile salmonids remained constant, with a strong year class in 1996;
- In 2002, CDFG made a population estimate of 720 coho spawners (95% confidence interval). The estimate was based on only one year of redd and carcass surveys, which can be highly variable.

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

Findings and Conclusions:

Erosion/Sediment

- Sources of fine sediment include Quaternary age deposits in the Inland Subbasin, geologically recent deposits in estuary, sediment stored in river terraces, historically active landslides, and turbid runoff from disturbed lands;
- Limited data collected in 1998 and 2001 reflect unsuitable levels of fine sediment <6.4mm, which exceed the TMDL target in some areas of the basin, while sediment <0.85 mm at the sample locations throughout the basin are below the TMDL target and therefore their suitability can not be determined at this time;
- In-channel fine sediment deposits in low gradient reaches of the Coastal Subbasin have contributed to poor habitat complexity.

Riparian Condition/Water Temperature

- Water temperatures are suitable at monitoring locations above tidal influence in the mainstem and all locations surveyed on tributaries, and generally suitable at the estuary sample site above Duck Pond Gulch (RM 5.6);
- Summer water temperatures may be deleterious for salmonids in areas within tidal influence in the mainstem estuary;

Instream Habitat

- There are several reaches of scoured bedrock dominated stream channels, a general lack of habitat complexity, and a shortage of gravel and gravel retention structures;
- Pool habitat, escape and ambush cover, and water depth are unsuitable for salmonids in many stream reaches;
- Low flow conditions during the summer and fall are causing intermittent pools and associated fish mortality on the upper mainstem, Marsh Creek, North Fork, Soda Springs Creek, and the upper South Fork;
- Two county road culverts have been identified to be problems for fish passage by a Mendocino County roads study
- There is an impassable dam in Marsh Creek.

Gravel/Substrate

- Available data from sampled streams reflects that there is a limited amount of suitable spawning substrate;
- The potential of recruiting and retaining appropriately sized gravel from natural processes appears to be poor;
- Gravel permeability at the location monitored on the South Fork Albion was low;
- Instream substrate particle size (D50) is generally small at monitoring locations throughout the basin;

Refugia Areas

- Salmonid habitat conditions in the Albion Basin are of medium potential; the refugia potential is somewhat better in the Inland Subbasin than in the Coastal Subbasin.

Other

- Water quality samples taken at sites in the estuary and North Fork indicate low levels of dissolved oxygen, although further study is necessary;
- Limited water quality data from mainstem sites above tidal influence appear to be suitable, as are pH levels at the North Fork site.

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

Findings and Conclusions:

- The basin has a 43 square mile catchment area and low elevation headwaters that normally do not receive or retain significant snowfall. This results in low winter flows that transport stream bedload only about 5% of the year. (GMA 2001);
- Large dormant rockslides and steep slopes are locations of many historically active landslides in the North and South forks of the basin;
- During the 19th and 20th centuries earthquakes were recorded that triggered landsliding throughout the basin. In addition, a tsunami in 1964 scoured the mouth of the river;
- The basin has been historically and is still dominated by conifer forests, primarily made up of redwood and Douglas fir;
- Poor fertility, an iron-rich hardpan layer, and associated soil wetness restricts vegetation growth and has created pygmy forests in areas along Albion Ridge;
- Vegetation in the basin has been influenced by a history of frequent, natural fires;
- Photo mapping of channel fluvial features suggesting sediment sources or depositions showed a reduction in the number and total length of mapped features (such as sediment bars) from 1984 to 2000;
- Air photo analysis of the lower Albion River at low tide shows a single thread channel, which has varied little in location within the stream channel from 1936 to 2000.

How has land use affected these natural processes?

Findings and Conclusions:

- Water diverted for irrigation and domestic uses is currently permitted for at least 0.5 cfs in upper areas of the basin (GMA 2001);
- Human activities have interacted with natural geologic instability to increase sediment production above natural background levels, although background levels remain indeterminate. Many of the impacts on instream habitat conditions are spatially and temporally distanced from their upland disturbance sources, which makes the determination of cause and effect indefinite;
- Historic timber harvest activities reduced riparian canopy. The canopy is currently recovering from those activities;
- As a result of timber harvest, the current landscape is comprised of smaller diameter forest stands than in pre-European times;
- The small diameter of near stream trees limits the recruitment potential of large woody debris to streams and contributes to the lack of instream habitat complexity;
- Historic construction of splash dams and the straightening of stream channels for log transport likely simplified the morphology of the stream and possibly help scour the instream substrate to bedrock;
- Construction of near-stream railroads and roads have constricted stream channels and destabilized streambanks throughout the basin;
- Development on the Albion River flats has reduced wetland habitat.

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

Findings and Conclusions:

Based on available information for the Albion Basin, the team believes that salmonid populations are currently being limited by:

- A lack of habitat complexity throughout the basin;

- A general lack of instream LWD and poor recruitment potential near-stream;
- Elevated fine sediment <6.4mm in some reaches;
- Lack of available, appropriately-sized spawning substrate;
- Potential dissolved oxygen content in the some areas of the estuary and North Fork Albion;
- Elevated summer water temperatures in parts of the estuary;
- Summer low flow water conditions in the Inland Subbasin;
- Reduced basin-wide coho and possibly steelhead meta-populations;
- Low instream gravel permeability at the location monitored on South Fork Albion;
- Instream substrate particle size (D50) is generally small at monitoring locations throughout the basin.

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

- Encourage water conservation during summer low flow periods to improve stream surface flows and fish habitat in the Inland Subbasin;
- Increase the use of water storage and catchment systems that collect rainwater in the winter for use during the drier summer season.

Erosion and Sediment Delivery Reduction Activities

- Encourage the use of Best Management Practices for all land use development activities to minimize erosion and fine sediment delivery to streams;
- Expand road assessment efforts because of the potential for further fine sediment delivery from active and abandoned roads, many of which are in close proximity to stream channels;
- Encourage restricted access to unpaved roads in winter to reduce road degradation and fine sediment release. Where restricted access is not feasible, encourage rocking and other measures to decrease fine sediment production from roads;
- Inventory and map sources of streambank erosion and prioritize them according to present and potential fine sediment yield. Identified sites should then be treated to reduce the amount of fine sediments entering the stream;
- Provide technical assistance and incentives to landowners/managers in developing and implementing fine sediment reduction plans to meet requirements of the TMDL.

Riparian and Habitat Improvement Activities

- Ensure that stream reaches with high quality habitat and refugia are protected;
- Support progress of CDFG/Mendocino County fish passage improvement projects;
- Work with landowners and managers to increase large organic debris and shelter structures in streams in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids;
- Improve gravel retention and recruitment by adding instream structures where appropriate/feasible;
- Encourage use of exclusion fencing where there is evidence of streambank erosion caused by grazing livestock;
- Where feasible, design and engineer pool enhancement structures to increase the number of pools. This must be done where the banks are stable or in conjunction with streambank armor to prevent erosion;
- Investigate the suitability and feasibility of introducing appropriate, local substrate to spawning reaches if studies show instream structures fail to retain gravel due to short supply from the system.

Education, Research, and Monitoring Activities

- Conduct salmonid surveys to develop population estimates, which are needed to help evaluate the viability of habitat improvement activities;
- Develop and support local education efforts about water conservation and water catchment and storage systems;
- Support and expand ongoing efforts that monitor summer water and air temperatures on a continuous 24-hour basis to detect long-range trends and short-term effects on the aquatic/riparian community;
- Conduct studies in the estuary to determine conclusively whether water temperature and dissolved oxygen are suitable for salmonids;
- Encourage ongoing habitat inventories and fishery surveys of tributaries throughout the Albion Basin;
- Encourage macroinvertebrate surveys throughout the Albion Basin;
- Train local landowners throughout the basin to conduct stream and fishery surveys on their own lands;
- Continue long-term monitoring at current locations and establish new stations for water chemistry, thalweg, and in-channel sediment parameters;
- Determine the cause of low gravel permeabilities at the location monitored on the South Fork Albion;
- Investigate the North Fork Albion River to determine whether dissolved oxygen levels are suitable for salmonids;
- Establish a local cooperative group to help facilitate restoration funding efforts and monitoring activities;
- Develop a bulk sediment sample wet to dry conversion factor for the Albion River Basin. Until this occurs, it is encouraged that all bulk sediment samples be wet sieved to directly compare them to the TMDL target value.

Subbasin Profiles and Synthesis

Coastal Subbasin

Albion River Mouth looking at the Pacific Ocean.

The Coastal Subbasin includes the watershed area of the mainstem Albion below its confluence with the South Fork Albion. Stream elevations range from sea level to 40 feet at the South Fork confluence. The highest point in the subbasin is Mathison Peak at 1,030 feet. The subbasin encompasses 12.6 square miles, occupying 29% of the total basin area (Figure 43). The estuary is large relative to the size of the basin, with tidal influence extending approximately five miles upstream from the ocean. The mouth of the river is a narrow opening approximately 50 feet wide along the south side of Albion Cove. The cove is protected by rocky headlands. This headland minimizes wave-induced longshore sediment transport and allows the mouth to remain open to the sea year round (Maahs and Cannata 1998).

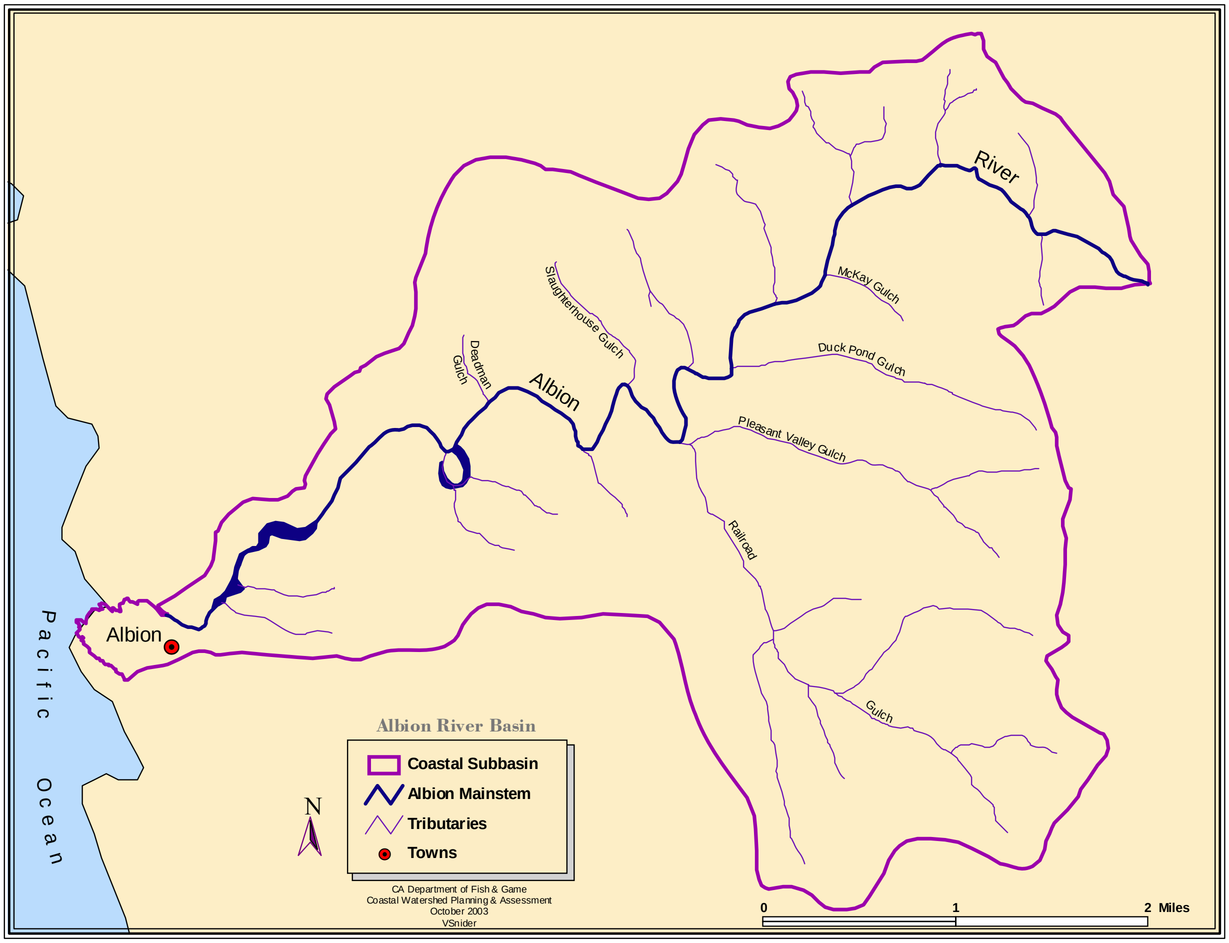


Figure 43. Coastal Subbasin, Albion Basin.

Climate

The weather of the Coastal Subbasin is characterized by a pattern of low-intensity rainfall in the winter and cool, dry conditions with coastal fog in the summer. Mean annual precipitation is about 40 inches at Fort Bragg near the western margin of the watershed. About 90% of the precipitation in this area falls between October and April, with the highest average precipitation in January. Air temperatures average 55°F and range from 40° to 65°F.

Hydrology

The Albion River is a relatively small coastal river with a catchment area of approximately 43 square miles. The mainstem becomes a third order stream downstream from the confluence with Railroad Gulch (RM 4.7) in the Coastal Subbasin. There are two subbasin tributaries shown as solid blue lines on the 7.5 minute USGS quadrangle are first order streams. Several intermittent streams drain into these tributaries or directly into the estuary itself (Figure 12). The Albion tributary system is dominated by intermittent and ephemeral streams, which are not used by CDFG in calculating stream order (Table 39). By convention, CDFG uses unbranched solid blue line streams as depicted on 7.5 minute USGS maps as their first order stream layer (Flosi et al. 1998).

An estuary is a coastal ecotone where salt water from the ocean mixes with fresh water from rivers. Salt and fresh water proportions within the estuary differ daily depending on the season, weather, and tides. Vital coastal ecosystems exist in these dynamic conditions. Ocean beaches, sand dunes, maritime forests, salt marshes, and tidal flats are found all along the coast and enable the estuary to act as a trap for nutrients washed down towards the sea.

The estuary is referred to as river-dominated because little mixing between salt and fresh water occur. The year-round freshwater flow changes seasonally, but floats on top of the salt water. The tidal marine water intrusion keeps summer temperatures low in the lower portion of the estuary. Further up the estuary, there is a gradual increase in water temperatures due to decreasing direct marine influences and increasing inland temperatures. The naturally occurring limited canopy cover, wide floodplain, and shallow stream conditions may create some seasonally unsuitable temperatures in summer and late fall. Additional and more detailed hydrology information is in the Albion Basin Profile (page 44).

Table 39. Coastal Subbasin streams and drainage areas.

CalWater Planning Watershed	River Mile	Bank (L/ R)	Stream	Perennial (miles)	Intermittent (miles)	Drainage Area (square miles)
Lower Albion River	0.5	R	Unnamed Tributary	0.7		0.2
	0.7	R	Unnamed Tributary		0.5	0.2
	2.6	R	The Lagoon			0.8
	2.9	L	Unnamed Tributary		0.4	0.2
	3.7	R	Unnamed Tributary		0.4	0.4
	4.2	L	Deadman Gulch		1.0	0.6
	4.7	R	Railroad Gulch	1.9	1.4	4.6
	5.2	L	Unnamed Tributary		1.0	0.3
	5.6	R	Duck Pond Gulch	1.1	0.7	0.7
	6.1	L	Unnamed Tributary		1.0	0.4
	6.5	R	McKay Gulch		0.6	0.3
	7.0	L	Unnamed Tributary		0.8	0.3
	7.6	L	Unnamed Tributary		0.6	0.3
	8.2	L	Unnamed Tributary		0.5	0.2
	8.4	R	Unnamed Tributary		0.4	0.1

Geology and Fluvial Geomorphology

The modern estuary occupies the drowned river mouth and comprises a relatively large portion of the river system. Sediment conditions in the estuary reflect tidal flooding and scour, marine storms, flooding, fluvial transport and deposition, and upland erosion. Natural disturbances and land use have also affected estuarine and fluvial sediment conditions. In 1964, a tsunami reportedly roared over a mile upriver and scoured out the river mouth (Lander et al. 1993). Two strong earthquakes, 1898 and 1906, damaged railroads, roads, and caused landsliding within the watershed (Toppozada et al. 1981; Stover and Coffman, 1993). The epicenter of the 1898 earthquake was estimated to be within the Flynn Creek drainage about two miles south of the Albion Basin (Toppozada et al. 2000). After the 1906 earthquake, liquefaction features (sand blows, fissures) were noted within the channels of the Big and Noyo Rivers and Pudding Creek. Severe damage to buildings was noted to occur on alluvial flats and marine terrace deposits (Lawson et al. 1908). Although liquefaction was not reported in the Albion River watershed, liquefaction probably disrupted the inter-tidal mudflats and upland marshes during these earthquakes.

Little quantitative information exists regarding changes in the estuary channel conditions. GMA (2001) notes a variety of anecdotal sources cited by Maahs and Cannata (1998). White (1984) cites a channel description in the 1940s as being 20-25 feet deep. About twenty years later, the average estimated depth was five to eight feet with a maximum of 20 feet deep (CDFG 1961; 1966). GMA (2001) states that it seems unlikely that the average depth would have declined so greatly during a 20-year period in which relatively little timber harvest was occurring in the watershed; however, the largest volume of landsliding did occur in the 1937-1952 period, which may have contributed to some channel shallowing (GMA 2001). Please refer to the discussion of the western geologic sub-region in the Albion Basin Profile section for more details (page 48).

Vegetation

Unless otherwise noted, the vegetation description in this section is based on manipulation of CalVeg 2000 data. The United States Forest Service, Remote Sensing Lab., interprets these vegetation data from satellite imagery. The minimum mapping size is 2.5 acres.

A Coastal Wetland Survey estimated that the estuary comprised approximately 100 acres of littoral habitat that was composed of 60 acres of marsh, 28 acres of eelgrass beds, and 11 acres of mud/sand flats (Dana 1978). The Coastal Subbasin vegetation is primarily redwood and Douglas fir forestland in various seral stages dependent primarily on logging history. Near stream areas are composed of grasslands and brush (Table 40). Grassland is concentrated at the upper portion of the estuary in the area near Railroad and Duck Pond gulches. These grasslands appear to be natural and are regularly flooded.

Table 40: Vegetation types along Class I streams based on Calveg 2000, USFS in the Coastal Subbasin.

Vegetation Type	Total Acreage	Percent of Total Area
Conifer	102	57
Mixed Forest	>1	>1
Grassland	14	8
Hardwood	2	1
Shrub	2	1
Urban	5	3
Water	52	29
Total	**178**	

This subbasin contains a larger percentage of conifer stands with trees 24 inches in diameter or larger than the basin as a whole. Forty percent of the trees in the forest stand types are in largest size class (Table 41).

Table 41. Tree size by diameter breast height in 2000 based on Calveg USFS in the Coastal Subbasin.

Tree Size	Total Acreage	Percent of Total Area
Sapling (1-6 inches)	0	0
Pole (6-11 inches)	0	0
Small Tree (11-24 inches)	34	19
Medium/Large Tree (>24 inches)	71	40
Other	73	41

Land Use

The developed area on the north side of the harbor is known as the Albion Flats. Currently, recreation, residential, moorage, research, and timber production are the major land uses. A private harbor/campground, an education/research facility, and a few residences constitute the extent of urbanization in the estuary area. Two stores, and a Post Office are located on the south side ridge overlooking the harbor. On the north side, a sea wall extends from the campground upstream approximately a half mile to Schooner's Landing. The sea wall protects a narrow spit that is only wide enough for a road except at the upstream end where a few campsites, another boat dock, and a house are located (Figure 44 andFigure 45). Because it is easily accessible, the Coastal Subbasin has been subject to timber harvest since the onset of logging in the mid 1800s. Recent harvest activities have centered on major tributaries and the upper reaches of the mainstem in this subbasin (

Table 42 andTable 43).

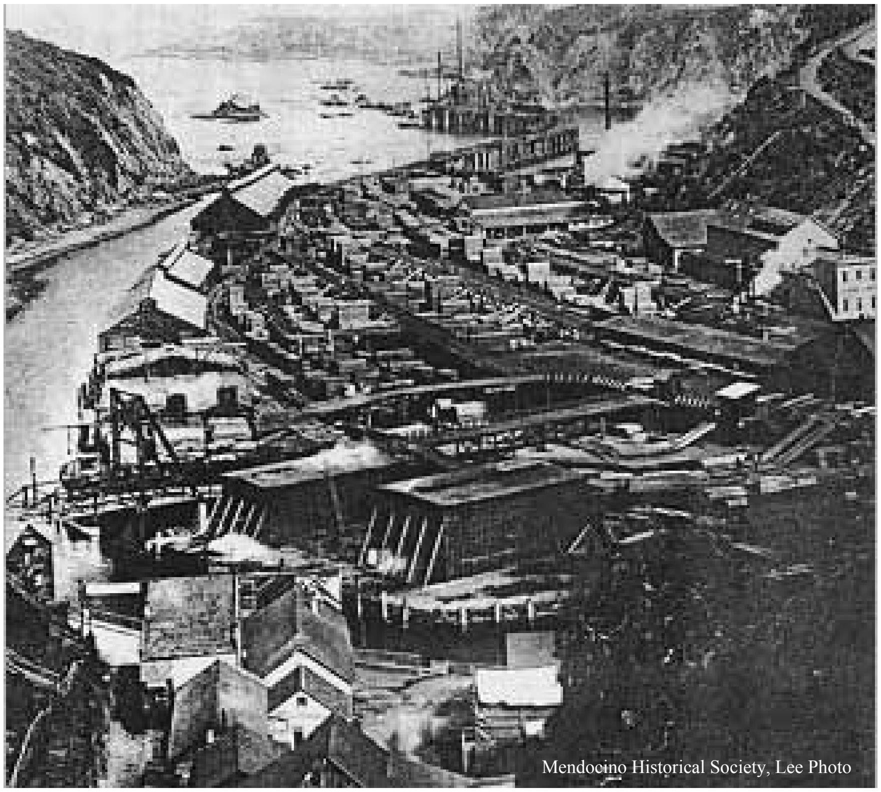


Figure 44. Landuse on the Albion flats in the early 1900s.

Figure 45. Landuse on the Albion flats in 2004.

Table 42: Timber harvest after 1930 in the Coastal Subbasin.

Timber Harvest Coastal Subbasin	Total Acres	Percent of Area	Percent Area Cut Annually
~1930 - 1936	80	1	<1
1937 - 1952	443	5	<1
1953 - 1963	640	8	0.7
1964-1972	578	7	0.9
1973-1987	1,379	17	1.2
1986 – 1989	679	8	2
1990 – 1999	2,297	28	2.8
2000 – 2002	850	11	3.7
Approved THPs, THP data	1525	19	Not applicable

Table 43: Current harvesting methods in the Coastal Subbasin.

Harvesting Time Period	Category 1 (acres) Includes clear-cut and seed tree seed step	Category 2 (acres) Includes shelterwood prep step, shelterwood removal step, and alternative prescriptions	Category 3 (acres) Includes selection and commercial thin	Total harvest by time period	Percentage cable or helicopter yarded
1990-1999	286	460	1,537	2,283	43%
2000-2002	45	232	527	804	49%
Open 2002	0	56	1,315	1,371	55%
Total by System	331	748	3379		

The mainstem channel has been changed over the years due to railroad construction and other timber production related activities. The mooring basin is the original course of the mainstem prior to the development of a new channel along the south bank when the original channel was blocked off for use as a millpond (White 1984). Fisher (1949) and Golden (personal comm. 2003) stated that there were no documented dredging records. However, a minor amount of dredging occurred in the early 1970s near the harbor mouth because fishing boats were scraping bottom at low tide (Jones personal comm. 2003).

The California Coastal Zone Conservation Commission Preliminary Report (1976) contains an Environmental Assessment of the estuary area. The assessment concluded that the Albion River estuarine area, both in terms of land and water, had reached its carrying capacity for intensive development of recreational and commercial fishing. Further intensive year round or seasonal expansion of existing facilities will adversely affect estuarine ecology. In the report, it was suggested that no further development should be allowed in the Albion River estuarine area or surrounding lands. See the Albion Basin Profile section for additional details about land use (page 57)

Water Quality

Temperature

Water temperature data from continuous recorders were available in this subbasin from three tidally influenced sites on the lower mainstem Albion River, two sites on Deadman Gulch (one tidally influenced), and one site on each of the following: Slaughterhouse Gulch (tidally influenced), Railroad Gulch (tidally influenced), Duck Pond Gulch, Pleasant Valley Gulch, and an Unnamed Tributary. Eleven samples from the lower mainstem and an additional eleven samples from these tributaries were collected during various years from 1994-2002 (Figure 46 and Table 44).

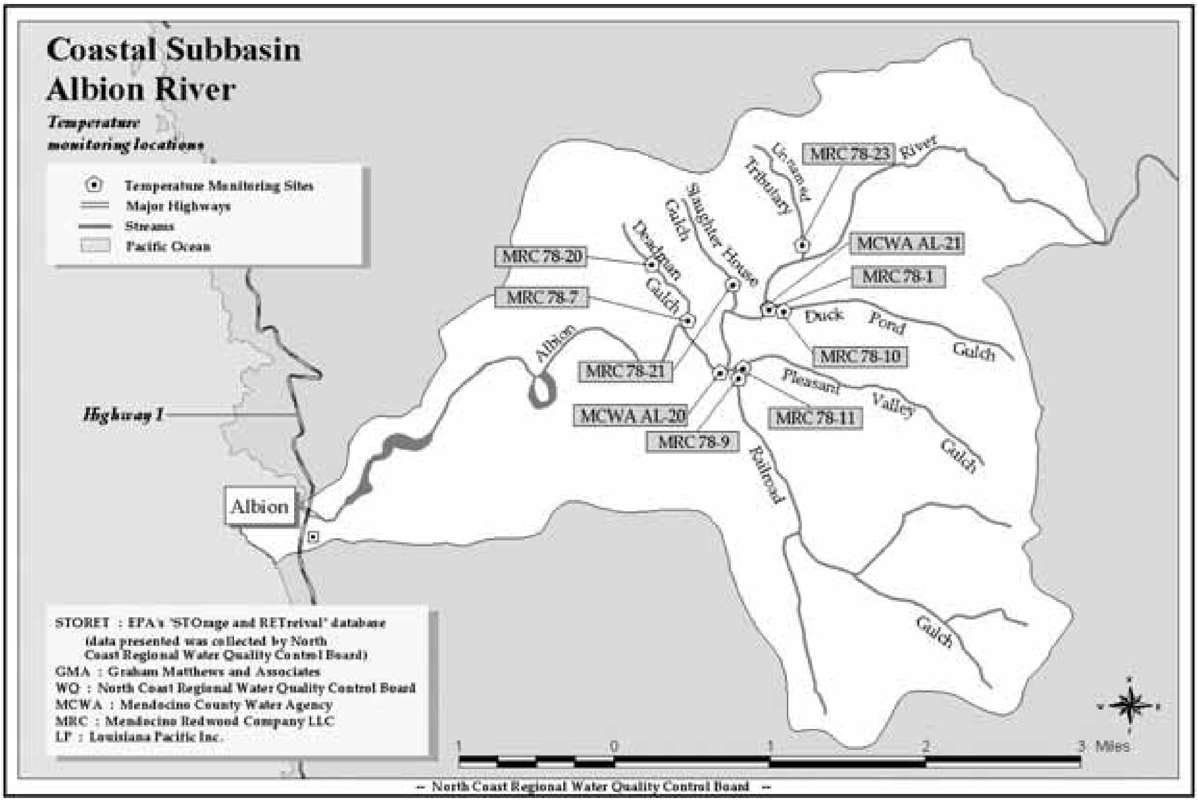


Figure 46. Water temperature monitoring sites from 1992-2002 in the Coastal Subbasin.

Table 44. Water temperature sampling site information for the Coastal Subbasin.

Water Temperature					
Location	**River Mile[3]**	**Report Station ID**	**Alt. Station ID(s)[4]**	**Contributor**	**Years Sampled**
Unnamed Tributary, lower	6.1 (SM 0.1)	MRC 78-23	78-8, 78-23	MRC	2000 & 2001
Duck Pond Gulch, lower	5.6 (SM 0.0)	MRC 78-10	78-10		2001
Lower Mainstem Albion River above Duck Pond Gulch	5.6	MRC 78-1[1]	78-1, 2094		1994-2001
	5.6	MCWA AL_21[1]	AL_21	MCWA	1998
Slaughter House Gulch, lower	5.2 (SM 0.2)	MRC 78-21[1]	78-21	MRC	2001 & 2002
Railroad Gulch, lower	4.7 (SM 0.1)	MRC 78-9[1]	78-9		2001
Pleasant Valley Gulch, lower	SM 0.0	MRC 78-11	78-11		2001 & 2002
Lower Mainstem Albion River below Railroad Gulch	4.7	MCWA AL_20[1]	AL_20	MCWA	1998-2001
Deadman Gulch, upper	4.2 (SM 0.5)	MRC 78-20	78-20	MRC	2001
Deadman Gulch, lower	4.2 (SM 0.0)	MRC 78-7[1]	78-7		2001 & 2002

[1]Located within tidal influence.
[2]Data was collected by the Coastal Land Trust and given the MCWA for their use.
[3]RM = river mile, SM = stream mile
[4]Station identification used by data contributor(s).

Maahs and Cannata (1998) collected weekly grab sample data at ten stations on the mainstem Albion in the estuary in 1997. Temperature profiles were collected from the mouth of the estuary up to Deadman Gulch. Although MWATs and seasonal maximum temperatures cannot be calculated from this information, if unsuitable temperatures were recorded it is an indication that temperature may be an issue and continuous monitoring should be performed to conclusively determine suitability. A brief discussion of these data is available in this section, and the sampling locations and raw data are available in the appendix to their document.

Estuary MWATs at sites located on tributaries were all fully suitable, while MWATs on the mainstem in the upper tidal reach of the estuary below Railroad Gulch (RM 4.7) were within the unsuitable range for salmonids (Table 45). Temperatures in the tidally influenced mainstem area above Duck Pond Gulch (RM 5.6) were generally suitable. However, in 2001 the MWAT at this site was 69°F which is unsuitable for salmonids. Data from previous years at this site do not reflect an increasing trend in temperature. It is unclear whether changes instream or upslope were altered resulting in higher temperatures at this monitoring location in 2001. Additional temperature data should be collected at this site to conclusively determine whether temperatures are beginning an upward trend or whether isolated conditions in 2001 brought about increased temperatures.

Marine influence in the lower portion of the estuary keeps summer temperatures low, although temperatures gradually increase in the upper estuary due to decreasing direct marine influence (Maahs and Cannata 1998). Forest canopy offers little shade to the mainstem throughout most of the estuary due to the width of the channel. According to MRC (1999), canopy along the lower mainstem in estuary is low (0-39%) until the area below Duck Pond Gulch where canopy increases to >70%. This change in marine influence and canopy is reflected in the temperatures throughout the estuary.

Table 45. EMDS ratings for MWATs in the Coastal Subbasin.

Watercourse	Number of Sites	Number of Samples	Period of Record	EMDS Suitability Rating						
				+++	++	+	0	-	--	---
Unnamed Tributary, lower	1	2	2000-2001	■	■					
Duck Pond Gulch, lower	1	1	2001		■					
Lower Mainstem Albion River above the confluence with Duck Pond Gulch (tidal influence)	2	7	1994-2001	■	■					■
Slaughterhouse Gulch, lower (Tidal influence)	1	2	2001-2002	■						
Railroad Gulch, lower (Tidal influence)	1	1	2001	■						
Pleasant Valley Gulch, lower	1	2	2001-2002	■						
Lower Mainstem Albion River below the confluence Railroad Gulch (Tidal influence)	1	4	1998-2001							■
Deadman Gulch, upper	1	1	2001	■						
Deadman Gulch, lower (Tidal influence)	1	2	2001-2002	■						

EMDS Ratings: +++ = fully suitable (50-60°F), ++ = moderately suitable (61-62°F), + = somewhat suitable (63°F), 0 = undetermined (between somewhat suitable and somewhat unsuitable) (64°F), - = somewhat unsuitable (65-66°F), -- = moderately unsuitable (67°F), --- = unsuitable (>68°F).

Seasonal maximum temperatures at sites on the three tributaries monitored in the estuary and the tidally influenced lower mainstem site above Duck Pond Gulch were all below the 75°F lethal threshold, and therefore suitable for salmonids (Table 46). Lower mainstem seasonal maximum temperatures at the site in the estuary below Railroad Gulch were unsuitable in two of the four years sampling was performed (1998 and 2001).

Table 46. MWATS and seasonal maximum temperatures in the Coastal Subbasin, Albion Basin.

Watercourse	Number of Sites	Number of Samples	Period of Record	Range of MWATs (°F)	Range of Seasonal Maxima (°F)
Unnamed Tributary, lower	1	2	2000-2001	56-61	58-65
Duck Pond Gulch, lower	1	1	2001	62	71
Lower Mainstem Albion River above the confluence with Duck Pond Gulch (tidal influence)	2	7	1994-2001	59-69	60-71
Slaughterhouse Gulch, lower (Tidal influence)	1	2	2001-2002	55	57
Railroad Gulch, lower (Tidal influence)	1	1	2001	57	60
Pleasant Valley Gulch, lower	1	2	2001-2002	56-57	59
Lower Mainstem Albion River below the confluence Railroad Gulch (Tidal influence)	1	4	1998-2001	71-74	73-77
Deadman Gulch, upper	1	1	2001	55	57
Deadman Gulch, lower (Tidal influence)	1	2	2001-2002	55-56	58

Grab sample temperatures from estuary sites monitored by Maahs and Cannata (1998) were lower in the fall and winter than they were during the summer, which is expected. Estuary water temperatures ranged from 45-77°F, and were fairly constant throughout the water column or in some cases decreased with depth. The exceptions to this were in November and December at river miles 0.6-3.2 where temperatures were cooler on the surface, most likely due to cool air temperatures. Water temperatures varied more widely in the upper estuary than they did near the mouth where the ocean has more of a moderating influence.

Due to the nature of grab sample data, MWATs and seasonal maximum temperatures cannot be calculated from this information. MWATs of 65°F or greater have been determined to be unsuitable to some degree for salmonids, with temperatures over 75°F being lethal if there is no escape. The grab sample water temperature data at all 10 stations monitored by Maahs and Cannata include readings over 65°F. When these grab samples are viewed in conjunction with continuous data from the tidally influenced site on the mainstem below Railroad Gulch, summer water temperature conditions in areas of the mainstem tidal estuary are in the unsuitable range for salmonids.

MWATs at tributary monitoring locations above tidal influence ranged from fully to moderately suitable, and seasonal maximum temperatures were fully suitable. There were no lower mainstem monitoring locations above tidal influence in this subbasin.

Sediment

Sediment data were available from five sites on the mainstem Albion, three sites on Railroad Gulch, two sites on Duck Pond Gulch, and one site on Pleasant Valley Gulch (Figure 47 and Table 47). Of these sites, one is located in the estuary on the lowest reach of Railroad Gulch and the remaining sites are located above tidal influence. The lack of sediment data collection in the estuary is not surprising. Sediment related parameters focusing on salmonid spawning suitability would not be applicable in the estuary, and it is assumed that in-stream substrate would be small due to tidal influence.

Sediment data in this subbasin were limited or unavailable for most of the parameters which assist in determining the suitability of instream substrate for salmonids.

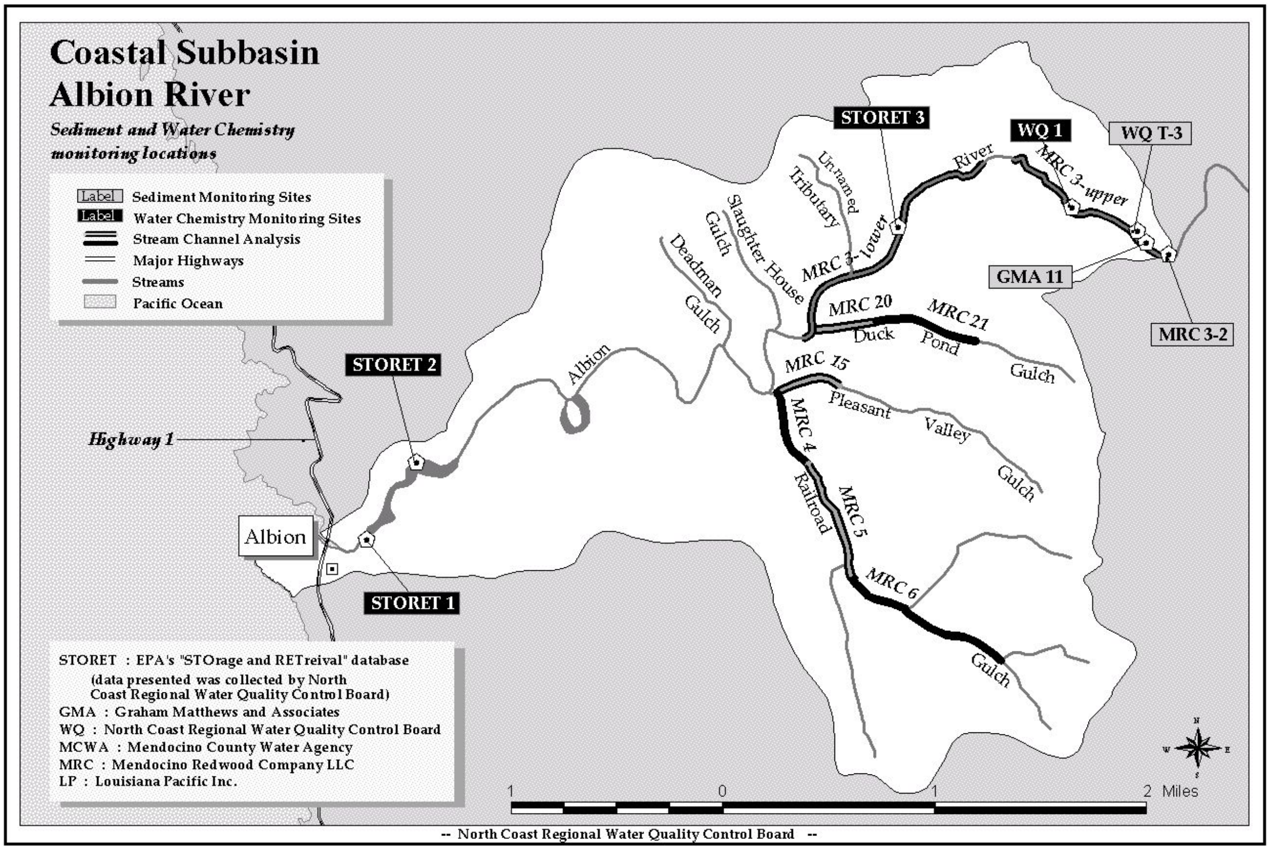


Figure 47. Instream sediment and water chemistry monitoring sites in the Coastal Subbasin.

The stream channel analysis sites on the map refer to areas where D50 data were collected.

Table 47. Sediment sampling site information for the Coastal Subbasin.

In-stream Sediment						
Parameter	**Location**	**River Mile**	**Report Station ID**	**Alt. Station ID(s)[2]**	**Contributor**	**Years Sampled**
D50	Lower Mainstem Albion River below South Fork	8.7	WQ T3	-	RWQCB	2001
	Lower Mainstem Albion River below South Fork	9.2	MRC 3-2	Seg 3(2)	MRC	1998 & 2000
	Lower Mainstem Albion River	7.8-9.2	MRC 3-upper	3(upper)		1998
	Lower Mainstem Albion River	5.5-7.2	MRC 3-lower	3(lower)		1998
	Duck Pond Gulch, middle	5.6 (SM 0.3-1.0)	MRC 21	21		1998
	Duck Pond Gulch, lower	5.6 (SM 0.0-0.3)	MRC 20	20		1998
	Railroad Gulch, upper	4.7 (SM 0.5-1.3)	MRC 6	6		1998
	Railroad Gulch, middle	4.7 (SM 0.5-1.3)	MRC 5	5		1998
	Railroad Gulch, lower	4.7 (SM 0.0-0.5)	MRC 4[1]	4		1998
	Pleasant Valley Gulch, lower	SM 0.0-0.4	MRC 15	15		1998

In-stream Sediment						
Parameter	Location	River Mile	Report Station ID	Alt. Station ID(s)[2]	Contributor	Years Sampled
Bulk Sediment Sample	Lower Mainstem Albion River below South Fork	9.2	GMA 11	ABSFA	GMA	2000
		9.2	MRC 3-2	Seg 3(2)	MRC	1998
Streambed Gravel Permeability	Lower Mainstem Albion River below South Fork	9.2	MRC 3-2	Seg 3(2)	MRC	1998 & 2000
Cross-Section	Lower Mainstem Albion River below South Fork	9.2	MRC 3-2	Seg 3(2)	MRC	1998 & 2000
		9.2	MRC 3-2	Seg 3(2)	RWQCB	2001
Thalweg	Lower Mainstem Albion River below South Fork	9.2	MRC 3-2	Seg 3(2)	MRC	2000
		9.2	MRC 3-2	Seg 3(2)	RWQCB	2001

[1] Located within tidal influence.

[2] Station identification used by data contributor(s).

Pebble Counts (D50)

The median particle size in the streambed, or D50, is a simple and rapid assessment method that can help in determining if land use activities or natural land disturbances are introducing fine sediment into the stream. Additionally, this data is useful in combination with stream flow and stream gradient information to assess the likelihood that particles of a given size will move downstream.

Most sites in this subbasin do not have multiple years of data, and therefore it is difficult to draw any conclusions about the sediment supply and transport in this subbasin. Overall, D50s at monitoring locations were of small size within this subbasin. A single pebble count sample in a tidally influenced lower reach of Railroad Gulch in 1998 had a D50 of 10 mm (Table 48). This small size of substrate is indicative of those particles found throughout sand dominated, depositional estuarine environments.

Table 48. Summary of in-stream sediment related parameters in the Coastal Subbasin.

Parameter	Stream	Number of Sites	Period of Record	Sample Range (Min-Max)	Notes
D50 (mm)	Lower Mainstem Albion River	4	1998, 2000-2001	9-28	Some cross-sections were not necessarily located on riffles in the streambed. Three different methods were used to collect data (see Water Quality Appendix).
Bulk Sediment Sample Median Percent <0.85 mm (%)	Lower Mainstem Albion River	2	1998 & 2001	7-9	Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.
Bulk Sediment Sample Median Percent <6.3/6.4 mm (%)	Lower Mainstem Albion River	2	1998 & 2001	30-31	Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.
Bulk Sediment Sample 50th percentile of particles (mm)	Lower Mainstem Albion River	2	1998 & 2001	11.8-21.8	25th percentile ranged from 3.6-5.1. 75th percentile ranged from 22.6-66.0.
Median Streambed Gravel Permeability (cm/hr)	Lower Mainstem Albion River	1	1998 & 2000	4656.5-27174.5	Median percent survival associated with these permeabilities is 42% to 68%, per McBain and Trush (2000).
D50 (mm)	Duck Pond Gulch, lower and middle	2	1998	14-20	Sample site was specifically chosen to look at bed mobility potential.
D50 (mm)	Railroad Gulch, middle and upper	2	1998	14	Sample site was specifically chosen to look at bed mobility potential.
D50 (mm)	Railroad Gulch, lower (Tidal influence)	1	1998	10	Sample site was specifically chosen to look at bed mobility potential.
D50 (mm)	Pleasant Valley Gulch, lower	1	1998	20	Sample site was specifically chosen to look at bed mobility potential.

Overall, D50s at monitoring locations above tidal influence on the lower mainstem Albion River were small, as were D50s at sites on upper Railroad, Pleasant Valley, and Duck Pond gulches. According to Matthews (2001), sediment does not have much of an opportunity for storage in the upper watershed. The sediment is flushed downstream to the lower watershed where the low gradient allows for the deposition of smaller particles. This is observed when looking at the small D50s at sites on the lower mainstem of this subbasin compared to those sites upstream.

According to MRC (1999), most of the D50 sampling locations on the lower mainstem in this subbasin were in low gradient areas (0-2%), with highly confined channels. The upper reaches of Duck Pond, Pleasant Valley, and Railroad gulches all have areas of steep v-shaped channels with high gradients (8-20%) and high transport capabilities. Further downstream on these tributaries, the channels are moderately to highly confined with low gradients of 0-4%. The lower reaches of these waterways are unconfined low gradient channels (0-4%) with high levels of deposition and terrace development. Additionally, the lower section of Railroad Gulch is in a low gradient (0-1%) depositional area within tidal influence (MRC 1999.) Most of the D50 monitoring locations in this subbasin were within depositional reaches of their respective channels. This is reflected in the small D50s of this subbasin.

Bulk Sediment:

The median percent of fine sediment < 0.85 mm and < 6.3/6.4 mm above tidal influence remained fairly constant from 1998 to 2001 at lower mainstem Albion monitoring locations in this subbasin (Table 48). Median values were at levels below TMDL targets for fine sediment < 0.85 mm (suitability undetermined), and equal to or slightly above targets for fines < 6.4 mm (unsuitable).

As is further discussed in the Water Quality Appendix, the targets for fine sediment < 0.85 mm and < 6.4 mm in the Albion River TMDL are for volumetric (wet sieved) data, and therefore are not directly comparable to these gravimetric (dry sieved) data. However, when material is wet sieved, water retained on the particles, especially those < 4 mm, becomes significant (Shirazi, Seim, and Lewis 1979). Therefore the percent finer than values calculated from dry sieved data would be lower than values that would be calculated from wet sieved material. Consequently, values that are equal to or above the targets can be considered unsuitable, while values below the targets were noted as such but no specific conclusion about the suitability of these areas can be made now. This being the case, lower Mainstem Albion data for the median percent of fines < 6.3/6.4 mm (30% and 31%) in both years indicates unsuitable levels of sediment at the locations monitored.

Acknowledging that the suitability of gravel substrate for spawning salmonids depends on fish size, Bjornn and Reiser (1991) compiled data from many sources about the substrate size criteria for anadromous salmonid spawning areas and found that in general particles from 6-102 mm in size are what salmonids use for spawning. In 1998, 75% of the instream substrate from the samples collected on the lower mainstem Albion above tidal influence were in the lower quarter of the 6-102 mm range used by salmonids for spawning. According to data received from MRC, only 2.5% of the particles in 1998 were greater than 50.8 mm. In 2001, a higher percentage of larger particles were available, although 50% of particles were still in the lower quarter of the range used by salmonids. This lack of larger particles could limit their usefulness to spawning salmonids. Additionally, redds created in small substrate are vulnerable to destruction by high flows. Smaller particles can be easily mobilized by small increases in flow, and this can present potential problems for spawning salmonids. If particles are mobilized at certain times of year it can affect the creation of redds, or the survival of eggs that have been laid in redds. Spawning substrate data are not available for the tributaries of this planning watershed.

Permeability

The survival of salmonid eggs depends in part on the permeability, or flow of water through the gravels. This serves to deliver oxygen to the incubating eggs and remove waste from the egg pocket. The intrusion of fine sediment into the gravel reduces this intergravel flow by reducing permeability, thus oxygen availability decreases and metabolic wastes build up, affecting embryo survival (McBain and Trush 2000).

Factors besides permeability which affect survival of salmonid eggs within redds include temperature, dissolved oxygen, flow, and fine sediment. Additionally, not all eggs laid in a redd are viable, and some will naturally die and disintegrate. Survival to emergence was calculated using an equation from McBain and Trush (2000), which relates this factor to permeability. If the survival to emergence value calculated from permeability is low, this is an indication that even if the other factors affecting survival of eggs and embryos are suitable there may still be low emergence. Conversely, if estimated survival values based on permeabilities are high, it indicates permeability is suitable although the other factors influencing survival may affect actual emergence.

Median permeability measurements on the lower mainstem Albion below the South Fork (Table 45) were higher in 1998 (27174.5 cm/hr) than they were in 2000 (4656.5 cm/hr). Based on these permeability samples, the median estimated percent survival to emergence at this site calculated from McBain and Trush (2000) were 68% in 1998 and 42% in 2000. These values reflect conditions at the site before a spawning fish has worked the gravels during redd construction.

As was previously mentioned, numerous factors can affect permeability, including fine sediment and stream flow. Fine sediment levels < 0.85 mm at this sample site in 1998 were below TMDL target values. However, because the suitability of fine sediment below TMDL target values cannot be assessed at this time, their affect on permeability is also undetermined. Data for fines are not available for this site in 2000. Stream flow records and data on other parameters that could affect permeability were not available for this site. Therefore, it is unknown what affect, if any, they had on permeability at this site.

Water Chemistry

Limited historic and current data for the mainstem Albion River were available for analysis. The Regional Water Board collected grab sample data at three mainstem locations (two in the estuary) during the period from 1976-1988, and one location in 2001 (Figure 47 and Table 49). Maahs and Cannata (1998) monitored ten mainstem Albion locations in the estuary for salinity and three for dissolved oxygen. Water chemistry data were not available for tributaries in this subbasin.

Limited current water chemistry data in this subbasin reflect conditions at monitoring locations, which are suitable for salmonids with respect to pH and specific conductance (S.C.), although at times dissolved oxygen (D.O.) appears to be unsuitable in the estuary (

Table 50). However, caution should be used when making assumptions about the entire subbasin from limited spatial and temporal data.

Table 49. Water quality sampling site information for the Coastal Subbasin.

Water Chemistry					
Location	**River Mile**	**Report Station ID**	**Alt. Station ID(s)**	**Contributor**	**Years Sampled**
Lower Mainstem Albion River	0.5	STORET-1[1]	WB01B041900	StoRet/ RWQCB	1985-1988
	1.0	STORET-2[1]	WB01B134002		1987-1988
	6.6	STORET-3	F8063000		1976-1977, 1985
	8.0	WQ-1	ALBMST	RWQCB	2001

Table 50. Water chemistry parameters in the Coastal Subbasin.

Parameter Name	Total Number Samples	Number Detect Samples	Period of Record	Detect Sample, Range (Min-Max	Criteria	Number Samples Violating Criteria	Criteria Source
Lower Mainstem Albion River (Tidal Influence)							
Dissolved Oxygen (mg/L)	12	12	1988 & 1997	4-12.0	≥7.0	7	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
pH (Standard Units)	10	10	1985-1988	7.5-8.0	6.5-8.5	0	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
Specific Conductance (umhos/cm)	9	9	1985-1988	7800-74000	none	-	-
Boron, Total (ug/L as B)	6	6	1987-1988	530-3600	630	5	US EPA IRIS one-in-a-million incremental cancer risk estimate for drinking water. See Marshack (2000).
Chloride, Total in Water (mg/L)	9	9	1985-1988	3000-19000	250	9	California Secondary MCL for drinking water. See Marshack (2000).
Iron, Total (ug/L as Fe)	6	6	1987-1988	30-1400	300	2	California Secondary MCL for drinking water. See Marshack (2000).
Sodium, Total (mg/L as Na)	6	6	1987-1988	1800-9800	2	6	US EPA Drinking Water Health Advisory or SNARL. See Marshack (2000).
Sulfate, Total (mg/L as SO4)	9	9	1985-1988	380-2900	250	9	California Secondary MCL for drinking water. See Marshack (2000).
Lower Mainstem Albion River (Non-Tidal Influence)							
Dissolved Oxygen (mg/L)	25	25	1976-1977, 1985, 2001	2.3-11.3	≥7.0	14 (H)	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
pH (Standard Units)	24	24	1976-1977, 1985, 2001	6.7-7.8	6.5-8.5	0	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
Specific Conductance (umhos/cm)	24	24	1976-1977, 1985, 2001	160-355	none	-	-
Iron, Total (ug/L as Fe)	5	4	1976-1977, 2001	110-1200	300	3 (H)	California Secondary MCL for drinking water. See Marshack (2000).
					1000	2 (H)	US EPA National Recommended Ambient Water Quality Criteria for Freshwater Aquatic Life Protection. See Marshack (2000).

H = Historic sample

[1] Samples were collected at two sites for each parameter, except dissolved oxygen which was collected at five sites.

Maahs and Cannata (1998) conducted salinity profiles in 1997 from May to December. They sampled ten locations in the Albion River estuary from the river's mouth to Deadman Gulch. Salinity profiles at each station were performed approximately every week throughout this time. Tidewater influence in the Albion extends approximately five miles upstream (Maahs and Cannata 1998). During November and December freshwater contribution becomes noticeable around 1.0 mile up the estuary when surface salinity levels decrease most likely due to increased stream flow from precipitation. During the other months monitored salinity levels were relatively constant throughout profiles of the estuary until around 1.8 miles up the estuary, where surface salinity levels decreased most likely due to freshwater contribution from tributaries.

Historically, dissolved oxygen levels at estuary sites in the Albion River were above 7.0 mg/L, and therefore fully supportive of salmonids. A recent study of the estuary by Maahs and Cannata (1998) found D.O. levels at several locations in the Albion River estuary below acceptable levels for salmonids, and therefore conditions may be unsuitable. During the 1997 study, D.O. levels in the upper estuary ranged from 5.5-6 mg/l at the surface, and from 4-7 mg/l at depths from 1-4 meters.

Historic specific conductance and pH levels at monitoring sites in the Albion River estuary were within ranges that were fully suitable for salmonids. No current data exists for these parameters in the estuary.

Historically, sites in the estuary occasionally violated various human health drinking water quality thresholds for boron, chloride, iron, sodium, and sulfate. These samples were collected in the saline water of the estuary, which is unlikely to be a source for drinking water. However, because the Albion River is designated as a municipal source (MUN) in the Basin Plan (2001), drinking water standards were applied even though it is highly unlikely that water from the estuary is or will be used for drinking water purposes. Marine aquatic life standards were not violated for these parameters, where they exist. Therefore, it appears that these parameters are within levels, which are suitable for salmonids. There were no current data available for any the above parameters in the estuary.

The majority of historic dissolved oxygen samples performed at the site on the lower mainstem Albion River above tidal influence in this subbasin was below 7.0 mg/L. Although historic D.O. levels are considered unsuitable for salmonids, data from the current monitoring location in the lower Albion were supportive of salmonids. Historic and current pH and specific conductance levels from the lower mainstem above tidal influence are considered suitable for salmonids at those locations monitored.

On occasion, the historic sample site on the lower mainstem Albion River above tidal influence in this subbasin exceeded drinking water standards and freshwater aquatic life protection standards for iron. Current data from the site on the lower mainstem for this parameter are within suitable levels for salmonids.

Aquatic/Riparian Conditions

The estuarine riparian vegetation extends from the mouth of the Albion River to Duck Pond Gulch about five miles upstream. Long ribbons of saline tolerant plants algae mats and eelgrass characterize this estuarine vegetation. The upper estuary has accumulations of sediment forming mud flats wherever the width of the valley is sufficient. These mud flats vary from being highly saline wetlands in the lower estuary to freshwater marsh in the upper estuary. A current list of the plant species observed in the Coastal Subbasin is in the CDFG Appendix.

According to CalVeg data (2000), vegetation within 150 feet of the centerline of streams is composed of 57% conifer forest, >1% hardwood, >1% mixed forest, and 8% grassland, while shrubs, water, agricultural and urban combined make up the remaining 33%.

Fish Habitat Relationship

Estuaries and coastal lagoons are critical habitats for anadromous salmonids. The mixing of sea and fresh waters creates conditions well suited for the anadromous life history strategies of salmonids. Salmonids pass through the estuary as juveniles during their seaward migrations and again as adults, swimming upstream to their freshwater spawning grounds. The brackish water of the estuary provides salmonids with an important area to acclimate to changes in salinity as they move between the freshwater and marine environments. Estuaries also are important nursery grounds due to high productivity of nutrients and relative isolation from predators.

During seaward migrations, all juvenile salmonids utilize at least a brief estuarine residence while they undergo physiological adaptations to salt water and imprint on their natal stream. Juvenile salmonids may also extend their estuarine residency to utilize the sheltered, food rich environments before entering the ocean. Studies have revealed that juvenile salmonids utilizing estuaries for three months or more return to their natal stream at a higher rate than non-estuarine reared members of their cohort (Reimers 1973; Nicholas and Hankin 1988). Estuarine reared salmonids may be at an advantage because they enter the ocean at a larger size or during conditions that are more favorable. Entering the ocean at a larger size may be advantageous by allowing juvenile salmonids to avoid predation or by increasing the variety and number of their prey items.

Salmonid utilization of the estuarine environment is a strategy that adds diversity to juvenile salmonid life history patterns and increases the odds for survival of a species encountering a wide range of environmental conditions in both the freshwater and marine environment. Additionally, an extended estuarine residency may be especially beneficial for salmonids from rivers where low summer flows or warm water temperatures severely limit summer rearing habitat. These benefits are enhanced by the estuary retaining its connection with cool, nutrient rich seawater, maintaining adequate depth and subsurface shelter complexity, and containing enough vegetation density (both in and out of the water), to supply temperature moderation, nutrition and cover.

There are 3.7 stream miles on three perennial tributaries in this subbasin. Two streams, Railroad and Pleasant Valley gulches, were surveyed by L-P in 1994 and again by CDFG in 2003 (Table 51). The surveys included channel typing using the classification system developed by David Rosgen (Rosgen 1996), habitat typing, and biological sampling as described in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998). Details of Coastal Subbasin surveys are in the CDFG Appendix.

Table 51. Coastal Subbasin surveyed tributary with Rosgen channel types.

Stream	CDFG Survey (Y/N)	Survey Length (miles)	Estimated Anadromous Habitat Length (miles)*	Reach	Channel Type
Lower Mainstem Albion River	N		5.0		
Railroad Gulch	Y	3.1	3.0	2	C4, F4
Pleasant Valley Gulch	Y	1.6	1.5	3	E4, B4, A4

CDFG protocol stream surveys observe measure, describe and record pool, flatwater, and riffle habitat units. During their freshwater life history, salmonids require access to all of these types of habitat and a balanced proportion is targeted. Dry units are also measured, and are indications of poor conditions for fish. All of the surveyed Coastal Subbasin streams in 2003 had less than 30% pool habitat by length (Figure 48). This is below the range considered fully suitable. No dry units were measured.

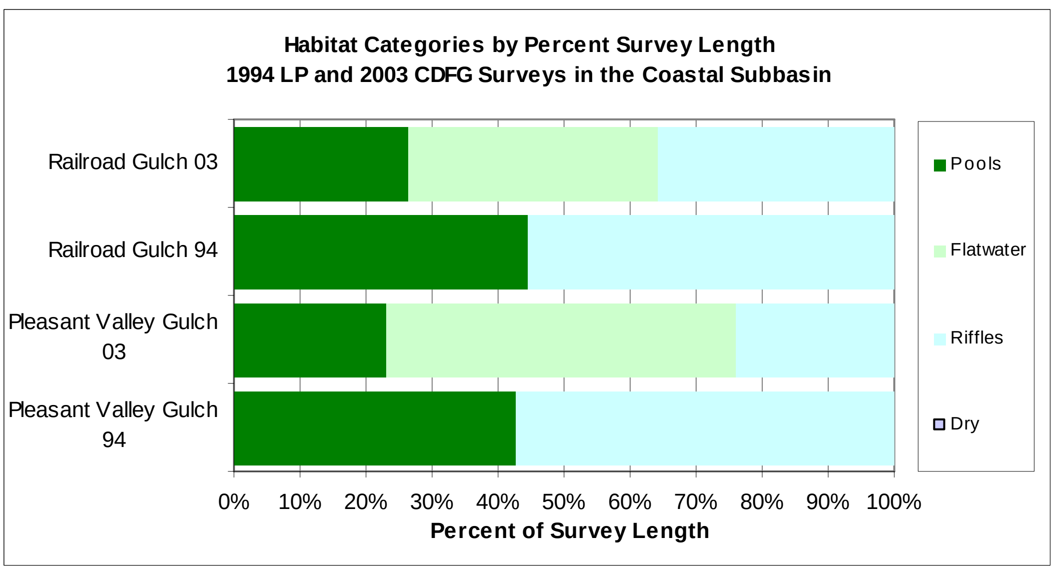


Figure 48. Percentage of pool habitat, flatwater habitat, riffle habitat, and dewatered channel by surveyed length, Coastal Subbasin. Streams in descending order by drainage area (largest at the top).

Canopy density, as estimated during CDFG surveys is a measure of the percentage of shade canopy over a stream. These measurements also provide an indication of the potential future recruitment of organic debris to the stream channel, as well as the insulating capacity of the stream and riparian areas during winter. Additionally, near stream forest density and composition can contribute to microclimate conditions that help moderate air temperature, which is an important factor in determining stream water temperature.

Stream canopy relative to the wetted channel normally decreases in larger streams as channel width increases due to increased drainage area.

The CDFG Restoration Manual sets a target of 80% for shade canopy along coastal streams. CDFG recommends areas with less than 80% shade canopy as candidates for riparian improvement efforts. In both the1994 and 2003 surveys, the canopy cover above the streams was estimated as fully suitable. The percentage of the coniferous component measured increased by 6% in Railroad Gulch and 17% in Pleasant Valley Gulch. A slight 4% decrease in overall canopy cover was estimated in Pleasant Valley Gulch (Figure 49). These slight differences could be attributable to observer variability.

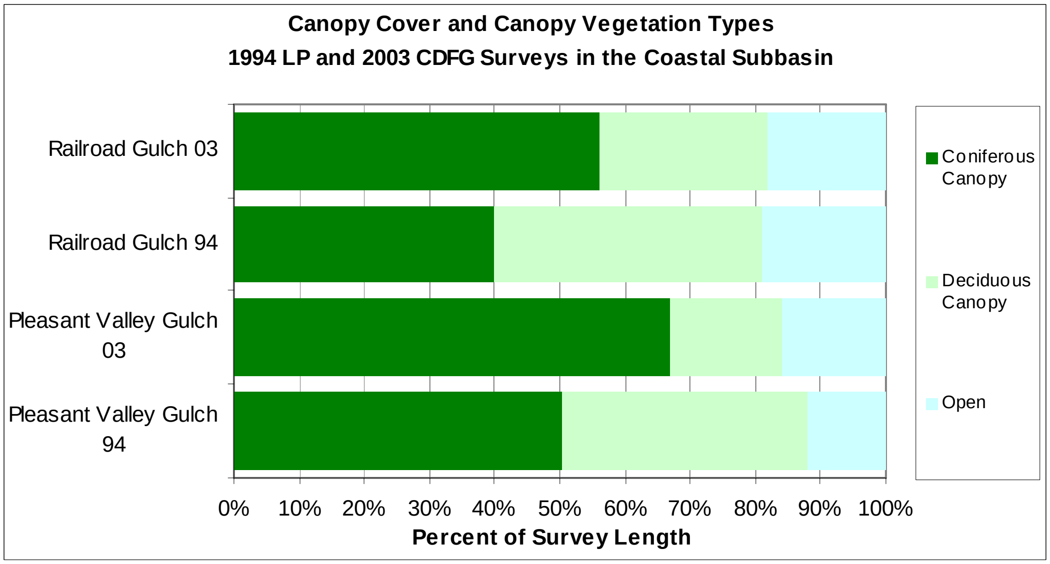


Figure 49. The relative percentage of coniferous, deciduous, and open canopy covering surveyed streams, Coastal Subbasin, Albion Basin. Streams in descending order by drainage area (largest at the top).

CDFG stream surveys measure embeddedness at pool tail crests. Crews examine several cobbles of average size for the stream reach at each sample site. Embeddedness is the percentage of the cobble surrounded by fine substrate. Category 1 is 0-25% embedded; Category 2 is 26-50% embedded; Category 3 is 51-75% embedded; Category 4 is 76-100% embedded, and Category 5 is unsuitable for spawning due to factors other than embeddedness (e.g. log sill, bedrock, boulders). Category 1 is best, category 2 is supportive, and category 3 and 4 are not within the suitable ranges for successful spawning or incubation of salmonids. Embeddedness value samples in the Coastal Subbasin indicated suitable conditions in both streams surveyed in 1994, and unsuitable conditions in 2003 (Figure 50).

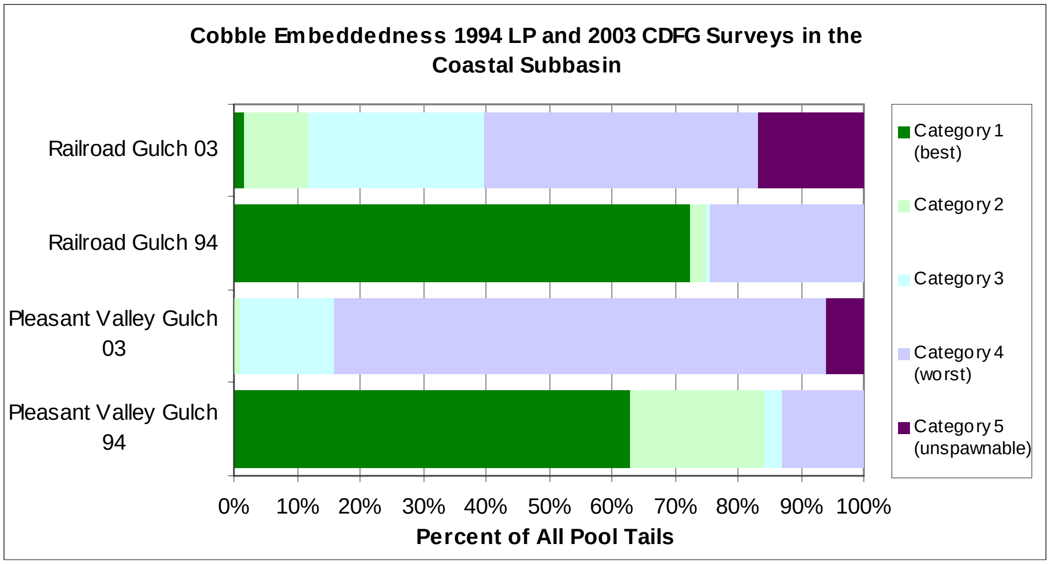


Figure 50. Cobble embeddedness categories as measured at pool tail crests in surveyed streams, Coastal Subbasin, Albion Basin. Streams in descending order by drainage area (largest at the top).

Pool depth is an important habitat component for salmonids. The CDFG Restoration Manual describes "primary" pools to be those with a maximum residual depth greater than 2' in first and second order streams, and greater that 3' in third and fourth order streams (Flosi et al. 1998). The CDFG target for primary pools is 40% of reach length as primary pools. Analysis of pool depths will indicate reach and stream conditions relative to other streams in a subbasin, and focus habitat improvement efforts.

L-P crews in 1994 did not measure pool depths, but the 2003 CDFG crews did. Pools by percent survey length were unsuitable according to the 2003 data (Figure 51).

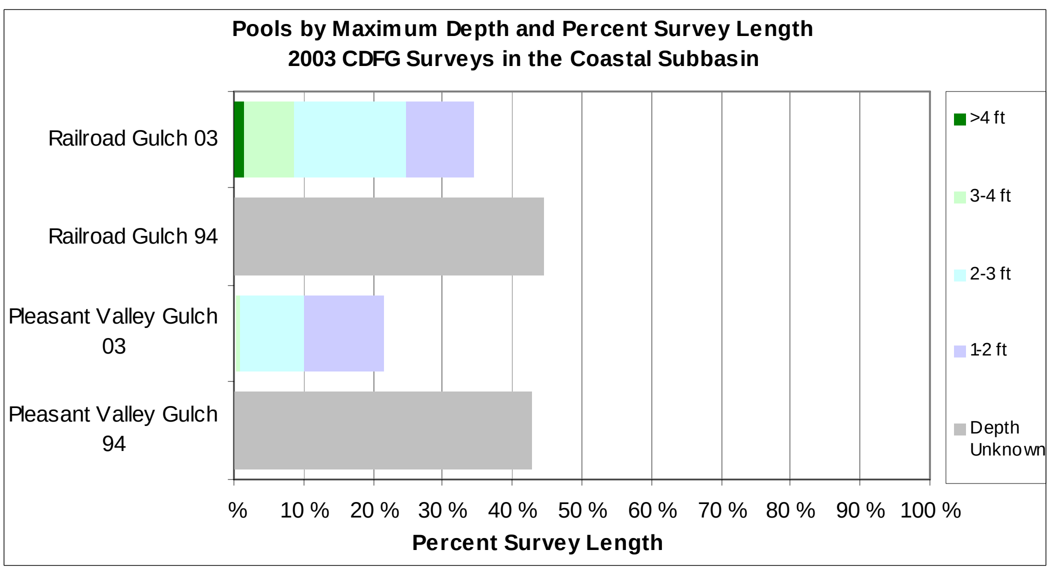


Figure 51. Percent length of a survey composed of deeper, high quality pools in the Coastal Subbasin. Streams in descending order by drainage area (largest at the top).

CDFG surveys measured pool shelter value. Pool shelter rating illustrates relative pool complexity, another component of pool quality. Ratings range from 0-300. The Stream Reach EMDS model evaluates pool shelter to be fully unsuitable when ratings are less than 30. The range from 100 to 300 is fully suitable. These values comport with CDFG targets. Pool shelter ratings in the Coastal Subbasin ranged from somewhat unsuitable to unsuitable (Figure 52).

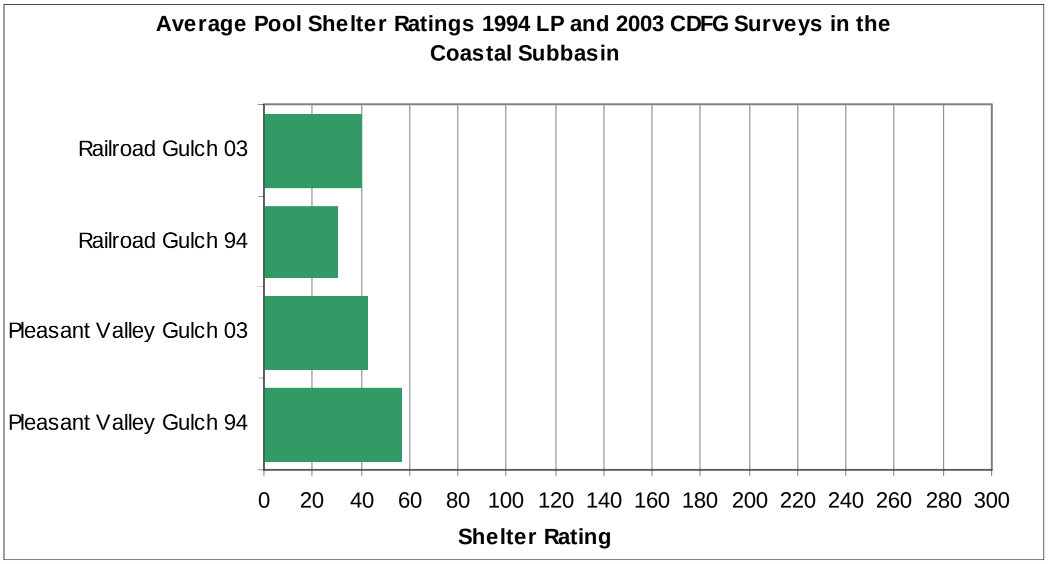


Figure 52. Average pool shelter ratings for 1994 L-P and 2003 CDFG surveys in the Coastal Subbasin. Streams in descending order by drainage area (largest at the top).

Fish Passage Problems and Barrier Removal History

A seawall located on the north side of the estuary at the Albion Flats campground is incomplete at this time and creates problems to anadromous salmonids and other wildlife. Problems occur due to increased velocities during periods of high discharge and tidal exchange because of the lack of roughness elements on the sea wall. This smooth surface has few places for salmonid fry and juveniles to escape the high energy of these events, causing fatigue and stress. The vertical wall is difficult or impossible to scale for other wildlife attempting to cross the river.

Stream clearing of large woody debris

Since 1966, a number of different logjam removal crews have worked in the Albion Basin. At the time of the earlier stream surveys (1961-66) it was believed that instream blockages caused by logjams hindered the up and down stream migrations of salmonids. In response to this belief, barrier removal projects were undertaken. In 1966, 62 sites were cleared of barriers. Six sites were in the Coastal Subbasin, on the mainstem Albion River.

In the late 70s and early 80s, two more barrier removal projects were conducted in the lower Albion River. The Center of Education and Manpower Resources (CEMR) removed accumulations from the lower mainstem of the Albion River in 1979-80 (W. Kidd personal communication). New Growth Forestry removed LWD from the lower mainstem of the Albion River on the MacDonald property in 1985. For further details, see the CDFG Appendix.

Fish History and Status

Historically, the Coastal Subbasin supported runs of coho salmon, steelhead trout, and possibly Chinook salmon. The CDFG stream surveys in the 1960s found coho salmon and steelhead trout in three streams: lower mainstem Albion River, and Railroad and Pleasant Valley Gulches. Currently, both species are present with coho salmon appearing to be more numerous.

A study of the estuary by Maahs and Cannata (1998) recorded the presence of coho salmon and steelhead trout in the lower mainstem of the Albion River. The study included seining and established length frequencies and utilization periods for coho salmon. Twenty-eight other species of marine and estuarine fishes were recorded (Maahs and Cannata 1998) (

Table 52).

Table 52 Current fish species in the Coastal Subbasin.

Common Name	Scientific Name
Arrow Goby	*Clevelandia ios*
Bay Pipefish	*Syngnathus leptorhynchus*
Cabezon	*Scorpaenichthys marmoratus*
Copper or Gopher Rockfish	*Sebastes caurinus or carnatus*
English Sole	*Parophrys vetulus*
Jack Smelt	*Atherinopsis californiensis*
Monkeyface Prickleback	*Cebidichthys violaceus*
Northern Anchovy	*Engraulis mordax*
Pacific Herring	*Cupea harengus pallasii*
Pacific Sardine	*Sardinops sagax caeruleus*
Pacific Staghorn Sculpin	*Leptocottus armatus*
Penpoint Gunnel	*Apodichthys flavidus*
Pile Surfperch	*Damalichthys vacca*
Plainfin Midshipman	*Porichthys notatus*
Rainbow Surfperch	*Hypsurus caryi*
Rubberlip Surfperch	*Rhacochilus toxotes*
Shiner Surfperch	*Cymatogaster aggregata*
Silverspot Sculpin	*Blepsias cirrhosus*
Speckled Sanddab	*Citharichthys stigmaeus*
Starry Flounder	*Platichthys stellatus*
Surf Smelt	*Hypomesus pretiosus*
Striped Surfperch	*Embiotoca lateralis*
Topsmelt	*Atherinops affinis*
Walleye Surfperch	*Hyperprosopon argenteum*
Yellowtail Rockfish	*Sebastes flavidus*
Coastrange Sculpin	*Cottus aleuticus*
Prickly Sculpin	*Cottus asper*
Threespine Stickleback	*Gasterosteus aculeatus*

Maahs and Cannata (1998) conducted twenty-six seining operations from May 22 through December 24, 1997. The length frequencies of the coho salmon captured during the seining were recorded to determine the average size of coho that utilize the estuary (Figure 48). The 1997 data indicate that most juvenile coho begin leaving the estuary for the ocean in June, and by August, few remain.

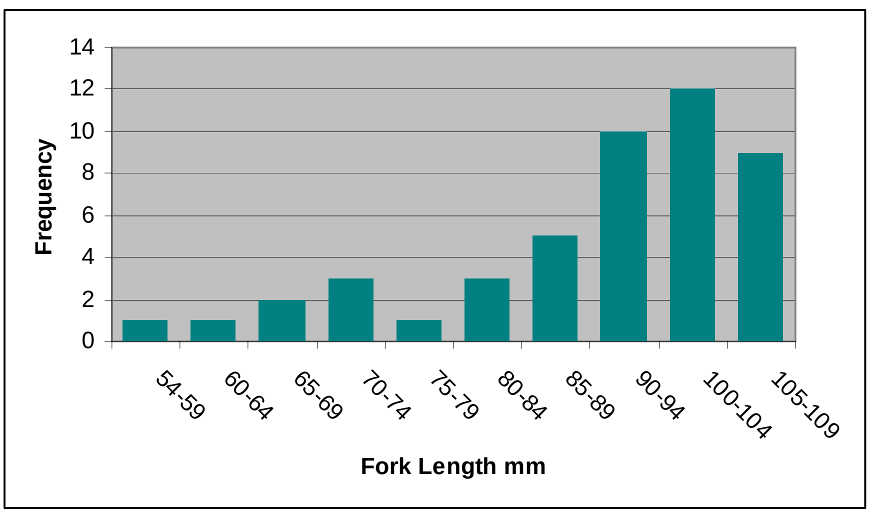


Figure 53: Length frequencies of coho from 1997 in the Coastal Subbasin.

Long time residents have reported observing sea lions feeding on adult salmonids in the fall and juveniles in the late summer. Populations of sea lions have been increasing since the passage of the Marine Mammal Protection Act in 1972 (CDFG Marine Resources Report 2001). The California sea lion population in the US waters have increased from approximately 25,000 in 1970 to over 150,000 to 1997 (Stewart 1997).

Recent studies estimated that seals and sea lions combined ate 2.3-2.6% of the fall Chinook salmon entering the Klamath estuary (Williamson 2002). A dietary analysis of California sea lions at the mouth of the Klamath found that lampreys were the main prey item and that 1-8% of diet samples included salmon (Bowlby 1981). No studies have been conducted specific to the Albion Basin estuary.

Coastal Subbasin Issues

From the various disciplines' assessments and constituent input, the following issues were developed for the Coastal Subbasin. These must be considered in context of the Albion's Franciscan mélange geology and the high percentage of low gradient depositional areas in the lower reaches of the subbasin tributaries and the long, tidally influenced estuary itself:

- CDFG surveys found fine sediment in low gradient stream reaches in the lower Albion River, and Railroad and Pleasant Valley gulches;
- Fine sediment <6.4 mm in the mainstem below the South Fork exceed TMDL targets and therefore are unsuitable;
- Water temperatures and dissolved oxygen in the upper tidal portion of the mainstem estuary below Railroad Gulch may be unsuitable for salmonids;
- In many reaches, instream habitat, escape and ambush cover, pool depth, and substrate embeddedness are unsuitable for salmonids;
- There is a lack of suitably sized spawning substrate in Railroad and Pleasant Valley gulches, and the lower mainstem below the South Fork;
- Reaches sampled in Lower Mainstem Albion, Duck Pond, Railroad, and Pleasant Valley gulches have small particle size (D50);
- Large woody debris recruitment potential in the Coastal Subbasin is poor overall due to the wide estuary flood plain and low transport flows;
- Rural subdivision and development in the estuary and Albion Ridge areas have increased land use impacts;
- There is a high density of current and legacy roads, some of which contribute fine sediment to streams in the subbasin;
- There have been negative impacts to streams and fish habitat from legacy timber harvest practices;
- The estuary may be shallower now than in the past and it currently lacks channel complexity.

Coastal Subbasin Integrated Analysis

The following analyses provide a dynamic, spatial picture of basin conditions for the freshwater life stages of salmonids. Comments are presented on the impacts of these conditions on the stream or fishery. Especially at the tributary and subbasin levels, the dynamic, spatial nature of these processes provides a synthesis of the basin condition and indicates the quantity and quality of the freshwater habitat for salmon and steelhead. In depth analyses of watershed processes were only conducted for water quality and instream habitat for the Albion Basin due to budgetary constraints.

Water Quality

Continuous water temperature data were available from three sites in the estuary during various years from 1994-2001 on the Lower mainstem Albion River, and from the lowest reach of each of three tributaries within tidal influence in various years from 2001-2002. Data were available for one site on each of four tributaries above tidal influence in various years during the period from 2000-2002.

Maahs and Cannata (1998) conducted estuary water temperature profiles in 1997 on a weekly basis from May to December. Samples were collected at ten locations from the mouth of the estuary to Deadman Gulch. Although MWATs and seasonal maximum temperatures cannot be calculated from these grab sample data, they are useful as indicators of locations in the estuary that may be unsuitable for salmonids and require further monitoring and analysis.

A single pebble count was available in the estuary for the lower reach of Railroad Gulch in 1998. The lack of sediment data in the estuary does not allow conclusions to be drawn about conditions for salmonids, although there is evidence of sediment accumulation in the estuary. Sediment data were available for five sites on the lower mainstem Albion River above tidal influence. Various parameters were collected during years from 1998-2001, including pebble counts (D50), bulk sediment samples, and permeability measurements. Pebble counts were performed on three tributaries above tidal influence in 1998 at five sites.

Water quality monitoring took place at two closely spaced locations on the mainstem in the estuary, but were sporadically sampled from 1985-1988. In 1997, Maahs and Cannata (1998) monitored three locations in the estuary for dissolved oxygen. Above tidal influence, historic samples are available from one lower mainstem location monitored in various years from 1976-1985. Current data are also available from one site on the lower mainstem Albion monitored in 2001. Water chemistry data are not available in the tributaries of this subbasin. In general, water chemistry data was inconsistently collected and it is difficult to make any significant conclusions with the limited data available.

The information in the tables below is a summary of the water quality data, which was presented earlier in this section, with additional information about the significance of each of the parameters.

Table 53. Water temperature summary table for the Coastal Subbasin.

<table>
<tr><th colspan="5">TEMPERATURE</th></tr>
<tr><th colspan="5">Significance-MWATs</th></tr>
<tr><td colspan="5">The maximum weekly average temperature (MWAT) is the maximum value of a seven-day moving average of the daily average temperatures. The MWAT range for "fully suitable conditions" of 50-60°F was developed as an average of the needs of several cold-water fish species, including coho salmon and steelhead trout. As such, it does not represent fully suitable conditions for the most sensitive cold-water species (usually considered to be coho). Temperatures between 61-62°F are considered "moderately suitable," while a temperature of 63°F is considered "somewhat suitable." The suitability of a 64°F temperature is considered "undetermined." Temperatures of 65°F and above are within the ranges considered "unsuitable" for salmonids (Refer to EMDS Appendix).</td></tr>
<tr><th colspan="5">Significance-Seasonal Maximum Temperatures</th></tr>
<tr><td colspan="5">The seasonal maximum temperature is the highest value of the maximum daily water temperatures during a calendar year. Through extensive literature research, it has been determined that once the threshold of 75°F is exceeded salmonids experience high levels of mortality if cold water refugia is unavailable (Sullivan et al. 2000). Therefore, seasonal maximum temperatures below 75°F are considered "suitable", while temperatures above this threshold are "unsuitable" for salmonids.</td></tr>
<tr><th colspan="2">MWATs</th><th colspan="2">Seasonal Maximum Temperatures</th><th>Discussion-MWATs</th></tr>
<tr><td colspan="4">Lower Mainstem Albion River (Tidally influenced)[1]</td><td rowspan="6">One site on the lower mainstem Albion River below Railroad Gulch in the estuary was unsuitable (1998-2001), and one record from the tidally influenced lower mainstem site above Duck Pond Gulch was unsuitable in 2001. Tributary monitoring locations within tidal influence were all fully suitable.

Tributary locations monitored above tidal influence were fully to moderately suitable.</td></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>6</td><td>5</td><td>9</td><td>2</td></tr>
<tr><td colspan="4">Tributaries (Tidally influenced) [2]</td></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>5</td><td>0</td><td>5</td><td>0</td></tr>
<tr><td colspan="4">Tributaries (Non-tidally influenced)[3]</td><th>Discussion-Seasonal Maximum Temperatures</th></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Record</td><td rowspan="5">Most estuary locations monitored were fully suitable, with the exception of two records on the mainstem Albion below Railroad Gulch in the estuary.

Tributary records above tidal influence were all fully suitable for salmonids.</td></tr>
<tr><td>6</td><td>0</td><td>6</td><td>0</td></tr>
<tr><td colspan="4">[1] Samples at one station from 1998-2001.</td></tr>
<tr><td>[2] Samples at three stations in 2001 & 2002.</td><td>0</td><td>6</td><td>0</td></tr>
<tr><td>[3] Samples at two sites from 1994-2001.</td><td>Data: MRC & MCWA</td><td></td><td></td></tr>
</table>

[1] Samples at three stations from 1994-2001.

[2] Samples at three stations in 2001 & 2002.

[3] Samples at four sites from 2000-2002.

MWATs in the estuary on the lower mainstem below Railroad Gulch (RM 4.7) were unsuitable in all years of collected data, and seasonal maximum temperatures were lethal to salmonids two of four years (Table 53). MWATs at the tidally influenced monitoring locations on the lower mainstem above Duck Pond gulch (RM 5.6) were generally fully to moderately suitable, although the 2001 MWAT was unsuitable. Seasonal maximum temperatures at this site were suitable. Tributary monitoring sites within tidal influence were fully suitable for salmonids with respect to both MWATs and seasonal maximum temperatures. Water temperatures from grab samples performed by Maahs and Cannata (1998) ranged from 45-77°F. The water temperatures at all 10 stations monitored include readings over 65°F, which are unsuitable to salmonids to varying degrees. Accordingly, there are periods when temperatures in areas of the estuary are unsuitable. This is consistent with observations based on the continuous monitoring data from the lower mainstem estuary site below Railroad Gulch. However, additional continuous monitoring of the estuary should be implemented to conclusively determine the suitability for salmonids.

MWATs at sites on the tributaries above tidal influence ranged from fully to moderately suitable, and seasonal maximum temperatures were all fully suitable.

Table 54. Instream sediment summary table Coastal Subbasin.

SEDIMENT
Significance-D50s
Pebble counts to determine the median particle size, or D50, of the streambed are used to characterize streambed substrate particle size distributions. Pebble counts are usually performed in the riffles of wadeable, gravel-bed streams. This simple and rapid method may help in determining if land use activities or natural land disturbances are introducing fine sediment into streams.

D50 (mm)		**Discussion-D50**
Tributaries (Tidally influenced) [2]		The D50 at the site on Railroad Gulch in the estuary indicates the presence of small sized particles on riffles in the size class of medium gravel (Rosgen 1996). Small particles would be expected in this area due to the effects of tidal influence depositing material at this location. Note: This sample site was specifically chosen to look at bed mobility potential.
Minimum	*Maximum*	
10		
Lower Mainstem Albion River (Non-tidally influenced) [1]		D50s at monitoring locations on the lower mainstem Albion above tidal influence in this subbasin were small ranging from medium to coarse gravel. D50s at sites on tributaries above tidal influence were also small ranging from medium to coarse gravel (Rosgen 1996). Note: Some cross-sections were not necessarily located on riffles in the streambed. Three different methods were used to collect data.
Minimum	*Maximum*	
9	28	
Tributaries (Non-tidally influenced) [3]		
Minimum	*Maximum*	
14	20	

Significance-Bulk Sediment Samples
The suitability of spawning gravels depends on the size of the fish, therefore a range of particle sizes (6 mm to 102 mm) are necessary to accommodate all sizes of salmonids (Bjorn and Reiser 1991). The instream substrate needs to be distributed over this range of sizes because of variations in salmonid size and their selection of spawning gravels. If all the particles were in the lower or upper part of this range it would limit the usefulness of these particles for salmonids. Bulk sediment samples are used to assess the amount of fine sediment and size of particles at pool tail-outs deemed suitable for spawning. Fine material < 0.85 mm can affect embryo survival by blocking the interstitial spaces between particles. This can decrease dissolved oxygen levels in the sediment, and prevent metabolic wastes from being carried away. Fine material < 6.4 mm have been known to impact salmonids during the emergence stage. Particles of this size can block the emergence of fry depending on the angularity of particles, and are inversely related to the size of emerging fry (Chapman 1988). The TMDL target values for fine sediment < 0.85 mm and < 6.4 mm (< 14% and < 30% respectively) are not directly comparable to the data due to different collection methodologies. However, it can be determined that fine sediment levels that exceed these targets are unsuitable for salmonids, while values below the targets are of unknown suitability (see Water Quality Appendix for further detail).

Bulk Sediment		**Discussion-Bulk Sediment (fine sediment)**
Median % <0.85 mm	**Median % <6.3/6.4 mm**	Median values for the percent of fine sediment <0.85 mm were below the TMDL target value, and therefore no determination can be made about their suitability at this time. The median percent <6.3/6.4 mm were equal to or slightly above the target at sites on the lower Mainstem Albion, and therefore considered unsuitable. Further investigation should be performed to determine conclusively whether fines at these locations are suitable for salmonids. Note: Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis (see discussion page 20 and Water Quality Appendix).
Lower Mainstem Albion River (Non-tidally influenced) [4]		
Minimum-Maximum	*Minimum-Maximum*	
7-9	30-31	

50th percentile of particles (mm)		Discussion- Bulk Sediment (particle distribution)
Lower Mainstem Albion River (Non-tidally influenced)[4]		At least 50% of the particles from instream substrate samples were in the lower quarter of the range used by spawning salmonids. This indicates a lack of larger particles at sampling locations in this subbasin, which could limit their usefulness to salmonids. Note: 75th percentile of particles ranged from 22.6-66.0 mm, and the 25th percentile of particles ranged from 3.6-5.1 mm.
Minimum	*Maximum*	
11.8	21.8	

Significance-Thalweg/Cross-sections
Stream transects, or cross-sections provide a bottom profile of the streambed along a transect perpendicular to the direction of the flow. Thalweg measurements help develop a picture of the profile of the stream by measuring the elevation (depth) of the stream along a longitudinal transect. Multiple year data sets can reveal whether a location is aggrading (accumulating sediment), degrading (losing stored sediment), undergoing channel shifts (changes within an established floodplain), or channel migration (changes beyond established floodplains).

Thalweg/Cross-sections	Discussion-Thalweg/Cross-sections
Lower Mainstem Albion River[5]	Limited Thalweg data did not allow for trend analysis. Cross-sections showed mostly channel shifts within the established floodplain. Aggradation, degradation, and shifts in the thalweg are apparent at some cross-sections. Sediment volumes were not calculated (Water Quality Appendix.)
1998, 2000, & 2001	

Significance-Streambed Permeability
The survival of salmonid eggs depend on the flow of water through the gravels. This serves to deliver oxygen to the incubating eggs and remove metabolic wastes from the egg pocket. The intrusion of fine sediment can reduce intergravel flow by reducing permeability, thus oxygen availability decreases and metabolic wastes build up (McBain and Trush 2000). Additional factors such as low flows can also affect substrate permeability. An equation which uses permeability to calculate the estimated percent survival to emergence was used to assess conditions for salmonid embryos (see Water Quality Appendix for more details).

Streambed Permeability		Discussion-Permeability and Percent Survival
Median Permeability (cm/hr)	**Median Survival (%)**	Median permeabilities and the estimated median percent survival at the monitoring locations on the lower mainstem Albion above tidal influence in this subbasin were lower in 2000 than they were in 1998. These values reflect conditions before a spawning fish has worked the gravels into a redd, and therefore it is assumed that permeability would improve to some degree through the creation of the redd.
Lower Mainstem Albion River (Non-tidally influenced)[6]		
Minimum-Maximum	*Minimum-Maximum*	
4656.5-27174.5	42-68%	

[1] Nine samples at four sites in 1998, 2000, & 2001.
[2] One sample at one station in 1998.
[3] Five samples at five sites in 1998.
[4] Two samples at two sites in 1998 & 2001.

Data: MRC, GMA, RWQCB

[5] Samples at one site.
[6] Two samples at one site in 1998 & 2000.

A D50 of 10 mm was calculated in the tidally influenced portion of Railroad Gulch (Table 54). This small size of substrate is what would be expected in the estuary. The lack of data does not allow for any significant analysis of sediment conditions in the estuary.

Above tidal influence, D50s at sampling locations were small on the lower mainstem Albion River and tributaries monitored. The median percent of fine sediment at sites on the lower Mainstem were below the TMDL target for fine sediment <0.85 mm, and therefore their suitability cannot be determined now. Data for the median percent of fines <6.3/6.4 mm were right at or slightly above the TMDL target value, indicating unsuitable levels of fine sediment <6.3/6.4 mm at lower Mainstem monitoring locations. The majority of particle sizes available to spawning salmonids were concentrated in the lower quarter of the 6-102 mm range, indicating a lack of larger particles at monitoring locations. Median permeabilities were lower in 2000 than they were in 1998 at the lower mainstem monitoring site, as were the calculated median percent survival to emergence values.

Table 55. Water chemistry summary table in the Coastal Subbasin.

<table>
<tr><th colspan="3">WATER CHEMISTRY</th></tr>
<tr><th colspan="3">Significance-Dissolved Oxygen (D.O.)</th></tr>
<tr><td colspan="3">Dissolved oxygen enters the water by photosynthesis of aquatic biota and by the transfer of oxygen across the air-water interface. The Basin Plan (RWQCB 2001) requires a minimum level of 7.0 mg/l be maintained to protect beneficial uses in the Albion River, including salmonids.</td></tr>
<tr><th colspan="3">Significance-pH</th></tr>
<tr><td colspan="3">The Basin Plan requires that pH be within the range from 6.5-8.5 to protect the beneficial uses in the Albion River, including salmonids. These pH levels help control/regulate the chemical state of nutrients such as CO2, phosphates, ammonia, and some heavy metals.</td></tr>
<tr><th colspan="3">Significance-Specific Conductance (S.C.)</th></tr>
<tr><td colspan="3">Specific conductance is the measure of ionic and dissolved constituents in aquatic systems. The quantity and quality of dissolved solids-ions can determine the abundance, variety and distribution of plant/animals in the aquatic environment. Osmoregulation efficiency largely dependent on salinity gradients. Estuary salinity is essential to outmigrant smoltification.</td></tr>
<tr><th colspan="2">Lower Mainstem Albion River (Tidally influenced)</th><th>Discussion-D.O., pH, S.C.</th></tr>
<tr><th colspan="2">Dissolved Oxygen (mg/L)[1]</th><td rowspan="20">Historic estuary grab sample data results are protective of the beneficial uses of water described in the Basin Plan for the Albion River, and therefore suitable for salmonids. The high specific conductance levels are what would be expected in the saline waters of the estuary. Current estuary data is sparse, although a study by Maahs and Cannata (1998) found D.O. levels were potentially limiting in at sites the upper estuary.

Historic data from the site on the lower Albion River above tidal influence in this subbasin are suitable for pH and S.C. although dissolved oxygen was unsuitable at times. Current data reflect conditions which are suitable at the monitoring location with respect to all three parameters.

Note: Grab samples are limited both spatially and temporally. Further study should be performed to conclusively determine current conditions for salmonids.</td></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>4</td><td>12.0</td></tr>
<tr><th colspan="2">pH (Standard Units)[2]</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>7.5</td><td>8.0</td></tr>
<tr><th colspan="2">Specific Conductance[3]</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>7800</td><td>74000</td></tr>
<tr><th colspan="2">Lower Mainstem Albion River (Non-tidally influenced)</th></tr>
<tr><th colspan="2">Dissolved Oxygen (mg/L)[4]</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>2.3</td><td>11.3</td></tr>
<tr><th colspan="2">pH (Standard Units)[5]</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>6.7</td><td>7.8</td></tr>
<tr><th colspan="2">Specific Conductance[5]</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>160</td><td>355</td></tr>
<tr><td colspan="2"></td></tr>
<tr><th colspan="3">Significance-Other Chemistry/Nutrients</th></tr>
<tr><td colspan="3">Quality and quantity of natural and introduced chemical/nutrient constituents in the aquatic environment can be toxic, beneficial, or neutral to organisms. Chemical composition can be influenced by rainfall, erosion and sedimentation, evaporation, and introduction of chemicals/nutrients through human and animal interactions.</td></tr>
<tr><th colspan="2">Lower Mainstem Albion River (Tidally influenced)</th><th>Discussion-Chemistry/Nutrients</th></tr>
<tr><th colspan="2">Boron, Total[6]</th><td rowspan="8">Historically, limited sampling was performed to collect information on other water chemistry parameters and nutrients in the estuary. On occasion, the data presented here exceeded various human health standards for drinking water. It is unlikely the saline waters of the estuary would be used for drinking water, but due to the designation of the Albion River as a municipal source in the Basin Plan (2001), drinking water standards are applied. Where marine aquatic life standards existed for these parameters, they were not exceeded.</td></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>530</td><td>3600</td></tr>
<tr><th colspan="2">Chloride, Total in Water (mg/L)[3]</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
<tr><td>3000</td><td>19000</td></tr>
<tr><th colspan="2">Iron, Total (ug/L as Fe)[6]</th></tr>
<tr><td>Minimum</td><td>Maximum</td></tr>
</table>

30	1400	In the lower mainstem Albion of this subbasin above tidal influence historic iron levels occasionally exceeded various human health and freshwater aquatic life standards at the locations monitored. Current data were within suitable levels for all parameters tested. Note: Grab samples are limited both spatially and temporally. Further study should be performed to conclusively determine current conditions for salmonids.
Sodium, Total (mg/L as N)[6]		
Minimum	*Maximum*	
1800	9800	
Sulfate, Total (mg/L as SO4)[3]		
Minimum	*Maximum*	
380	2900	
Lower Mainstem Albion River (Non-tidally influenced)		
Iron, Total (ug/L as Fe)[7]		
Minimum	*Maximum*	
110	1200	

Data: STORET, RWQCB, Maahs and Cannata (1998)
[1]Twelve samples from five sites in 1988 & 1997.
[2] Ten samples from two sites in 1985-1988.
[3] Nine samples from two sites in 1985-1988.
[4]Twenty-five samples from two sites in 1976-1977, 1985, and 2001.
[5] Twenty-four samples from two sites in 1976-1977, 1985, and 2001.
[6] Six samples from two sites in 1987-1988.
[7] Five samples from one site in 1976-1977 and 2001.

Historic water chemistry data in the estuary are very limited, as are current data. The data available are inadequate to paint a complete picture of conditions in the estuary. Historically, dissolved oxygen, pH, and specific conductance in the estuary appear to have been suitable for salmonids at the times and locations where sampling was performed (

Table 55). Other water quality parameters violated various human health standards, although no marine aquatic life standards were violated. Current data for dissolved oxygen at sites in the estuary provide a partial snapshot of conditions, which appear to be generally unsuitable for salmonids.

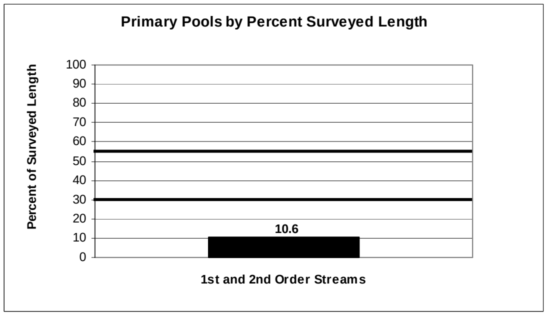
As was the case in the estuary, water chemistry data for the lower mainstem Albion above tidal influence are limited. Over half of the historic dissolved oxygen samples from the lower mainstem Albion site above the estuary were unsuitable for salmonids, while historic pH and specific conductance levels were suitable. Occasionally, iron levels historically violated freshwater aquatic life standards and drinking water standards. Current data for pH, S.C., and D.O. at the lower mainstem site appear to be suitable for salmonids, although with such limited information it is difficult to draw any significant conclusions.

Instream Habitat

Introduction

The products and effects of the watershed delivery processes examined in the Integrated Analyses tables are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Albion Basin are presented in the CDFG Instream Habitat Integrated Analysis. Instream habitat data presented here were compiled from stream inventories, an estuary study, and fish passage barrier removal projects. Details of these reports are presented in the CDFG Appendix.

Primary Pools



Mean target value 42.5%

Figure 54: Primary pools in Pleasant Valley and Railroad gulches in the Coastal Subbasin.

Pools greater than 2 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30-55% of its length in primary pools to be suitable for salmonids. In first and second order streams, a primary pool is described as being at least two feet deep. In third and fourth order streams, a primary pool is described as being at least three feet deep.

Comments: The percent of primary pools by length in tributaries in the Coastal Subbasin is generally below target values for salmonids. Pool depth and frequency data were collected in 2003 by the California Department of Fish and Game.

Spawning Gravel Quality

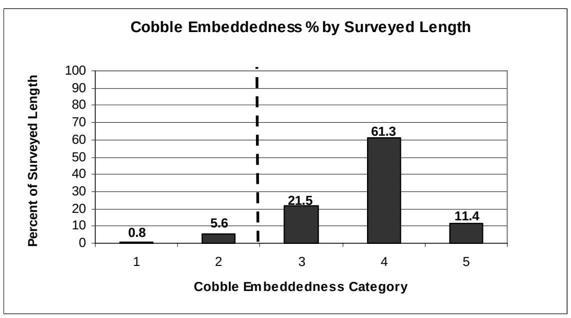


Figure 55: Embeddedness in Pleasant Valley and Railroad gulches in the Coastal Subbasin.

Significance: Successful salmonid egg and embryo survival diminishes when spawning occurs in streambeds with excessive silt, clay, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble at a pool tail out embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded and category 4 is 76%-100% embedded. Cobble embeddedness categories 3 and 4 are not within the suitable range for successful use by salmonids. Category 5 describes pool tail outs with unspawnable substrate such as bedrock, log sills, or boulders.

Comments: Most of the tidal and lower, silt dominated, depositional stream reaches in Coastal Subbasin tributaries have cobble embeddedness in excess of 51% (Categories 3 and 4). These are not considered to be eligible spawning areas, but skew the subbasin results toward unsuitability.

Shade Canopy

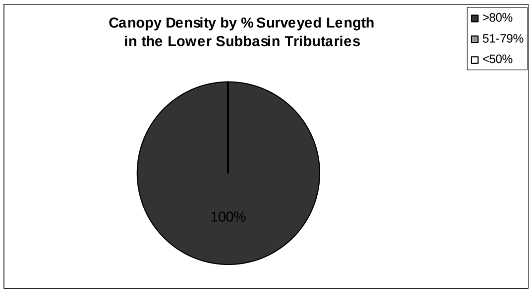


Figure 56: Shade canopy in Pleasant Valley and Railroad gulches in the Coastal Subbasin, Albion.

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is unsuitable and greater than 85% is fully suitable.

Comments: All survey reaches in the lower estuary met the target value for canopy density.

Fish Passage

There are no recorded barriers on Railroad or Pleasant Valley gulches.

Large Woody Debris

There are no data on LWD in the subbasin.

Discussion

In fish habitat relationship present in the Coastal Subbasin, it appears that the habitat is somewhat unsuitable for salmonids. Temperature data appear to be suitable on the two tributaries surveyed by CDFG. Coho salmon and steelhead are present in spite of the lack of shelter cover and pool depth. No dry channel units were found.

Stream Reach Conditions EMDS

The anadromous reach condition EMDS evaluates the condition for salmonids in a stream reach based upon instantaneous water temperature, riparian vegetation, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG habitat inventory surveys. Currently, data exist in the Albion Basin to evaluate overall reach, water temperature, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. Details on how the EMDS system calculates habitat variable are in the EMDS Appendix. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time surveyed.

EMDS stream scores are weighted by stream length to obtain overall scores for tributaries and the entire Coastal Subbasin. Weighted average reach conditions on surveyed streams in the Coastal Subbasin were evaluated by the EMDS as somewhat unsuitable for salmonids (Table 56). Suitable conditions exist for canopy in both of the streams surveyed. Unsuitable conditions exist for reach, in channel, and pool shelter in all tributaries evaluated.

As described in the EMDS response curves, total canopy exceeding 85% is considered fully suitable, and total canopy less than 50% is unsuitable for contributing to cool water temperatures that support salmonids. The surveyed stream reaches of the Coastal Subbasin have canopy levels that were rated by the EMDS as fully suitable for helping maintain water temperature to support anadromous salmonid production

The EMDS Reach Model considers cobble embeddedness greater than 50% to be somewhat unsuitable and 100% to be fully unsuitable for the survival of salmonid eggs and embryos. Embeddedness values in the Coastal Subbasin tributaries surveyed by CDFG in 2003 are currently unsuitable or somewhat unsuitable for successful salmonid egg and embryo development. The L-P data showed that although conditions were fully suitable in 1994 on Railroad and Pleasant Valley gulches, they were re-surveyed in 2003 and were not suitable

Generally, a reach must have 30 – 55% of its length in primary pools for its stream class to be in the suitable ranges. The EMDS rates pool quality in all Coastal Subbasin streams as moderately unsuitable or unsuitable for supporting anadromous fish populations.

As described in the EMDS response curves, average pool shelter ratings exceeding 80 are considered fully suitable and average pool shelter ratings less than 30% are fully unsuitable for contributing to shelter that supports salmonids. Pool shelter ratings in the Coastal Subbasin ranged from somewhat unsuitable to unsuitable.

Table 56: EMDS reach model scores anadromous reach condition model results the Coastal Subbasin.

Stream	Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Pleasant Valley Gulch	-	+++	+++	U	- -	- - -	- - -	- - -	- - -
Railroad Gulch	-	+++	+++	U	- -	- - -	- - -	- - -	- - -

+++ =Fully Suitable; ++ = Moderately Suitable; + = Somewhat Suitable; U= Undetermined- =Moderately Unsuitable; - - =Somewhat Unsuitable; --- =Fully Unsuitable

Analysis of Tributary Recommendations

L-P and CDFG inventoried 2.5 and 4.8 miles of stream habitat respectively in the Coastal Subbasin. The estuary/harbor area was surveyed through direct observation by numerous CDFG biologists. A CDFG biologist selected and ranked recommendations for restoration for each of the inventoried streams based on the results of these standard habitat inventories (Table 57). More details about the tributary recommendation process are given in the Albion Synthesis Section of the Basin Profile (page 93).

Table 57. Ranked tributary recommendation summary in the Coastal Subbasin.

Stream	# Stream Miles Surveyed	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
Estuary Harbor Area	1.0	3	2								1
Lower Mainstem	2.5	2	3							4	1
Pleasant Valley Gulch	1.7					3	2	1			
Railroad Gulch	3.1					3	2	1			

Bank = stream banks are failing and yielding fine sediment into the stream; Roads = fine sediment is entering the stream from the road system; Canopy = shade canopy is below target values; Temp = summer water temperatures seem to be above optimum for salmon and steelhead; Pool = pools are below target values in quantity and/or quality; Cover = escape cover is below target values; Spawning Gravel = spawning gravel is deficient in quality and/or quantity; LDA = large debris accumulations are retaining large amounts of gravel and could need modification; Livestock = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; Fish Passage = there are barriers to fish migration in the stream.

To better examine Coastal Subbasin issues through tributary recommendations given in CDFG habitat inventory surveys, the top categories were collapsed into five different categories: Erosion/Sediment, Riparian/Water Temperature, Instream Habitat, Gravel/Substrate, and other (Table 58). When examining recommendation categories by number of tributaries, the most important recommendation categories in the Coastal Subbasin are Erosion/Sediment and Instream Habitat. The high number of Instream Habitat Recommendations in the Coastal Subbasin indicate that high priority should be given to restoration projects emphasizing banks/roads and pool/cover.

Table 58. Ranking recommendation categories by number of tributaries in the Coastal Subbasin.

Coastal Subbasin Target Issue	Related Table Categories	Count
Erosion / Sediment	Bank / Roads	4
Riparian / Water Temp	Canopy / Temp	0
Instream Habitat	Pool / Cover	4
Gravel / Substrate	Spawning Gravel / LDA	2
Other	Livestock / Barrier	3

However, when comparing recommendation categories in the Coastal Subbasin by number of tributaries could be confounded by the differences in the number of stream miles surveyed on each tributary. Therefore, the number of stream miles in the subbasin assigned to various recommendation categories was calculated (Figure 57). When examining recommendation categories by number of stream miles, the most important ones remain Erosion/Sediment and Instream Habitat. Gravel/Substrate and Others are also important categories in the lower mainstem and harbor area. These comprise the top tier of recommended improvement activity focus areas.

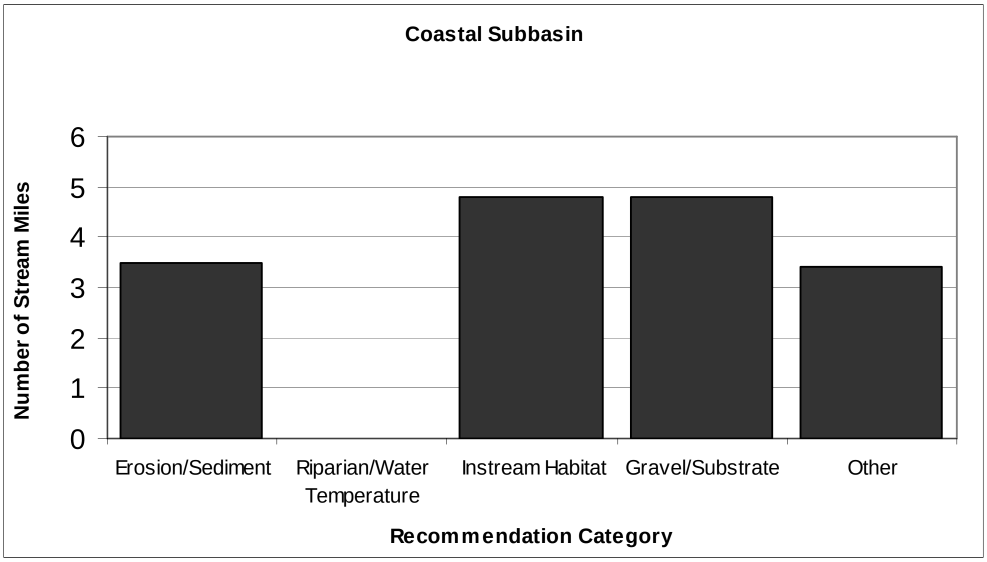


Figure 57. Recommendation categories by stream miles in the Coastal Subbasin.

Refugia Areas

An interdisciplinary refugia identification team from CDFG and the Water Board identified and characterized refugia habitat in the Coastal Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by EMDS at the stream reach and planning watershed/subbasin scales.

The most complete data available in the Coastal Subbasin were for tributaries surveyed by CDFG and long term monitoring sites from MRC. However, many of these areas were still lacking data and are noted as such in the table below. Additionally, areas such as Slaughterhouse Gulch had suitable temperatures, but did not have any other water quality data and were not surveyed by CDFG. Therefore, these locations are listed as critical contributing areas although not enough information exists to rate their potential as refugia.

Salmonid habitat conditions in the Coastal Subbasin on surveyed streams were generally rated as medium potential refugia. Additionally, some of the tributaries surveyed serve as critical contributing areas. The following refugia area rating table summarizes subbasin salmonid refugia conditions (Table 59).

Table 59: Tributary salmonid refugia area ratings in the Coastal Subbasin.

Stream	Refugia Categories:				Other Categories:		
	High Quality	**High Potential**	**Medium Potential**	**Low Quality**	**Non-Anadromous**	**Critical Contributing Area**	**Data Limited**
Lower Mainstem (within tidal influence)				X		X	X
Lower Mainstem (above tidal influence)			X				
Pleasant Valley Gulch			X				X

Stream	Refugia Categories:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area	Data Limited
Railroad Gulch			X				X
Slaughter House Gulch						X	X
Duck Pond Gulch						X	X
Unnamed Tributary						X	X
Deadman Gulch						X	X

Responses to Assessment Questions

What are the history and trends of the sizes, range, and relative health and diversity of salmonid populations within the Coastal Subbasin?

Findings and Conclusions:

- Both historic and current data are limited. Little data are available on population trends, relative health, or diversity. According to NOAA Fisheries listing investigations, the populations of salmonids have likely decreased in the Albion Basin as they have elsewhere along California and the Pacific Coast;
- Based on MRC and CDFG presence surveys since the 1960s, the distribution of coho salmon and steelhead trout have not changed;
- Coho salmon were observed more frequently than steelhead trout by CDFG in all surveyed reaches.

What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?

Findings and Conclusions:

- **Erosion/Sediment**
  - Data collected at the monitoring location on the mainstem below the South Fork Albion reflect unsuitable levels of instream fine sediment <6.4mm, which are above the TMDL target, while fine sediment <0.85 mm were below the target and therefore their suitability can not be determined.
- **Riparian/Water Temperature**
  - High summer water temperatures in surveyed reaches of the lower mainstem Albion below Railroad Gulch within tidal influence are deleterious to summer rearing salmonid populations, while water temperatures at the sample site in the lower mainstem above Duck Pond Gulch, an unnamed tributary, Duck Pond, Slaughter House, Railroad, Pleasant Valley, and Deadman gulches were all suitable.
- **Instream Habitat**
  - In the estuary, escape and ambush cover are unsuitable for salmonids;
  - In the mainstem Albion above tidal influence LWD recruitment potential is low;
  - CDFG surveyed reaches of Pleasant Valley and Railroad gulches documented flow, water temperature, and canopy cover as positive attributes;
  - CDFG surveyed reaches of Pleasant Valley and Railroad gulches documented embeddedness, pool depth and frequency, and shelter cover as negative attributes.
- **Gravel Substrate**
  - Data from the lower mainstem Albion below the South Fork reflect a limited amount and distribution of high quality spawning gravels for salmonids;
  - Instream substrate particle size (D50) is small at monitored locations on the lower mainstem, Duck Pond, Railroad, and Pleasant Valle gulches.

- **Other**
  - A seawall located on the north side of the estuary at the Albion Flats campground is incomplete at this time and is deleterious to anadromous salmonids because of its lack of natural roughness and tendency to accelerate the velocity of flows;
  - Dissolved oxygen samples at river miles (RM) 1.3, 2.1, and 3.7 on the mainstem estuary reflect conditions that may be potentially limiting for salmonids;
  - Limited water quality data from the lower mainstem Albion site above tidal influence appears to be suitable for salmonids.

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

Findings and Conclusions:

- In 1964, a tsunami consisting of four or five surges reportedly extended over a mile upriver and scoured out the river mouth (Lander et al. 1993);
- Vegetation in estuarine areas is reflective of natural conditions;
- Air photo analysis of the lower Albion River at low tide shows a single thread channel, which has varied little in location within the stream channel from 1936 to 2000;
- Mapping of fluvial features in the estuary from 1984 imagery identified a greater number of bars and areas of sediment deposition due primarily to their exposure at low tide. These lower channel features typically lack significant vegetation and are characteristic of tidal mud flats.

How has land use affected these natural processes?

Findings and Conclusions:

- Construction of near stream railroads and roads have constricted stream channels and destabilized streambanks throughout the basin;
- Wetland habitat was reduced by historic sawmills and development on the Albion River flats;
- The California Coastal Zone Conservation Commission Preliminary Report (1976) suggested that no further development be allowed in the Albion River estuarine area or surrounding lands;
- A large meander in the mainstem Albion at RM 2.3 was disconnected from the river, creating an oxbow and shortening the mainstem;
- Historic timber harvest activities reduced riparian canopy. The canopy is currently suitable in Pleasant Valley and Railroad gulches;
- As a result of timber harvest, the current landscape is comprised of smaller diameter forest stands than in pre-European times;
- The small diameter of near stream trees in Pleasant Valley and Railroad gulches limits the recruitment potential of large woody debris to streams and contributes to the lack of instream habitat complexity.

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

- Lack of shelter/cover, available and appropriately sized spawning substrate, pool frequency, and pool depth are limiting salmon and steelhead health and production.

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

Recommendations:

- Improve instream structures for ambush cover and escape where appropriate/feasible;

- Consider limiting development that encroaches upon the estuarine area on both the north and south sides of the lower Albion Flats estuary area;
- Establish monitoring stations to track instream sediment in the upper portion of the estuary, lower mainstem above tidal influence, and Railroad and Pleasant Valley gulches;
- Support and encourage existing and active road management programs undertaken by MRC and the large percentage of small landowners with NTMPs to improve road standards throughout the basin;
- Completion of the seawall is a high priority for subbasin landowners. It should be done according to the plan developed by CDFG, Central Coast Region. To complete the seawall, the following steps are recommended: 1) backfilling of the existing wall; 2) compaction of the back filled soil; 3) completion of the "dead men" anchors along the wall; 4) completion and repair of the broken support/retainer beams (whalers); 5) removal of the jagged vinyl panel ends; 6) planting of the area; 7) development of provisions for storm water runoff from the unpaved road into the channel. Additionally, roughness elements should be incorporated into the project to develop complex near shore, emergent fry habitat;
- Conduct studies in the estuary to determine conclusively whether water temperature and dissolved oxygen are suitable for salmonids.
- Continue water temperature monitoring at current locations and sustain conditions that are leading to suitable temperatures;
- Establish long-term water chemistry monitoring stations in the lower mainstem Albion. If there are indications of problems, monitoring should be implemented in tributaries as necessary to determine the source of the issue;
- Conduct salmonid surveys of the mainstem Albion River, and tributaries considered as salmonid habitat;
- Develop more stream inventories and fishery surveys of tributaries within this subbasin.

Subbasin Conclusions

Historical accounts indicate that the conditions in the Coastal Subbasin have been favorable for salmonid populations. However, splash damming, railroad construction on the flood plain, and other land use practices have likely impacted estuarine conditions and the river channel, and reduced the complexity of habitat in the tidal estuary reach. Conditions in subbasin tributaries appear to have also degraded in recent years. Aquatic and channel conditions at the most downstream section of a river system are a response to watershed products transported from throughout the basin.

Today, fine sediment and warm water are the two most deleterious watershed products affecting the estuary's fisheries. Accordingly, there are opportunities for improvements to juvenile salmonid rearing habitat. Water temperature monitoring in the estuary, sediment source monitoring, and adding LWD to improve channel complexity are examples of appropriate short-term improvement activities that can be initiated in the estuary and tributary streams. As such, long-term improvements in the estuary must be produced by careful watershed stewardship throughout the Albion Basin.

In general, the Albion Basin is largely composed of a preponderance of naturally unstable and erosive terrain. In this fragile environment, land use project planning must include consideration of appropriate Best Management Practices (BMPs). These should be prescribed and followed during the course of any land use project to minimize erosion and sediment delivery and to prevent vegetation removal near streams. Many current landowners and managers are interested and motivated to eliminate watershed and stream impacts related to land use, and wish to accelerate a return to stable, beneficial conditions for salmonids. They are encouraged to do so, enlisting the aid and support of agency technology, experience, and funding opportunities.

Inland Subbasin

Mainstem Albion River downstream of East Railroad Gulch.

Introduction

The Inland Subbasin includes the watershed area of the mainstem Albion above its confluence with the South Fork Albion, and includes the South Fork Albion drainage as well. Elevations range from 40 feet at the South Fork confluence to approximately 600 feet in the headwaters of the tributaries. The highest point in the subbasin is Mathison Peak at 1,030 feet.

Climate

The Inland Subbasin has a higher average rainfall than the Coastal Subbasin with an average of 56 inches of rainfall each year. Temperatures are typically cooler in the winters and warmer in the summers than coastal areas, although the marine influence still moderates temperatures and prevents extremes. Temperatures range from below freezing to over 90°F seasonally.

Hydrology

The Inland Subbasin is a relatively small coastal catchment area of approximately 30.4 square miles. The subbasin contains seven perennial and numerous intermittent streams that drain approximately 19,442 acres (Figure 58). The mainstem becomes a second order stream downstream from the confluence with Marsh Creek (RM 16.9) near Comptche (Figure 12). The tributary system is dominated by intermittent and ephemeral streams, which are not used by CDFG in calculating stream order (Table 60). By convention, CDFG uses unbranched solid blue line streams as depicted on 7.5 minute USGS maps as their first order stream layer (Flosi et al. 1998).

Table 60 Inland Subbasin streams and drainage areas.

CalWater Planning Watershed	River Mile	Bank (L / R)	Stream	Perennial (miles)	Intermittent (miles)	Drainage area (square miles)
South Fork Albion River	9.2	R	South Fork Albion River	1.2	6.1	8.9
			Anderson Gulch		0.7	0.5
			Gunari Gulch		0.7	0.2
			Mack Gulch		0.4	0.2
			Norden Gulch		1.4	0.7
			Little North Fork		1.6	0.9
			Soda Spring Gulch		1.1	0.4
			Nursery Gulch		0.9	0.3
			Larmer Gulch		0.5	0.2
			Bull Team Gulch		1.3	0.8
			Winery Gulch		1.4	0.5
Middle Albion River	9.2	R	Unnamed Tributary		0.6	0.1
	10.0	L	Glenbrook Gulch		1.5	0.8
			Kaisen Gulch		1.3	1.6
	11.2	L	Unnamed Tributary		0.7	0.2
	12.0	R	Railroad Gulch	2.0	0.2	1.0
	12.3	L	Unnamed Tributary		0.7	0.1
	12.5	L	Tom Bell Creek		3.0	1.6
	12.8	L	Unnamed Tributary		0.7	0.2
	12.9	L	Unnamed Tributary		0.8	0.2
	14.6	R	Unnamed Tributary		0.3	0.1
	14.8	R	Morrison Gulch	0.8	0.2	0.5
Upper Albion River	15.2	L	North Fork Albion River	2.9	2.3	5.2
			Soda Spring Creek		1.8	1.4
			Portuguese Gulch		1.4	0.6
	15.5	L	Unnamed Tributary	1.3	0.1	0.6
	16.9	R	Marsh Creek	3.3		2.1
	17.6	R	McDonald Gulch		2.1	1.0
	17.7	R	Little McDonald Gulch		0.9	0.3
	18.7	L	Unnamed Tributary	1.1	0.2	0.8
	19.2	L	Unnamed Tributary	0.7	0.3	0.4
	19.6	R	Unnamed Tributary	0.4	0.2	0.3
	20.4		End Perennial	0.8		Need
	20.9		End Intermittent		0.5	Need

Data collected on the mainstem between RM 9.2 (South Fork confluence) and RM 15.2 (North Fork confluence) show that high flows during storms are of very short duration, generally lasting only one to two days (GMA 2001). Analyses indicate that the Albion River at the USGS gage site at RM 15.2 only exceeds 173 cubic feet per second (cfs) 10% of the time, or 36 days per year on average, while 50% of the time flows are below 13 cfs. Flows exceed 1045 cfs in the Albion River only 1% of the time, or 3.6 days per year on average. Relatively little bedload transport probably occurs below 400 cfs.

Flow conditions in the Albion Basin are surprisingly low. Almost 30% of the time, flow at the USGS gage site during the period of record was below 1 cfs, while about 5% of the time there was zero flow. Thus, for about 3 to 4 months out of every year, flows are less than 1 cfs in the upper portions of the basin.

During summer months, these naturally low flows may be further reduced by diversions for irrigation and domestic uses (GMA 2001). A brief review of water rights permits indicates there are diversions currently permitted for at least 0.5 cfs in areas upstream of the site of the former USGS gage at RM 15.2. Most of them are near Comptche, with a few others in the North Fork drainage. These low summer flows may limit juvenile salmonid production in the upper portion of the watershed, and may create a limiting factor in salmonid production in this upper portion of the watershed (GMA 2001). More detailed hydrology information is in the Albion Basin Profile (page 44).

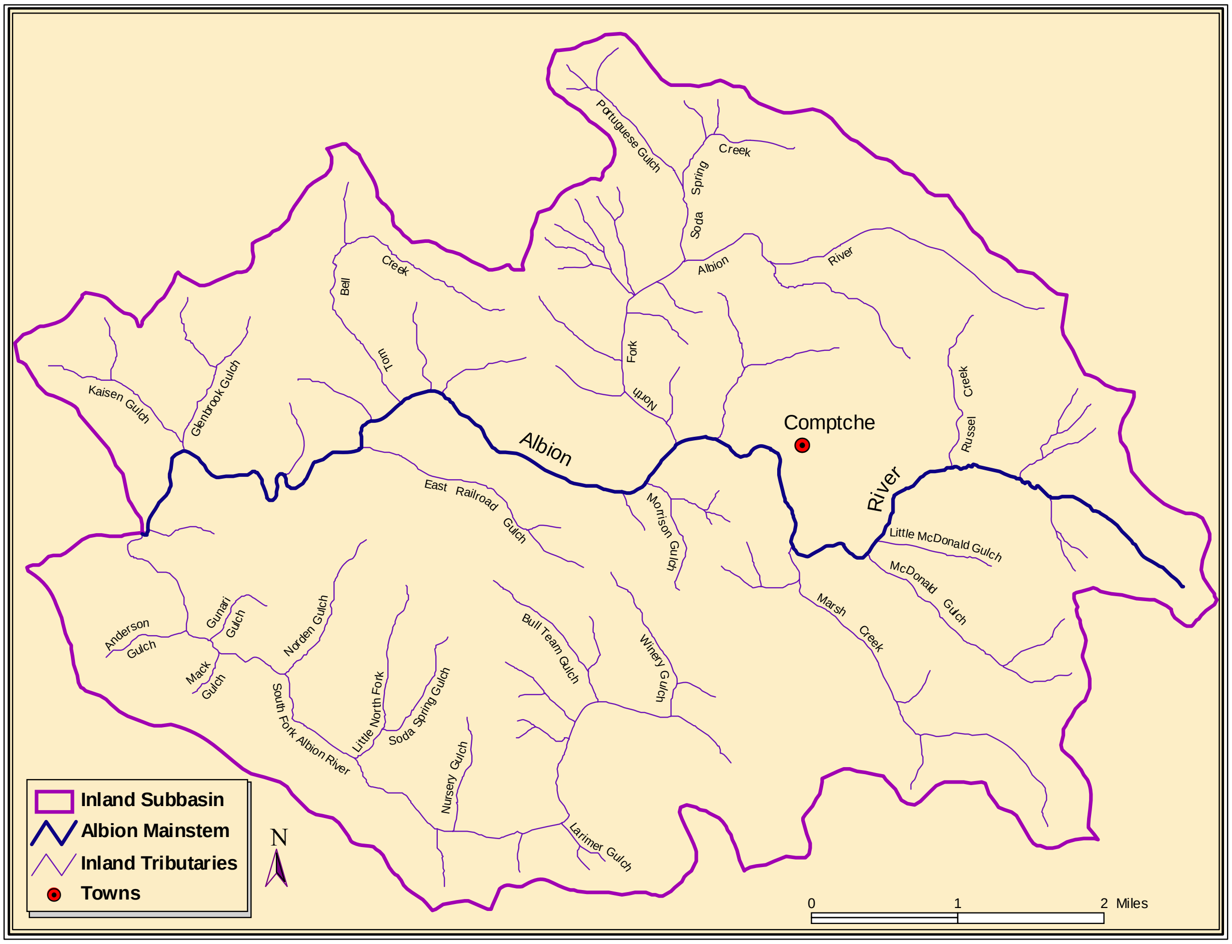


Figure 58. Inland Subbasin, Albion Basin.

Vegetation

The Inland Subbasin is primarily redwood and Douglas fir forestland. These forests are in various seral stages of growth depending on their logging history (Table 61). An additional 40% of this subbasin is mixed forest. The mixed (conifer and hardwood) forest type is a broad category that allows for a wide range of coniferous presence in the stand type. The minimum requirement is at least 10% conifer and at least 20% hardwood.

Table 61. Vegetation type and percent coverage in the Inland Subbasin.

Inland Subbasin Vegetation		
Vegetation Type	**Total Acreage**	**Percent of Total Area**
Conifer	9,098	47
Mixed Forest	7,754	40
Grassland	1,282	6
Hardwood	1,142	6
Shrub	57	<1
Barren	81	<1
Agricultural	27	0
Totals	***19,441***	***~100%***

Land Use

The Inland Subbasin is composed of various sized parcels with the smaller ones centered around the town of Comptche and the upper North Fork Albion. MRC owns 76% of the Inland Subbasin and consequently the major land use is timber production. Timber harvesting has dominated the subbasin throughout its modern history with increased harvest activity on second and third growth forests since 1990 (Table 62 andTable 63). Other land uses in the subbasin include grazing and rural residential.

Table 62. Timber harvest history since 1930 in the Inland Subbasin.

Timber Harvest Coastal Subbasin	Total Acres	Percent of Area	Percent Area Cut Annually
~1930 - 1936	69	0	>1
1937 - 1952	1,580	8	>1
1953 - 1963	596	3	>1
1964-1972	1,645	9	>1
1973-1985	3,380	18	1
1986 – 1989	1,249	7	2
1990 – 1999	8,094	42	4
2000 – 2002	3,600	19	6
Approved THPs, THP data	2268	12	Not applicable

Table 63. Summary of timber harvest history by method.

Harvesting Time Period	Category 1 (acres) Includes clear-cut and seed tree seed step	Category 2 (acres) Includes shelterwood prep step, shelterwood removal step, and alternative prescriptions	Category 3 (acres) Includes selection and commercial thin	Total harvest by time period	Percentage cable or helicopter yarded
1990-1999	1,022	3,804	3,208	8,034	43
2000-2002	264	549	2,762	3,575	37
Open 2002	0	347	1,730	2,077	59
Total by System	1,286	4,700	7,700		

Water Quality

Temperature

Water temperature data from continuous records were available in this subbasin from three sites on the mainstem Albion River, two sites on East Railroad Gulch and the South Fork Albion, and one site on each of Gunari Gulch, Anderson Gulch, and Marsh Creek (Figure 59 and Table 64). Data from mainstem sites were available from seventeen samples collected in various years from 1992-2002. Twenty-one samples were available for tributaries from 1992-2002. Fifteen of the tributary samples were from the South Fork Albion River.

Water temperatures at monitoring locations in this subbasin were generally within suitable ranges for salmonids (Table 65 andTable 66). The exception to this was in 1999 on the mainstem Albion River above the South Fork Albion, where a seasonal maximum temperature of 75°F was recorded. Temperatures in the years proceeding and following this year have been fully suitable and MWATs have hovered around 64°F. Therefore, this area of the middle mainstem is considered suitable for salmonids.

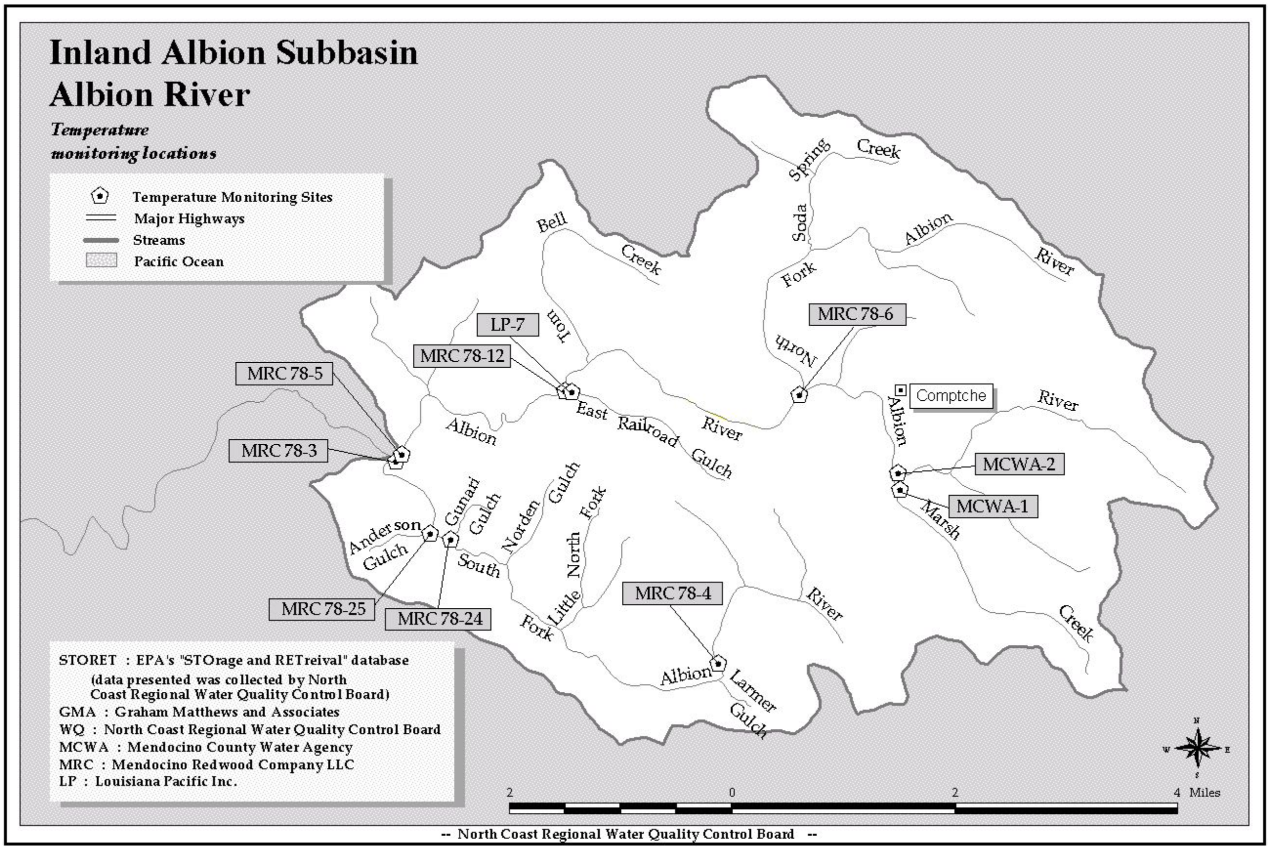


Figure 59. Water temperature monitoring sites in the Inland Subbasin.

Table 64. Water temperature sampling site information for the Inland Subbasin.

Water Temperature					
Location	**River Mile**	**Report Station ID**	**Alt. Station ID(s)[2]**	**Contributor**	**Years Sampled**
Middle Mainstem Albion River below North Fork	15.2	MRC 78-6	78-6, 2091, 2	MRC	1993-2002
East Railroad Gulch, lower	12.0 (SM 0.0)	LP 7[1]	7		1993
		MRC 78-12	78-12		2002
Middle Mainstem Albion River above South Fork	9.2	MRC 78-5	78-5, 2092, 1		1992-2002
South Fork Albion above Larmer Gulch	9.2 (SM 4.4)	MRC 78-4	78-4, 2096, 4		1992-2001
Gunari Gulch, lower	(SM 0.0)	MRC 78-24	78-24		2001
Anderson Gulch, lower	(SM 0.0)	MRC 78-25	78-25		2001
South Fork Albion above Mainstem Albion	9.2 (SM 0.0)	MRC 78-3	78-3, 2093, 3		1993-2002
Marsh Creek, lower	16.9 (SM 0.0)	MCWA-1	MCWA-1	MCWA	2001 & 2002
Upper Mainstem Albion River above Marsh Creek	16.9	MCWA-2	MCWA-2		2001 & 2002

1 Data was collected by Louisiana Pacific and given to MRC when ownership was transferred
2 Station identification used by data contributor(s).

Table 65. EMDS ratings for MWATs in the Inland Subbasin.

Watercourse	**Number of Sites**	**Number of Samples**	**Period of Record**	**EMDS Suitability Rating**						
				+ + +	+ +	+	0	-	- -	- - -
Middle Mainstem Albion River	2	15	1992-2002	■	■	■				
East Railroad Gulch, lower	2	2	1993 & 2002	■						
South Fork Albion River	2	15	1992-2002	■	■					
Gunari Gulch, lower	1	1	2001	■						
Anderson Gulch, lower	1	1	2001	■						
Upper Mainstem Albion River	1	2	2001 & 2002	■	■					
Marsh Creek, lower	1	2	2001 & 2002	■						

EMDS Ratings: +++ = fully suitable (50-60°F), ++ = moderately suitable (61-62°F), + = somewhat suitable (63°F),
0 = undetermined (between somewhat suitable and somewhat unsuitable) (64°F), - = somewhat unsuitable (65-66°F),
-- = moderately unsuitable (67°F), --- = unsuitable (>68°F).

Table 66. MWATs and seasonal maximum temperatures in the Inland Subbasin.

Watercourse	Number of Sites	Number of Samples	Period of Record	Range of MWATs (F)	Range of Seasonal Maxima (F)
Middle Mainstem Albion River	2	15	1992-2002	59-63	62-75
East Railroad Gulch, lower	2	2	1993 & 2002	57-58	60-62
South Fork Albion River	2	15	1992-2002	57-61	59-67
Gunari Gulch, lower	1	1	2001	57	58
Anderson Gulch, lower	1	1	2001	56	57
Upper Mainstem Albion	1	2	2001 & 2002	60-61	62-63
Marsh Creek, lower	1	2	2001 & 2002	58	58-60

Sediment

Sediment data were limited in this subbasin, and no data existed for instream sediment above MRC's ownership. Instream sediment data were available for nine locations on the mainstem Albion River in this subbasin. Thirteen sites on tributaries were monitored, including eight on the South Fork Albion, two on East Railroad Gulch and the North Fork Albion, and one on the Little North Fork (Figure 60 and Table 67). Sediment data were available from 1998-2001, and included pebble counts (D50), bulk sediment samples, permeability, and V-Star (V*).

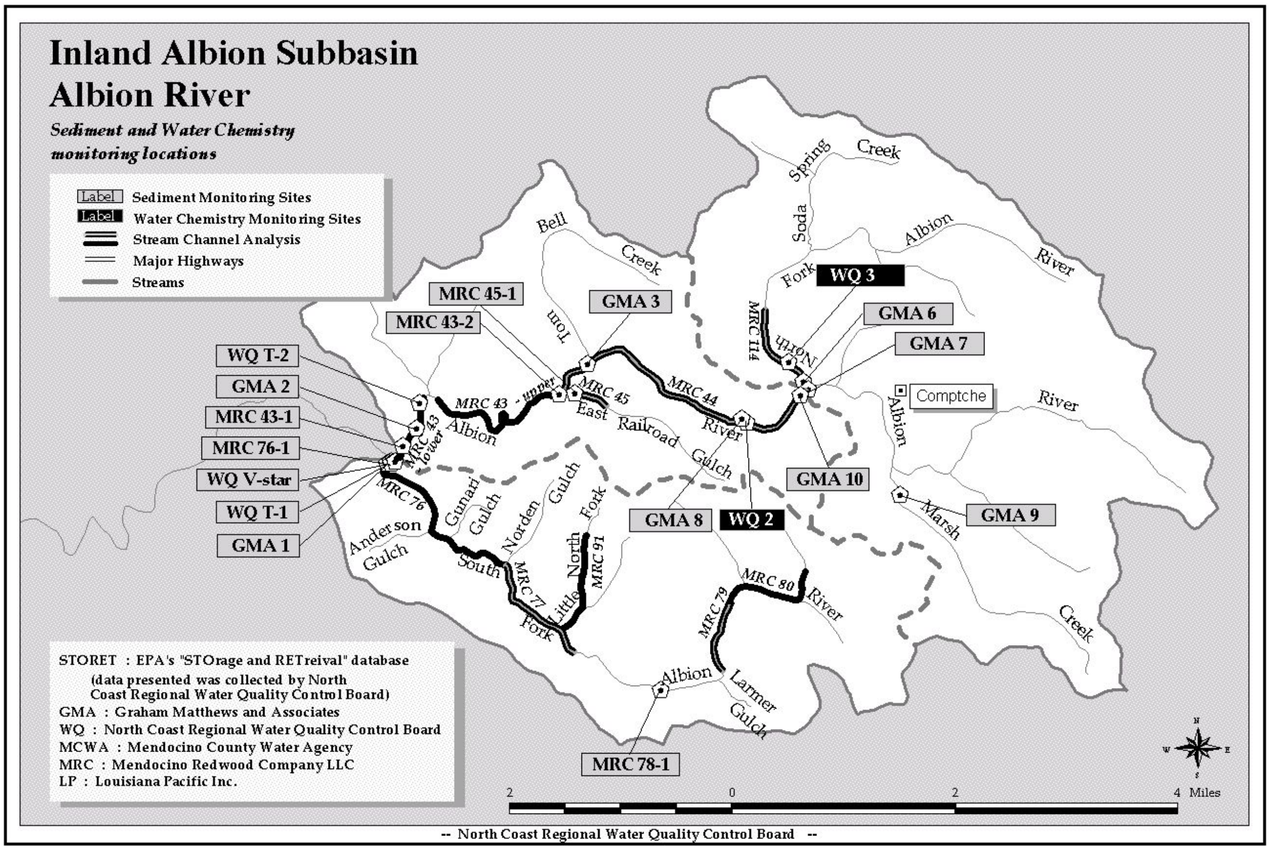


Figure 60. Instream sediment and water chemistry monitoring locations in the Inland Subbasin.

Table 67. Water quality sampling site information for the Inland Subbasin.

In-stream Sediment						
Parameter	**Location**	**River Mile**	**Report Station ID**	**Alt. Station ID(s)[1]**	**Contributor**	**Years Sampled**
D50	Middle Mainstem Albion River	12.0-15.2	MRC 44	44	MRC	1998
	East Railroad Gulch, lower	12.0 (SM 0.0-0.4)	MRC 45	45		1998
		12.0 (SM 0.0)	MRC 45-1	Seg 45		1998 & 2000
	Middle Mainstem Albion River	12.0	MRC 43-2	Seg 43(2)		1998 & 2000
		10.0-12.0	MRC 43-upper	43(upper)		1998
		9.2-9.8	MRC 43-lower	43(lower)		1998

In-stream Sediment						
Parameter	Location	River Mile	Report Station ID	Alt. Station ID(s)[1]	Contributor	Years Sampled
	Middle Mainstem Albion River above South Fork	9.3	MRC 43-1	Seg 43(1)		1998 & 2000
		9.8	WQ T2	-	RWQCB	2001
	South Fork Albion River	9.2 (SM 5.0-6.0)	MRC 80	80	MRC	1998
		9.2 (SM 4.4-5.0)	MRC 79	79		1998
	Little North Fork Albion River, lower	(SM 0.0 - 0.8)	MRC 91	91		1998
	South Fork Albion River	9.2 (SM 1.8-2.8)	MRC 77	77		1998
		9.2 (SM 0.0-1.8)	MRC 76	76		1998
	South Fork Albion above Mainstem Albion	9.2 (SM 0.0)	MRC 76-1	Seg 76		1998 & 2000
			WQ T1	-	RWQCB	2001
	North Fork Albion River, lower	15.2 (SM 0.0-1.0)	MRC 114	114	MRC	1998
Bulk Sediment Sample	Middle Mainstem Albion River	15.2	GMA 10	ABNFA	GMA	2000
	Middle Mainstem Albion, River below East Railroad Gulch	12.0	MRC 43-2	Seg 43(2)	MRC	1998
	Middle Mainstem Albion River above South Fork	9.6	GMA 2	AASFA	GMA	2000
		9.3	MRC 43-1	Seg 43(1)	MRC	1998
	South Fork Albion above Mainstem Albion	9.2 (SM 0.0)	GMA 1	SFAAA	GMA	2000
			MRC 76-1	Seg 76	MRC	1998
	Upper Mainstem Albion River above North Fork	15.2	GMA 7	AANFA	GMA	2000
	North Fork Albion River, lower	15.2 (SM 0.0)	GMA 6	NFAAA		2000
V*	South Fork Albion above Mainstem Albion	9.2 (SM 0.1)	WQ V-Star	V*	RWQCB	2001
Streambed Gravel Permeability	Middle Mainstem Albion River below East Railroad Gulch	12.0	MRC 43-2	Seg 43(2)	MRC	1998 & 2000
	Middle Mainstem Albion River above South Fork	9.3	MRC 43-1	Seg 43(1)		1998 & 2000
	South Fork Albion above Mainstem Albion	9.2 (SM 0.0)	MRC 76-1	Seg 76	MRC	1998 & 2000
Cross-Section	East Railroad Gulch, lower	12.0 (SM 0.0)	MRC 45-1	Seg 45	MRC	1998 & 2000
	Middle Mainstem Albion River below East Railroad Gulch	12.0	MRC 43-2	Seg 43(2)		1998 & 2000
	Middle Mainstem Albion River above South Fork	9.3	MRC 43-1	Seg 43(1)		1998 & 2000
			MRC 43-1	Seg 43(1)	RWQCB	2001
	South Fork Albion River	9.2 (SM 3.8)	MRC 78-1	Seg 78	MRC	1998 & 2000
	South Fork Albion above Mainstem Albion	9.2 (SM 0.0)	MRC 76-1	Seg 76		1998 & 2000
			MRC 76-1	Seg 76	RWQCB	2001
Thalweg	East Railroad Gulch, lower	12.0 (SM 0.0)	MRC 45-1	Seg 45	MRC	1998 & 2000
	Middle Mainstem Albion River below East Railroad Gulch	12.0	MRC 43-2	Seg 43(2)		1998 & 2000
	Middle Mainstem Albion River above South Fork	9.3	MRC 43-1	Seg 43(1)		1998 & 2000
	South Fork Albion River	9.2 (SM 3.8)	MRC 78-1	Seg 78		1998 & 2000
	South Fork Albion above Mainstem Albion	9.2 (SM 0.0)	MRC 76-1	Seg 76		1998 & 2000
Turbidity/ Suspended Sediment Concentration / Flow	Middle Mainstem Albion River	14.4	GMA 8	-	GMA	2000 & 2001
	Middle Mainstem Albion River below Tombell Ck	12.5	GMA 3	-		2000 & 2001
	Middle Mainstem Albion River above South Fork	9.6	GMA 2	AASFA		2000 & 2001
	South Fork Albion above Mainstem Albion	9.2 (SM 0.0)	GMA 1	SFAAA		2000 & 2001
	Marsh Creek, lower	16.9 (SM 0.2)	GMA 9	-		2000 & 2001
	Upper Mainstem Albion River above North Fork	15.2	GMA 7	AANFA		2000 & 2001
	North Fork Albion River, lower	15.2 (SM 0.0)	GMA 6	NFAAA		2000 & 2001

1 Station identification used by data contributor(s).

Pebble Counts (D50)

The median particle size in the streambed, or D50, is a simple and rapid assessment method that can help in determining if land use activities or natural land disturbances are introducing fine sediment into the stream. Additionally, this data is useful in combination with stream flow and stream gradient information to assess the likelihood that particles of a given size will move downstream. D50 samples at stream channel analysis and monitoring sites in this subbasin are small or moderate. At locations on the mainstem and South Fork of this subbasin, they were small to moderate, while those in the Little North Fork, East Railroad Gulch, and the North Fork Albion, were small (Table 68). Overall, the range of D50s at sites in the mainstem of this subbasin was larger than the range of D50s at sites downstream in the Coastal Subbasin. It is difficult to draw conclusions about sediment supply and transport in this subbasin, because most monitoring locations do not have more than one year of data.

According to MRC (1999), the middle mainstem Albion is a low gradient channel (0-2 %), confined between steep adjacent side slopes and fill terraces. The headwaters of East Railroad Gulch are a high gradient transport reach (8-20 %) with a steep-sided, tightly confined channel. The remainder of this stream is lower gradient (0-4 %) with moderate to confined channels. At the location of the D50 site on the North Fork Albion the stream channel is a low gradient (0-2 %) confined channel (MRC 1999).

The headwaters of the South Fork are low gradient (0-4 %) with moderately confined to confined channels. The middle reaches of the South Fork flow through low gradient (0-2 %) unconfined canyons and show high levels of deposition and terrace development. The lower reaches of the South Fork are typically low gradient channels (0-2 %) that are highly confined (MRC 1999).

Table 68. Summary of the instream sediment related parameters in the Inland Subbasin.

Parameter	Number of Sites	Period of Record	Sample Range (Min-Max)	Notes
Middle Mainstem Albion River				
D50 (mm)	6	1998, 2000-2001	8-55	Some cross-sections were not necessarily located on riffles in the streambed. Three different methods were used to collect data.
Bulk Sediment Sample Median Percent <0.85 mm (%)	4	1998 & 2001	4-11	Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.
Bulk Sediment Sample Median Percent <6.3/6.4 mm (%)	4	1998 & 2001	25.7-59.8	Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.
Bulk Sediment Sample 50th percentile of particles (mm)	4	1998 & 2001	3.7-23.8	25th percentile ranged from 1.8-6.0. 75th percentile ranged from 19.1-70.2.
Median Streambed Gravel Permeability (cm/hr)	2	1998 & 2000	1017- 17519.5	Median percent survival associated with these permeabilities are 20% to 62%.
South Fork Albion River				
D50 (mm)	6	1998, 2000-2001	10-55	Some cross-sections were not necessarily located on riffles in the streambed. Three different methods were used to collect data.
Bulk Sediment Sample Median Percent <0.85 mm (%)	2	1998 & 2001	7.5-8	Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.
Bulk Sediment Sample Median Percent <6.3/6.4 mm (%)	2	1998 & 2001	28.3-31.5	Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.
Bulk Sediment Sample 50th percentile of particles (mm)	2	1998 & 2001	15.3-24.1	25th percentile ranged from 4.4-4.7. 75th percentile ranged from 46.7-62.9.
V*	1	2001	0.2	V* was determined from sampling on one pool with in the reach.
Median Streambed Gravel Permeability (cm/hr)	1	1998 & 2000	121-796	Median percent survival associated with these permeabilities are 0% to 17%.
Upper Mainstem Albion River				
Bulk Sediment Sample Median Percent <0.85 mm (%)	1	2001	1	Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.
Bulk Sediment Sample Median Percent <6.4 mm (%)	1	2001	4.5	Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.
Bulk Sediment Sample 50th percentile of particles (mm)	1	2001	39.7	25th percentile was 22.4. 75th percentile was 75.4.
D50 (mm) East Railroad Gulch, lower	2	1998 & 2000	7-27	Some cross-sections were not necessarily located on riffles in the streambed. Two different methods were used to collect data.
D50 (mm) Little North Fork Albion River, lower	1	1998	28	Sample site was specifically chosen to look at bed mobility potential.

Parameter		Number of Sites	Period of Record	Sample Range (Min-Max)	Notes
D50 (mm)	North Fork Albion River, lower	1	1998	38	Sample site was specifically chosen to look at bed mobility potential.
Bulk Sediment Sample Median Percent <0.85mm (%)	North Fork Albion River, lower	1	2001	6.5	Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.
Bulk Sediment Sample Median Percent <6.4mm (%)	North Fork Albion River, lower	1	2001	23.3	Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.
Bulk Sediment Sample 50th percentile of particles (mm)	North Fork Albion River, lower	1	2001	33.3	25th percentile was 7.4. 75th percentile was 80.6.

Bulk Sediment:

Mainstem Albion monitoring locations reflect median fine sediment levels <0.85 mm which were below TMDL targets, while the median percent of fines <6.3/6.4 mm ranged from below to much higher than target values (Table 68).

As is further discussed in the Water Quality Appendix, the targets for fine sediment <0.85 mm and <6.4 mm in the Albion River TMDL are for volumetric (wet sieved) data, and therefore are not directly comparable to these gravimetric (dry sieved) data. However, when material is wet sieved water retained on the particles, especially those <4 mm, becomes significant (Shirazi, Seim, and Lewis 1979). Therefore, the percent finer than values calculated from dry sieved data would be lower than the values that would be calculated from wet sieved material. Consequently, values, which are equal to or above the targets, can be considered unsuitable, while values below the targets were noted as such but no specific conclusion about the suitability of these areas can be made now.

In 1998, the median percent of fine sediment <6.3 mm on the middle Mainstem above the South Fork was 40%, which is above the TMDL target of <30% and considered unsuitable. However, the median percent of fine sediment <6.4mm in 2001 at this location was 25.7% indicating that much of the fine sediment which was present subsequently moved through the system. Data from both the middle Mainstem below East Railroad Gulch (1998) and the middle Mainstem below the North Fork (2001) reflect unsuitable median fine sediment levels <6.3/6.4 mm over TMDL target values (33.5% and 59.8% respectively).

All monitoring locations on the Mainstem had at least 50% of the particles from the substrate samples in the lower quarter of the 6-102 mm range used by salmonids for spawning, and two of these sites had 75% of the particles in the lower quarter of the range. The upper Mainstem above the North Fork in 1998 had 75% of particles in the lower quarter of the range; however, in 2001 50% of the particles were in the lower quarter of the range. The middle Mainstem below the North Fork had 75% of particles in the lower quarter of the range in 2001. This is the same location where in 2001 the median level of fine sediment <6.4 mm was 59.8%. These results indicate that there is a lack of larger particles at sampling sites on the Mainstem. This could limit the usefulness of these particles for spawning salmonids. Additionally, small particles are easily mobilized by small increases in flow. This can affect the creation of redds or egg survival.

The median percent of fines <0.85 mm and <6.3/6.4 mm at monitoring locations on the South Fork and North Fork Albion Rivers were generally below TMDL targets and therefore their suitability cannot be determined. The exception to this was on the South Fork below the Mainstem in 1998, where the median percent of fine sediment < 6.3 mm was 31.5% (unsuitable). However, in 2001 the median percent of fine sediment < 6.4 mm was 28.3%, below the TMDL target.

The South Fork above the Mainstem had 50% of the particles from substrate samples in the lower quarter of the range used by salmonids, while the North Fork above the Mainstem had 50% of particles in the lower third of the range. This indicates a lack of larger particles at these sampling locations. Spawning substrate conditions on other tributaries in this subbasin cannot be assessed due to a lack of data.

*V**

The V* value at the monitoring site on the South Fork Albion River (0.20) is suitable, and indicative of low residual pool filling (Knopp 1993) (Table 68). This value is comparable to the Albion River TMDL numeric mean target value of <0.21. Additional and more robust sampling should be conducted in the future to gain a broader picture about fine sediment levels in pools in this subbasin and in the watershed as a whole. This small sample size limits the utility of this data, yet it provides a snapshot of conditions at this location in the South Fork Albion.

Permeability:

Factors besides substrate size and fine sediment should be taken into account when considering the suitability of instream substrate for salmonids. The intergravel flow (permeability) must also be considered. Survival to emergence calculated from permeability values do not necessarily indicate the actual emergence values, due to the influence of other parameters on survival and egg viability factors.

Median permeability measurements from locations on the middle mainstem Albion River decreased from 1998 to 2000, and as a result, the calculated median percent survival to emergence per McBain and Trush (2000) also decreased (Table 68). Median permeability samples on the middle mainstem above the South Fork were 17,519.5 cm/hr in 1998 and 1,679.5 cm/hr in 2000. The estimated median percent survival to emergence calculated from these permeabilities was 62% in 1998 and 28% in 2000. Median permeability samples on the middle mainstem below East Railroad Gulch were 2051 cm/hr 1998 and 1017 cm/hr in 2000, and the resulting estimated median percent survival to emergence were 30% and 20% respectively.

Numerous factors can affect permeability, including fine sediment accumulation and stream flow. McNeil results from 1998 at both sites reflected median fine sediment levels <0.85 mm below TMDL target values. However, because the suitability of fine sediment below TMDL target values cannot be assessed at this time, their effect on permeability is also undetermined. Fine sediment data are not available for these locations in 2000. No data for stream flow or other parameters affecting permeability were available at these locations.

Median permeability measurements on the South Fork Albion River above the mainstem were lower in 1998 than in 2000: 121 cm/hr and 796 cm/hr respectively. The estimated median percent survival to emergence based on these permeability measurements was 0% in 1998, and 17% in 2000. Median values for fine sediment <0.85 mm were below the TMDL target in this reach in 1998 and therefore their effect on permeability cannot be determined at this time. Data for fines are not available for this site in 2000. Stream flow records and data for other parameters that could affect permeability, were not available at this site.

Water Chemistry

Limited water chemistry data are available in this subbasin for 2001 from one site on the middle mainstem Albion River, and one site on the North Fork Albion (Table 69 and

Table 70). Data collection on the middle mainstem were in the form of grab samples, while data from the North Fork were collected with a continuous monitor every fifteen minutes for a period of three days.

Table 69. Sediment sampling site information for the Inland Subbasin.

Water Chemistry					
Location	**River Mile**	**Report Station ID**	**Alt. Station ID(s)1**	**Contributor**	**Years Sampled**
Middle Mainstem Albion River	14.4	WQ-2	ALBCOM	RWQCB	2001
North Fork Albion River, lower	15.2 (SM 0.5)	WQ-3	-		2001

1Station identification used by data contributor(s).

Table 70. Water chemistry parameters in the Inland Subbasin.

Parameter Name1	Total Number Samples	Number Detect Samples	Period of Record	Detect Sample, Range (Min/Max)	Criteria	Number Samples Violating Criteria	Criteria Source
Middle Mainstem Albion River[1]							
Dissolved Oxygen (mg/L)	3	3	2001	9.4-11.3	≥7.0	0	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
pH (Standard Units)	3	3	2001	7.1-8.2	6.5-8.5	0	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
Specific Conductance (umhos/cm)	3	3	2001	175-319	none	-	-
North Fork Albion River, lower[2]							
Dissolved Oxygen (mg/L)	263	263	2001	6.8-7.6	≥7.0	13	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
pH (Standard Units)	263	263	2001	7.9-8.1	6.5-8.5	0	Basin Plan, Table 3-1, p 3-7.00 (RWQCB 2001)
Specific Conductance (umhos/cm)	263	263	2001	601-606	none	-	-

1 Samples were collected at one site.
2 Samples taken at one site every 15 minutes for a period of three days using a continuous datalogger.

Dissolved oxygen, pH, and specific conductance (S.C.) were all suitable at the monitoring location on the middle mainstem Albion River (

Table 70). Generally, D.O. levels at the site on the North Fork were above the specified minimum limit of 7.0 mg/L, although there were occasions where it was below the limit. pH levels at the North Fork site were within the parameters specified (6.5-8.5) by the Basin Plan, and therefore would be considered suitable for salmonids. Specific conductance measurements at the North Fork monitoring location were approximately twice the levels found at other locations in the Albion Basin, with the exception of the estuary. This monitoring location is below the confluence with Soda Springs Creek that, as its name implies, is fed mostly from sodium rich spring water. Therefore, S.C. levels in the North Fork below the confluence with this tributary would naturally be higher than at other freshwater locations.

While these basic water chemistry parameters are generally suitable for salmonids, it is difficult to make any significant conclusions with such limited information.

Aquatic/Riparian Conditions

Unless otherwise noted, the vegetation description in this section is based on manipulation of CalVeg 2000 data. The United States Forest Service, Remote Sensing Lab., interprets this vegetation data from satellite imagery. The minimum mapping size is 2.5 acres.

Riparian vegetation within 150 feet of the centerline of streams is dominated by conifers and to a lesser extent hardwood forest. Mixed Forest, grassland vegetation and grassland cover smaller percentages. Visual observation along the county roads adjacent to the Albion River and the downstream reaches of the North Fork and Marsh Creek indicates that the riparian area is often constrained and defined by the location of these near stream roads.

Fish Habitat Relationship

There are 23 perennial stream miles on seven perennial tributaries in this subbasin. CDFG, L-P, and/or CLT crews have surveyed six of these tributaries since 1994. The surveys included channel typing using the classification system developed by David Rosgen (Rosgen 1996), habitat typing, and biological sampling as described in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998). There were 26 reaches determined by their individual channel types, on 10 tributaries, totaling 18.6 miles of inventoried streams (

Table 71). Details of surveys are in the CDFG Appendix.

Table 71. Inland Subbasin surveyed tributary with Rosgen channel types.

Stream	CDFG Survey (Y/N)	Survey Length (miles)	Estimated Anadromous Habitat Length (miles)*	Reach	Channel Type
Middle and Upper Albion River	Y	7.6	8.7	7	F4, F1
North Fork	Y	2.2	2.2	5	F4, F1, E6
Soda Springs Creek	Y	0.8	0.8	3	F4, F1, F5
Portuguese Gulch	N		0.5		
Marsh Creek	Y	0.5	0.5	1	F4
East Railroad Gulch	N		0.5		
South Fork	Y	7.1	7.1	6	F4, F3, E6
Little North Fork	Y	0.4	0.4	1	F4
Soda Springs Gulch	Y	0.1	0.8	1	
Bull Team Gulch	Y	0.7	1	1	
Winery Gulch	N		0.5		

CDFG protocol stream surveys observe, measure, describe, and record pool, flatwater, and riffle habitat units. During their freshwater life history, salmonids require access to all of these types of habitat and a balanced proportion is targeted. Dry units are also measured, and are indications of poor conditions for fish (Figure 61).

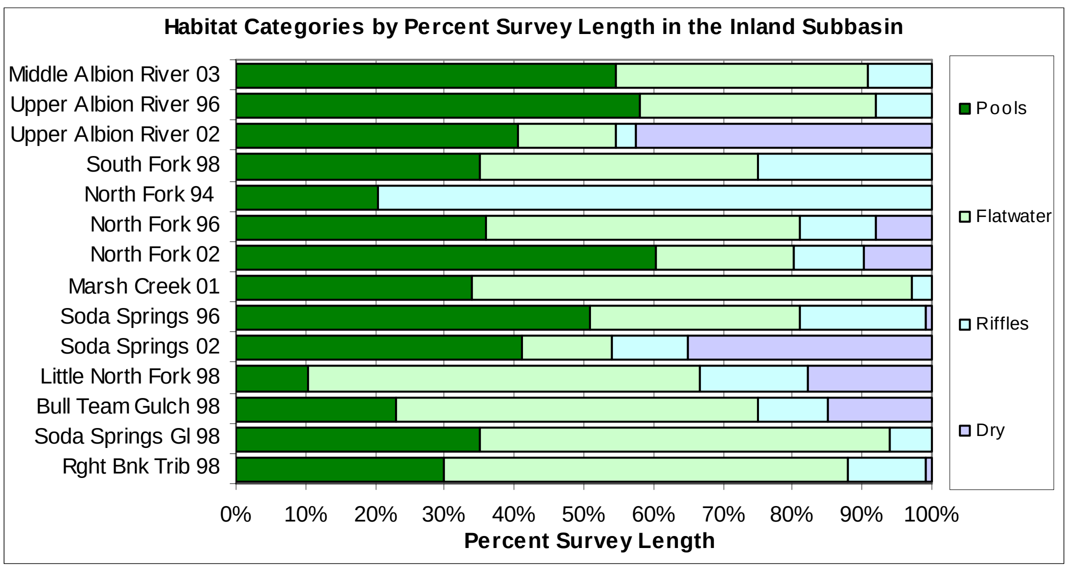


Figure 61. Percentage of pool habitat, flatwater habitat, riffle habitat, and dewatered channel by surveyed length, Inland Subbasin..

Streams in descending order by drainage area (largest at the top).

Canopy density, as estimated during CDFG surveys is a measure of the percentage of shade canopy over a stream. These measurements also provide an indication of the potential future recruitment of organic debris to the stream channel, as well as the insulating capacity of the stream and riparian areas during winter. Additionally, near stream forest density and composition can contribute to microclimate conditions that help moderate air temperature, which is an important factor in determining stream water temperature. Stream canopy relative to the wetted channel normally decreases in larger streams as channel width increases due to increased drainage area.

The CDFG Restoration Manual sets a target of 80% for shade canopy along coastal streams. CDFG recommends areas with less than 80% shade canopy as candidates for riparian improvement efforts. All surveyed reaches in the Inland Subbasin exceeded the CDFG 80% canopy target value (Figure 62).

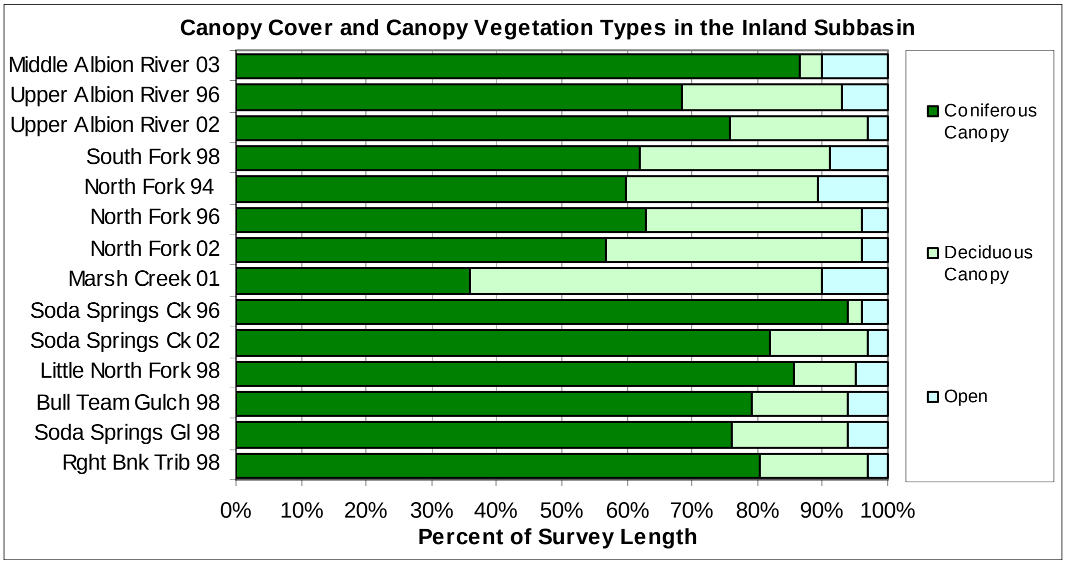


Figure 62. The relative percentage of coniferous, deciduous and open canopy above surveyed streams in the Inland Subbasin.

Streams in descending order by drainage area (largest at the top).

CDFG stream surveys measure embeddedness at pool tail crests. Crews examine several cobbles of average size for the stream reach at each sample site. Embeddedness is the percentage of the cobble surrounded by fine substrate. Category 1 is 0-25% embedded; Category 2 is 26-50% embedded; Category 3 is 51-75% embedded; Category 4 is 76-100% embedded, and Category 5 is unsuitable for spawning due to factors other than embeddedness (e.g. log sill, bedrock, boulders). Category 1 is best, category 2 is supportive, and category 3 and 4 are not within the suitable ranges for successful spawning or incubation of salmonids.

Embeddedness value samples in the Inland Subbasin indicated suitable conditions in Soda Springs, North Fork, and the Upper Albion (Figure 63). The other surveyed streams indicated conditions were moderately unsuitable or unsuitable for widely successful salmonid spawning and incubation

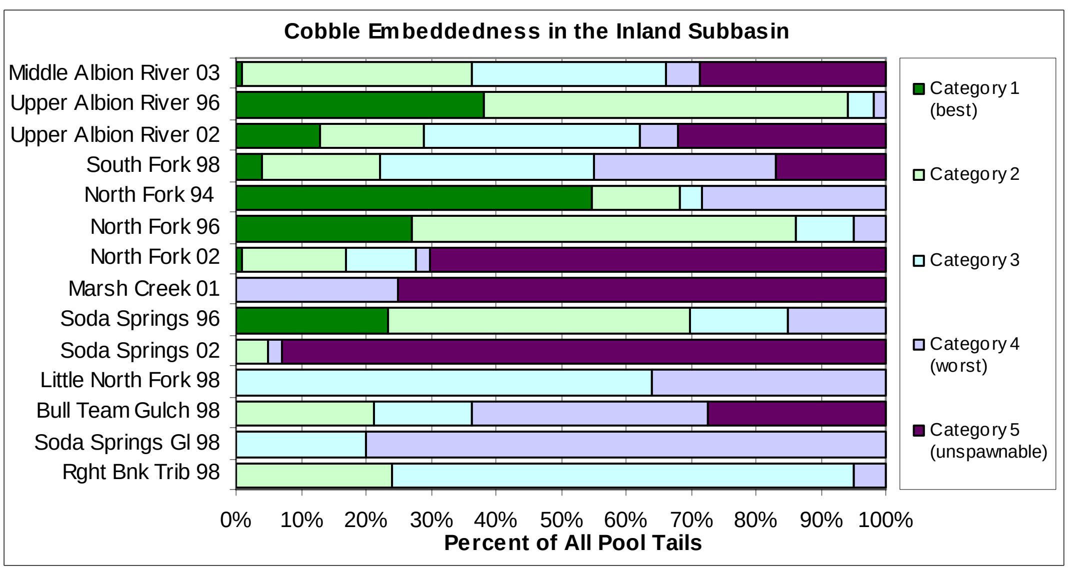


Figure 63. Cobble embeddedness categories as measured at pool tails in surveyed streams in the Inland Subbasin.

Streams in descending order by drainage area (largest at the top).

Pool depth is an important habitat component for salmonids. The CDFG Restoration Manual describes "primary" pools to be those with a maximum residual depth greater than 2 foot in first and second order streams, and greater that 3 foot in third and fourth order streams (Flosi et al. 1998). The CDFG target for primary pools is 40% of reach length to be in primary pools. Analysis of pool depths will indicate reach and stream conditions relative to other streams in a subbasin, and focus habitat improvement efforts.

The middle reach of the mainstem Albion River (RM 9.2 to RM 15.2) has the best pool habitat in the subbasin and had suitable pool habitat. All other surveyed reaches were below CDFG target values. However, five other first order streams exceeded 30% in pools greater than 2 foot depth, and could be short-term good candidates to benefit from activities to improve pool conditions (Figure 64).

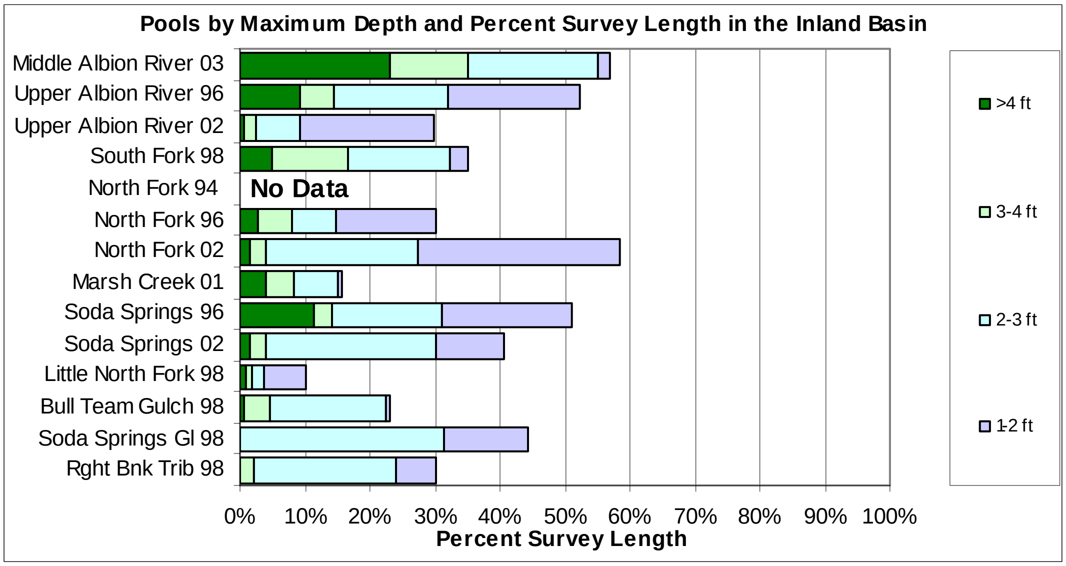


Figure 64. Percent length of survey composed of pools in the Inland Subbasin.

Streams in descending order by drainage area (largest at the top).

Pool shelter rating illustrates the relative pool complexity, another component of pool quality. Ratings range from 0-300. The Stream Reach EMDS model evaluates pool shelter to be fully unsuitable when ratings are less than 30. The range from 100 to 300 is fully suitable. These values comport with CDFG Restoration Manual targets. The Little North Fork provided the best shelter of all surveyed reaches in the subbasin with a fully suitable rating above 125. Six other reaches exceeded a rating of 30 at the time of the surveys; others were fully unsuitable (Figure 65).

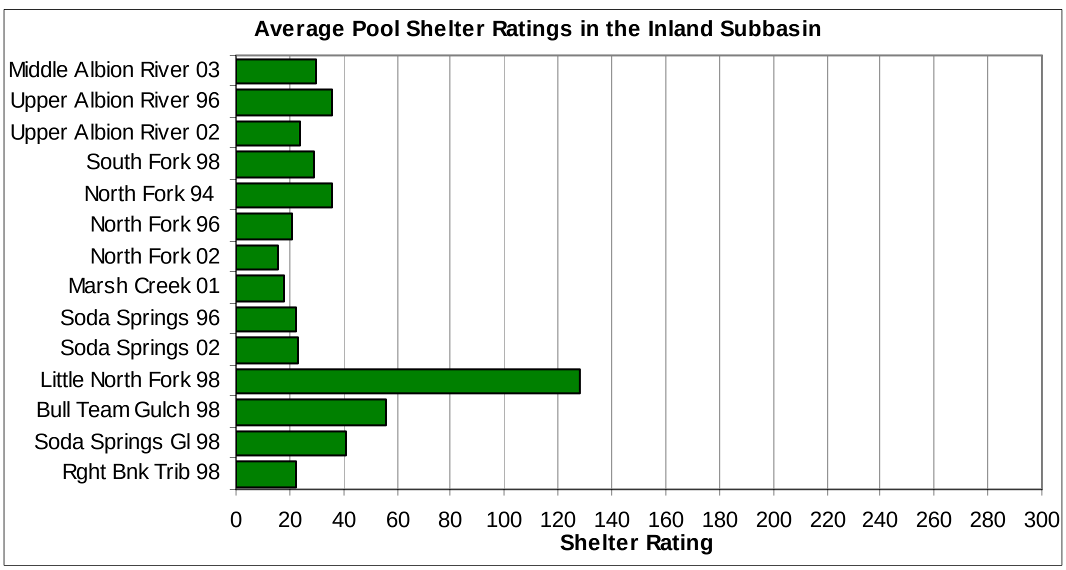


Figure 65. Average pool shelter ratings from stream surveys in the Inland Subbasin.

Streams in descending order by drainage area (largest at the top).

Fish Passage Barriers

Stream Crossings

Two stream crossings were surveyed in the Albion Basin as a part of the coastal Mendocino County culvert inventory and fish passage evaluation conducted by Ross Taylor and Associates (2001). These culverts were located on the Upper mainstem Albion and Marsh Creek. Both culverts were considered total salmonid barriers (Table 72). Priority ranking of 24 culverts in coastal Mendocino County for treatment to provide unimpeded salmonid passage to spawning and rearing habitat placed the culvert on the upper mainstem Albion River at number one and the culvert on Marsh Creek at number four. There is also an impassable dam on Marsh Creek. Criteria for priority ranking included salmonid species diversity within stream reach of interest (and federal listing status), extent of barrier for each species and life stage for range of estimated migration flows, quality and quantity of potential upstream habitat gains, sizing of current stream crossing (risk of fill failure) and condition of current growing (life expectancy).

Table 72. Culverts surveyed for barrier status in the Inland Subbasin (Taylor 2001).

Stream Name	Road Name	Priority Rank	Barrier Status	Upstream Habitat	Treatment
Upper Mainstem Albion	Flynn Creek Road	1	Total barrier. A barrier for adult coho salmon and steelhead trout and all age classes of juveniles due to excessive velocities over the smooth concrete lining, a lack of depth at lower migration flows, and the leap required to enter the culvert.	Approximately 4.6 miles of good salmonid habitat.	In Progress
Marsh Creek	Flynn Creek Road	4	Total barrier. A barrier for all age classes of juveniles due to excessive velocities over the smooth concrete lining.	Approximately 0.7 miles of fair salmonid habitat to an old mill pond; and approximately 1.7 additional miles of fair salmonid habitat upstream from the pond.	In Progress

Dry Channel

A main component of CDFG Stream Inventory Surveys is habitat typing, in which the amount and location of pools, flatwater, riffles, and dry channels are recorded. Although the habitat typing survey only records the dry channels present at the time when the survey was conducted, this measure of dry channel can give an indication of summer passage barriers to juvenile salmonids. Dry channel conditions in the Inland Subbasin generally occur from late July through early September. Therefore, CDFG stream surveys conducted outside this period are less likely to encounter dry channels.

Dry channels disrupt the ability of juvenile salmonids to move freely throughout stream systems. Juvenile salmonids need free movement to find food, escape from high water temperatures, escape from predation, and migrate out of their stream of origin. The amount of dry channels reported in surveyed stream reaches in the Inland Subbasin is less than 8.0% of the total length of stream surveyed. Dry habitat units occurred at the upper limit of anadromy in all six tributaries with measured dry channel (Table 73). Dry channel at the mouth of a tributary disconnects that tributary from the mainstem Albion River, which can disrupt the ability of juvenile salmonids to access tributary thermal refugia in the summer. Dry channel in the middle reaches of a stream disrupts the ability of juvenile salmonids to forage, escape predation, and reach areas upstream.

Table 73. Dry channel recorded in CDFG stream surveys in the Inland Subbasin.

Stream	Survey Period	# of Dry Units	Dry Unit Length (ft)	% of Survey in Dry Channel
Albion River	June/October	79	4,509	12%
Bull Team Gulch	July	9	582	15%
Little North Fork	July	3	344	17%
North Fork	July	50	1,118	9%
Soda Springs Creek	July/October	15	1,483	32%
Soda Springs Gulch	July	0	0	0
South Fork	July	1	33	>1%

Various field observations have indicated low flow problems in the Inland Subbasin. THP 1-91-08MEN describes the Albion as a water-scarce system, where low flows limit juvenile salmonid rearing habitat, particularly in the upper reaches of the drainage. It has been postulated that residential water demand, especially in the Comptche area, coupled with low rainfall years, has had some effect on overall flows in the Albion River. The Sediment Budget TMDL (U.S. EPA 2001, pg 17 and Figure 10) states that low flows at the Albion stream gage are 1 cu ft/sec or less 30% of the time over a period of analysis 1952-1997. At least 0.5 cu/ft are permitted upstream of the gage. Historic stream surveys note low or no flow conditions due to residential and agricultural uses in the 1960s and 70s (CDFG Appendix).

Fish History and Status

Spawning surveys, stream surveys, and interviews with local residents indicate that coho salmon, steelhead trout, and a few Chinook salmon are found throughout the Inland Subbasin. CDFG stream surveys in the 1960s found coho salmon in four out of five streams surveyed and steelhead trout in all five of streams surveyed. Currently, coho salmon were present on 11 out of 17 of the streams surveyed and steelhead trout were present on all. More detailed summaries of stream surveys and fisheries studies in the Inland Subbasin are provided in the CDFG Appendix.

Inland Subbasin Issues

From the various disciplines' assessments and constituent input, the following issues were developed for the Inland Subbasin. These must be considered in context of the Albion's Franciscan mélange geology and the low gradient depositional areas in the lower reaches of the subbasin tributaries:

- Low stream flow in the late summer and fall from water extraction and diversions;
- Dissolved oxygen may be unsuitable in the North Fork Albion;
- Samples taken in the South Fork Albion indicated low permeability;
- Levels of fine sediment <6.4 mm were unsuitable in samples from mainstem reach sites above the South Fork, below East Railroad Gulch, below the North Fork, and in the lower South Fork;
- CDFG surveys found fine sediment in low gradient stream reaches in Marsh Creek, the middle and upper South Fork, the upper North Fork, and the upper mainstem Albion River;
- There is concern that livestock may be damaging stream channel and riparian areas in parts of the upper Inland Subbasin;
- Currently, there is no systematic road assessment program in this subbasin;
- Subdivision development within this subbasin could potentially exacerbate erosion and landslides to a greater degree than elsewhere in the Albion Basin;
- In many reaches, pool habitat, escape and ambush cover, water depth, substrate embeddedness and gravel size are unsuitable for salmonids;
- Large woody debris recruitment potential is poor overall, and may be exacerbated by past land use practices;
- There is a lack of available data on macroinvertebrate and other food availability;
- There is a lack of available data on pH, dissolved oxygen, nutrients, and other water chemistry parameters;
- There is an assessment need for survey information on a few streams in this subbasin;
- Better fish population information is needed;
- There is a limited amount and distribution of suitably sized spawning gravels at surveyed/monitored locations in the middle and upper mainstem Albion, Marsh Creek, the South Fork, and lower and upper North Fork;
- Instream substrate particle sizes (D50) are generally small at sites monitored on the Middle Mainstem, South Fork Albion, East Railroad Gulch, Little North Fork, and the North Fork Albion River;
- There are two county road culverts identified as barriers to fish passage;
- Marsh Creek has a dam that is not passable to salmonids.

Inland Subbasin Integrated Analysis

The following analyses provide a dynamic, spatial picture of the basin conditions for the freshwater life stages of salmonids. Comments are presented on the impacts of these conditions on the stream or fishery. Especially at the tributary and subbasin levels, the dynamic, spatial nature of these processes provides a synthesis of the basin condition and indicates the quantity and quality of the freshwater habitat for salmon and steelhead. In-depth analyses of watershed processes were only conducted for water quality and instream habitat for the Albion Basin due to budgetary constraints.

Water Quality

Continuous water temperature data were available from three sites on the mainstem Albion in this subbasin during the period from 1992-2002. Data were available on the South Fork Albion River from two sites during various years from 1992-2002, and at three sites on other tributaries from 2001-2002. Temperature data for most of the tributaries in this subbasin and the upper mainstem above Marsh Creek are not available, and therefore no conclusion can be made about the suitability of these areas for salmonids.

Instream sediment data were collected for various parameters including pebble counts (D50), bulk sediment samples, V-Star (V*), and permeability. Data were available from nine mainstem Albion locations, eight sites on the South Fork Albion River, and five sites from other tributaries during various years from 1998-2001. Sediment data for most tributaries and much of the mainstem in this subbasin were not available for analysis in this report.

Water chemistry data were limited in this subbasin and it is difficult to make any significant conclusions from the available data. Data from one monitoring location on the middle mainstem Albion River, and one location on the North Fork Albion were available from 2001.

The information in the tables below is a summary of the water quality data which were presented earlier in this section, with additional information about the significance of each of the parameters.

Table 74. Inland Subbasin water temperature summary table.

<table>
<tr><th colspan="5">TEMPERATURE</th></tr>
<tr><th colspan="5">Significance-MWATs</th></tr>
<tr><td colspan="5">The maximum weekly average temperature (MWAT) is the maximum value of a seven-day moving average of the daily average temperatures. The MWAT range for "fully suitable conditions" of 50-60°F was developed as an average of the needs of several cold-water fish species, including coho salmon and steelhead trout. As such, it does not represent fully suitable conditions for the most sensitive cold-water species (usually considered to be coho). Temperatures between 61-62 F are considered "moderately suitable," while a temperature of 63°F is considered "somewhat suitable." The suitability of a 64°F temperature is considered "undetermined." Temperatures of 65 °F and above are within the ranges considered "unsuitable" for salmonids (Refer to EMDS Appendix).</td></tr>
<tr><th colspan="5">Significance-Seasonal Maximum Temperatures</th></tr>
<tr><td colspan="5">The seasonal maximum temperature is the highest value of the maximum daily water temperatures during a calendar year. Through extensive literature research, it has been determined that once the threshold of 75°F is exceeded salmonids experience high levels of mortality if cold water refugia is unavailable (Sullivan et al 2000). Therefore, seasonal maximum temperatures below 75°F are considered "suitable", while temperatures above this thresholds are "unsuitable" for salmonids.</td></tr>
<tr><th colspan="2">MWATs</th><th colspan="2">Seasonal Maximum Temperatures</th><th>Discussion-MWATs</th></tr>
<tr><th colspan="4">Middle Mainstem Albion River[1]</th><td rowspan="9">Mainstem Albion River records were fully to somewhat suitable, and tributary sites ranged from fully to moderately suitable.</td></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>15</td><td>0</td><td>14</td><td>1</td></tr>
<tr><th colspan="4">Upper Mainstem Albion River[2]</th></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>2</td><td>0</td><td>2</td><td>0</td></tr>
<tr><th colspan="4">South Fork Albion River[1]</th></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>15</td><td>0</td><td>15</td><td>0</td></tr>
<tr><th colspan="4">Other Tributaries[3]</th><th>Discussion-Seasonal Maximum Temperatures</th></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td><td>Suitable Records</td><td>Unsuitable Records</td><td rowspan="2">Mainstem records were mostly fully suitable with one unsuitable record on the middle mainstem above the South Fork Albion River in 1999. Tributary sites were all fully suitable.</td></tr>
<tr><td>6</td><td>0</td><td>6</td><td>0</td></tr>
</table>

[1] Samples at two sites from 1992-2002. Data: MRC & MCWA
[2] Samples at one site in 2001 & 2002. [3] Samples at five sites in 1993, 2001, & 2002.

MWATs at mainstem Albion monitoring sites in this subbasin ranged from fully to somewhat suitable (Table 74). Seasonal maximum temperatures at sites on the mainstem were generally fully suitable, with the exception of the temperature above the South Fork Albion in 1999 that was unsuitable (75°F). MWATs at South Fork Albion River monitoring locations ranged from fully to moderately suitable, and MWATs at sites on other tributaries were all fully suitable. Seasonal maximum temperatures at all tributary monitoring locations were fully suitable.

Table 75. Inland Subbasin sediment summary table.

SEDIMENT

Significance-D50s

Pebble counts to determine the median particle size, or D50, of the streambed are used to characterize streambed substrate particle size distributions. Pebble counts are usually performed in the riffles of wadeable, gravel-bed streams. This simple and rapid method may help in determining if land use activities or natural land disturbances are introducing fine sediment into streams.

D50 (mm)	
Middle Mainstem Albion River[1]	
Minimum	*Maximum*
8	*55*
South Fork Albion River[2]	
Minimum	*Maximum*
10	*55*
Other Tributaries[3]	
Minimum	*Maximum*
7	38

Discussion-D50

D50s at the middle mainstem Albion and tributary locations monitored in the Inland Subbasin were small to moderate, ranging from fine to very coarse gravel (Rosgen 1996).

Note: Some cross-sections were not necessarily located on riffles in the streambed. Three different methods were used to collect data.

Significance-Bulk Sediment Samples

The suitability of spawning gravels depends on the size of the fish, therefore a range of particle sizes (6 mm to 102 mm) are necessary to accommodate all sizes of salmonids (Bjorn and Reiser 1991). The instream substrate needs to be distributed over this range of sizes because of variations in salmonid size and their selection of spawning gravels. If all the particles were in the lower or upper part of this range, it would limit the usefulness of these particles for salmonids. Bulk sediment samples are used to assess the amount of fine sediment and size of particles at pool tail-outs deemed suitable for spawning. Fine material < 0.85 mm can affect embryo survival by blocking the interstitial spaces between particles. This can decrease dissolved oxygen levels in the sediment, and prevent metabolic wastes from being carried away. Fine material <6.4 mm have been known to impact salmonids during the emergence stage. Particles of this size can block the emergence of fry depending on the angularity of particles, and are inversely related to the size of emerging fry (Chapman 1988). The TMDL target values for fine sediment <0.85 mm and < 6.4 mm (<14% and <30% respectively) are not directly comparable to the data due to different collection methodologies. However, it can be determined that fine sediment levels that exceed these targets are unsuitable for salmonids, while values below the targets are of unknown suitability (see Water Quality Appendix for further detail).

Bulk Sediment	
Median % <0.85 mm	**Median % <6.3/6.4 mm**
Middle Mainstem Albion River[7]	
Minimum-Maximum	*Minimum-Maximum*
4-11	25.7-59.8
Upper Mainstem Albion River[8]	
Minimum-Maximum	*Minimum-Maximum*
1	4.5
South Fork Albion River[6]	
Minimum-Maximum	*Minimum-Maximum*
7.5-8	28.3-31.5
Other Tributaries[8]	
Minimum-Maximum	*Minimum-Maximum*
6.5	23.3

Discussion-Bulk Sediment (fine sediment)

Median values for fine sediment <0.85 mm on the Mainstem were below the TMDL target value, and therefore their suitability can not be determined at this time. The median percent of fines <6.3/6.4 mm ranged from below to much higher than the target value. The target for fines <6.4 mm (<30%) was exceeded (unsuitable) on the middle Mainstem above the South Fork in 1998 (40%), but was below the target value in 2001 (suitability undetermined). The median percent of fines <6.3 mm in 1998 on the middle Mainstem below east Railroad Gulch, and <6.4 mm in 2001 on the middle Mainstem below the North Fork also exceeded the target value (33.5% and 59.8% respectively), and therefore were unsuitable.
The median percent of fine sediment <0.85 mm and <6.3/6.4 mm at the South Fork and North Fork monitoring locations were generally below TMDL target values, and therefore their suitability can not be determined at this time. However, in 1998 the median percent of fines <6.3 mm on the South Fork Albion above the Mainstem was 31.5% (unsuitable), although 2001 levels were below the target value (suitability undetermined).
Note: Samples were dry-sieved and the percentage of sediment was calculated on a by weight basis.

50th percentile of particles (mm)	
Middle Mainstem Albion River[7]	
Minimum	*Maximum*
3.7	23.8
Upper Mainstem Albion River[8]	
Minimum	*Maximum*
39.7	
South Fork Albion River[6]	
Minimum	*Maximum*
15.3	24.1
Tributaries[8]	
Minimum	*Maximum*
33.3	

Discussion- Bulk Sediment (particle distribution)

At least 50% of the particles at bulk sediment sampling locations were in the lower quarter of the range used by salmonids. This indicates that there is a lack of larger particles at sampling locations in this subbasin, which could limit their usefulness to salmonids.
Note: 75th percentile of particles on the mainstem ranged from 19.1-75.4 mm, and the 25th percentile of particles ranged from 1.8-22.4 mm. The 75th percentile of particles on tributaries ranged from 46.6-80.6 mm, and the 25th percentile of particles ranged from 4.4-7.4 mm.

Significance-V*

V* (V-Star) measures the percent of a pools volume filled with fine sediment. Low V* values may indicate relatively low watershed disturbances. The following V* ranges, derived from Knopp (1993), are meant as reference markers and should not be construed as regulatory targets: V* ≤ 0.30 = low pool filling; correlates well with low upslope disturbance, V* > 0.30 and ≤ 0.40 = moderate pool filling; correlates well with moderate upslope disturbance, V* > 0.40 = high pool filling, correlates well with high upslope disturbance. The Albion River TMDL (US EPA 2001) set a regulatory numeric mean target value of <0.21 for the Albion Basin.

V*	Discussion-V*
South Fork Albion River[8]	A V* value of 0.20 is suitable and indicates low pool filling. This value is comparable to the Albion River TMDL numeric mean target value. <u>Note:</u> This value was determined by sampling one pool within the reach.
0.20	

Significance-Thalweg/Cross-sections

Stream transects, or cross-sections provide a bottom profile of the streambed along a transect perpendicular to the direction of the flow. Thalweg measurements help develop a picture of the profile of the stream by measuring the elevation (depth) of the stream along a longitudinal transect. Multiple year data sets can reveal whether a location is aggrading (accumulating sediment), degrading (losing stored sediment), undergoing channel shifts (changes within an established floodplain), or channel migration (changes beyond established floodplains).

Thalweg/Cross-sections	Discussion-Thalweg/Cross-sections
Middle Mainstem Albion River[10]	Limited Thalweg data did not allow for trend analysis. Cross-sections showed mostly channel shifts within the established floodplain. Aggradation, degradation, and shifts in the thalweg are apparent at some sites from year to year. Sediment volumes were not calculated (Water Quality Appendix).
1998, 2000, & 2001	
South Fork Albion River[10]	
1998, 2000, & 2001	
Tributaries[9]	
1998 & 2000	

Significance-Streambed Permeability

The survival of salmonid eggs depend on the flow of water through the gravels. This serves to deliver oxygen to the incubating eggs and remove metabolic wastes from the egg pocket. The intrusion of fine sediment can reduce intergravel flow by reducing permeability, thus oxygen availability decreases and metabolic wastes build up (McBain and Trush 2000). Additional factors such as high temperature and egg disintegration can also embryo survival. An equation, which uses permeability to calculate the estimated percent survival to emergence, was used to assess conditions for salmonid embryos (see Water Quality Appendix for further detail).

Streambed Permeability		Discussion-Permeability and Percent Survival
Median Permeability (cm/hr)	**Median Survival (%)**	Median permeabilities and the estimated median percent survival to emergence at middle mainstem Albion monitoring sites were lower in 2000 than they were in 1998. South Fork Albion median permeabilities were higher in 2000 than in 1998, as was the calculated median percent survival. These values reflect conditions before a spawning fish has worked the gravels into a redd, and therefore it would be assumed that permeability would improve to some degree through the creation of the redd.
Middle Mainstem Albion River[12]		
Minimum-Maximum	*Minimum-Maximum*	
1017-17519.5	20-62%	
South Fork Albion River[11]		
Minimum-Maximum	*Minimum-Maximum*	
121-796	0-17%	

Significance-Suspended Sediment vs. Turbidity

Turbidity occurs when suspended and dissolved materials in the water cause light to be scattered and absorbed, rather than transmitted through the water column. A relationship can be developed between turbidity and suspended sediment for a waterbody that enable one to be used as a reasonable estimator of the other. Increases in turbidity can have negative effects of salmonids and other aquatic species. Varying degrees of turbidity can result in the following: decreased production and abundance of plant material, decreased abundance of fish food organisms, decreased production and abundance of fish, decreased feeding rates, altered normal behavior patterns, as well as other effects.

Suspended Sediment vs. Turbidity	Discussion-Suspended Sediment vs. Turbidity
Middle Mainstem Albion River10	Suspended sediment and turbidity data were collected sporadically, and data are insufficient to assess the impacts to salmonids. The data provide a preliminary look at the relationship between turbidity and suspended sediment in the Albion Basin
WY 2000-2001	
Upper Mainstem Albion River9	
WY 2000-2001	
South Fork Albion River9	
WY 2000-2001	
Tributaries13	
WY 2000-2001	

[1] Fifteen samples at six sites in 1998, 2000, & 2001.
[2] Thirteen samples at six sites in 1998, 2000, & 2001.
[3] Twenty 2001samples at nine sites in 1998, 2000, & 2001
[4] One sample at one site in 1998.
[5] One sample at one site in 2001.
[6] Two samples at two sites in 1998 & 2001.
[7] Four samples at four sites in 1998 & 2001.

Data: MRC, GMA, RWQCB
[8] One sample at one site in 2001.
[9] Samples at one site.
[10] Samples at two sites.
[11] Two samples at one site in 1998 & 2000.
[12] Four samples at two sites in 1998 & 2000.
[13] Samples at three sites.

D50s were small to moderate at mainstem and tributary locations monitored (Table 75). At pool tail-outs, the median percent of fines < 0.85 mm were below the TMDL target value, and therefore their suitability cannot be determined at this time. The median percent of fine sediment < 6.3/6.4 mm ranged from below (suitability undetermined) to well above the target value (unsuitable). At mainstem and tributary monitoring locations, at least half of the particles were in the lower quarter to third of the range used by salmonids for spawning. The amount of fine sediment in the pool (V*) measured on the South Fork Albion River was suitable. Median permeabilities on the South Fork and their associated calculated percent survival to emergence increased from 1998 to 2000, although middle mainstem median values decreased during this time.

Table 76. Inland Subbasin water chemistry summary table.

WATER CHEMISTRY
Significance-Dissolved Oxygen (D.O.)
Dissolved oxygen enters the water by photosynthesis of aquatic biota and by the transfer of oxygen across the air-water interface. The Basin Plan (RWQCB 2001) requires a minimum level of 7.0 mg/l be maintained to protect beneficial uses in the Albion River, including salmonids.
Significance-pH
The Basin Plan requires that pH be within the range from 6.5-8.5 to protect the beneficial uses in the Albion River, including salmonids. These pH levels help control/regulate the chemical state of nutrients such as CO2, phosphates, ammonia, and some heavy metals.
Significance-Specific Conductance (S.C.)
Specific conductance is the measure of ionic and dissolved constituents in aquatic systems. The quantity and quality of dissolved solids-ions can determine the abundance, variety, and distribution of plant/animals in the aquatic environment. Osmoregulation efficiency is largely dependent on salinity gradients. Estuary salinity is essential to outmigrant smoltification.

Middle Mainstem Albion River		**Discussion-D.O., pH, S.C.**
Dissolved Oxygen (mg/L)[1]		Current middle mainstem data reflect suitable conditions for salmonids with respect to all three parameters at the monitoring location. Data from the North Fork Albion river site reflects D.O. levels which were below suitable levels at times. pH levels at the site were within the suitable range. S.C. was higher than normal for freshwater streams, although the monitoring location is below Soda Springs Creek which is fed mostly from sodium rich spring water. This may account for the elevated S.C. levels. **<u>Note</u>:** Further data collection should be performed for conclusive results. All samples were grab samples which are limited both spatially and temporally.
Minimum	*Maximum*	
9.4	11.3	
pH (Standard Units)[1]		
Minimum		
7.1	*Maximum*	
Specific Conductance[1]	8.2	
Minimum		
175	*Maximum*	
Tributaries	319	
Dissolved Oxygen (mg/L)[2]		
Minimum		
6.8	*Maximum*	
pH (Standard Units)[2]	7.6	
Minimum		
7.9	*Maximum*	
Specific Conductance[2]	8.1	
Minimum		
601	*Maximum*	

Data: STORET, RWQCB
[1] Three samples from one site in 2001.
[2] Samples taken at one site in 2001, every 15 minutes for a period of three days (263 samples total) using a continuous data logger.

As mentioned, water chemistry data in this subbasin were extremely limited. Middle mainstem Albion River dissolved oxygen, pH, and specific conductance levels were all suitable at the monitoring location (Table 76). At the North Fork Albion River site, dissolved oxygen levels were generally suitable, although there were occasions where they were below 7.0 mg/L. North Fork pH levels were within the suitable range, and specific conductance levels were elevated at the monitoring site compared to values in other freshwater portions of the Albion River Basin. This is most likely due to the location of the monitoring site below Soda Springs Creek which spring fed and thus has higher conductivity levels.

Instream Habitat

Introduction

The products and effects of the watershed delivery processes examined in the Integrated Analyses tables are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Albion Basin are presented in the CDFG Instream Habitat Integrated Analysis. Instream habitat data presented here were compiled from stream inventories, an estuary study, and fish passage barrier removal project. Details of these reports are presented in the CDFG Appendix.

Pool Quality and Quantity

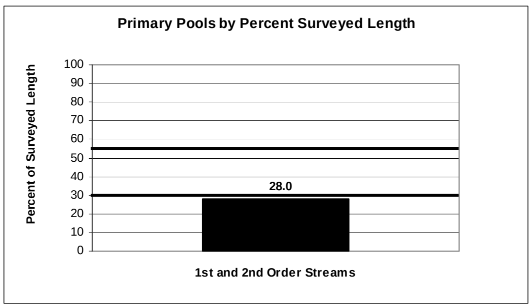


Figure 66. Primary pools in the Inland Subbasin.

Pools greater than 2 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30-55% of its length in primary pools to be suitable for salmonids.

Comments: The percent of primary pools by length in the Inland Subbasin is below target values for salmonids, and appears to be less suitable in lower order streams than in higher order streams.

Spawning Gravel Quality

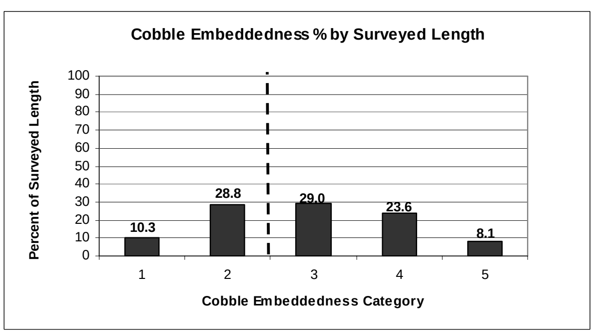


Figure 67. Embeddedness in the Inland Subbasin.

Significance: Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clay, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded and category 4 is 76%-100% embedded. Cobble embeddedness categories 3 and 4 are not within the fully supported range for successful use by salmonids and category 5 is not suitable because of the absence of spawnable substrates.

Comments: More than one half of the surveyed stream lengths within the Inland Subbasin have cobble embeddedness in excess of 50% in categories 3 and 4, which does not meet spawning gravel target values for salmonids.

Shade Canopy

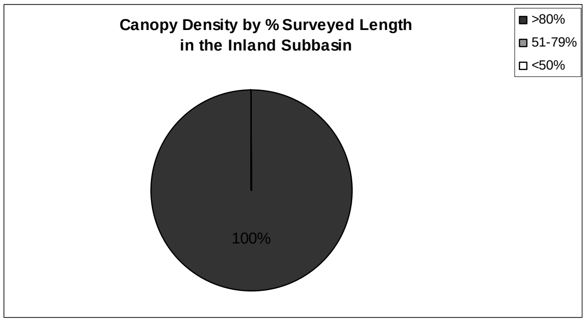


Figure 68. Shade canopy in the Inland Subbasin.

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50%by survey length is below target values and greater than 85% is fully meets target values. Overall, the Inland Subbasin fully meets these target values.

Comments: All of the surveyed stream lengths within the Inland Subbasin have canopy densities greater than 80%. This is above the canopy density target values for salmonids.

Fish Passage

There are three recorded barriers in the Inland Subbasin. Two culverts are at least partial barriers to juvenile salmonids. One is on Marsh Creek where Flynn Creek Road crosses, and the other is on the upper Albion River where Flynn Creek Road also crosses it. The third barrier is the dam on Marsh Creek, which is a complete barrier to all ages of salmonids.

Large Woody Debris

There are no LWD data for the Inland Subbasin.

Discussion

The Inland Subbasin contains both spawning habitat and rearing habitat. Instream conditions were generally good in the middle reaches of the Albion River and the first reach of the North Fork, fair on the lower South Fork, and poor in all the other streams surveyed. The percent of primary pools in first and second order streams for the entire subbasin was just below recommend parameters.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the condition for salmonids in a stream reach based upon water temperature, riparian vegetation, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG habitat inventory surveys. EMDS calculated its findings with the most recent data sets. Currently, data exist in the Inland Subbasin to evaluate overall reach, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS system calculates habitat variable can be found in the EMDS Appendix. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time surveyed.

EMDS stream scores were weighted by stream length to obtain overall scores for tributaries and the Inland Subbasin. Weighted average reach conditions on surveyed streams in the Inland Subbasin were evaluated by the EMDS as somewhat unsuitable for salmonids (Table 77).

The EMDS response curves describe total canopy exceeding 85% to be fully suitable, and less than 50% as unsuitable. The surveyed stream reaches of the Inland Subbasin have canopy levels that are rated by the EMDS as fully suitable for helping maintain water temperature to support anadromous salmonid production. Suitable conditions exist for canopy in all of the streams surveyed except Marsh Creek.

As described in the EMDS response curves, a stream must have 30-55% of its length in primary pools to provide stream conditions that are fully suitable for salmonids. Streams with <20 % or >90% of their length in primary pools provide conditions that are fully unsuitable for salmonids. Pool depth was in the suitable ranges on the Middle Mainstem and on the North Fork, but unsuitable on the other tributaries surveyed.

As described in the EMDS response curves, average pool shelter ratings exceeding 80 are considered fully suitable and average pool shelter ratings less than 30% are fully unsuitable for contributing to shelter that supports salmonids. Pool shelter was unsuitable on all of the tributaries surveyed except on the Little North Fork of the South Fork, which was fully suitable.

The EMDS Reach Model considers cobble embeddedness greater than 50% to be somewhat unsuitable and 100% to be fully unsuitable for the survival of salmonid eggs and embryos. The South Fork Albion was rated as somewhat suitable. The other streams surveyed were in the unsuitable ranges.

Table 77. EMDS reach model scores in the Inland Subbasin.

Stream Name	Canopy	Embeddedness	Pool Depth	Pool Shelter	Reach Condition
Inland Subbasin	+++	--	--	--	-
Middle Mainstem	+++	-	++	---	-
North Fork	+++	--	+	---	-
Soda Springs Creek	+++	- - -	- - -	- - -	-
Upper Mainstem	+++	-	- - -	- - -	-
Marsh Creek	-	- - -	- - -	- - -	-
Bull Team Gulch	+++	- -	- - -	- - -	-
Little North Fork	+++	- - -	- - -	+++	-
Soda Springs Gulch	+++	- - -	- - -	- - -	-
South Fork	+++	+	-	- -	-
Unnamed Right Bank Tributary	+++	- - -	- - -	- - -	-

+++ =Fully Suitable; ++ = Moderately Suitable; + = Somewhat Suitable; U= Undetermined- =Moderately Unsuitable; - - =Somewhat Unsuitable; --- =Fully Unsuitable

Analysis of Tributary Recommendations

CDFG inventoried 19.5 miles of streams in the Inland Subbasin. A CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard habitat inventories (Table 78). More details about the tributary recommendation process are given in the Albion Synthesis section of the Basin Profile.

Table 78. Ranked tributary recommendation summary in the Inland Subbasin.

Stream Name	Survey ed Stream Length Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Live stock	Fish Passage
Middle Mainstem Albion	5.4	3	5			2	1		4		
North Fork	2.2	2	3			5	1	4		6	
Soda Springs Creek	0.8					3	1	2			
Upper Mainstem Albion	2.0	2	3			4	5	6		7	1
Marsh Creek	0.5	6	5			2	3	4		7	1
Bull Team Gulch	0.7					3	1	2			
Little North Fork	0.4					2		1			
Soda Springs Gulch	0.08					3	1	2			
South Fork Albion	7.1	5	6			2	1	3	4		
Unnamed Right Bank Tributary	0.3					2	1				

Bank = stream banks are failing and yielding fine sediment into the stream; Roads = fine sediment is entering the stream from the road system; Canopy = shade canopy is below target values; Temp = summer water temperatures seem to be above optimum for salmon and steelhead; Pool = pools are below target values in quantity and/or quality; Cover = escape cover is below target values; Spawning Gravel = spawning gravel is deficient in quality and/or quantity; LDA = large debris accumulations are retaining large amounts of gravel and could need modification; Livestock = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; Fish Passage = there are barriers to fish migration in the stream.

To better examine Inland Subbasin issues through the tributary recommendations given in CDFG habitat inventory surveys, the recommendations were collapsed into five categories: Erosion/Sediment, Riparian/Water Temperature, Instream Habitat, Gravel/Substrate, and Other (Table 79). When examining recommendation categories by number of tributaries, the most important recommendation category in the Inland Subbasin is Instream Habitat as related to Pool/Cover, then Erosion/Sediment as related to Bank/Roads and Gravel/Substrate as related to Spawning Gravel/LDA are the next priorities. The high number of Instream Habitat Recommendations in the Inland Subbasin indicates that the highest priority should be given to restoration projects emphasizing Pool/Cover.

Table 79 Top three ranking recommendation categories by number of tributaries in the Inland Subbasin.

Inland Subbasin Target Issue	Related Table Categories	Count
Instream Habitat	Pool / Cover	17
Erosion / Sediment	Bank / Roads	5
Gravel / Substrate	Spawning Gravel / LDA	5
Other	Livestock / Barrier	3
Riparian / Water Temp	Canopy / Temp	0

However, comparing recommendation categories in the Inland Subbasin by number of tributaries could be confounded by the differences in the number of stream miles surveyed on each tributary. Therefore, the number of stream miles in each subbasin assigned to various recommendation categories was calculated Figure 69). When examining the recommendation categories by number of stream miles, the most important are Instream Habitat, Erosion/Sediment, and Gravel/Substrate. Riparian/Water Temperature and Other were not priorities.

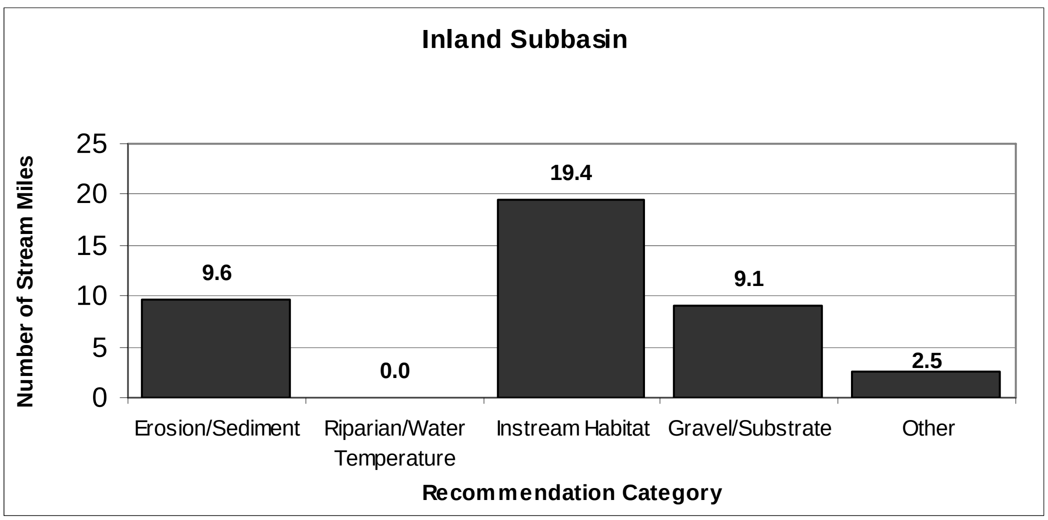


Figure 69. Top ranking recommendation categories by stream miles in the Inland Subbasin.

Refugia Areas

The refugia identification team from CDFG, CDF, and the Water Board assessed and characterized refugia habitat in the Inland Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the EMDS at the stream reach and planning watershed/subbasin scales.

The most complete data available in the Inland Subbasin were for tributaries surveyed by CDFG and long term monitoring sites from MRC. However, many of these areas were still lacking data and are noted as such in the table below. Additionally, areas such as Anderson Gulch had suitable temperatures, but did not have any other water quality data and were not surveyed by CDFG. Therefore, these locations are listed as critical contributing areas although not enough information exists to rate their potential as refugia. Salmonid habitat conditions in the Inland Subbasin on surveyed streams generally rated as medium to low potential refugia (Table 80). Additionally, tributaries serve as critical contributing areas. The following refugia area-rating table summarizes subbasin salmonid refugia conditions:

Table 80: Refugia categories in the Inland Subbasin.

Stream	Refugia Categories:				Other Categories:		
	High Quality	**High Potential**	**Medium Potential**	**Low Quality**	**Non-Anadromous**	**Critical Contributing Area**	**Data Limited**
North Fork			X				X
Soda Springs Creek				X			X
Middle Mainstem		X					X
Upper Mainstem			X			X	X
Marsh Creek				X			X
Bull Team Gulch			X				X
Little North Fork			X				X
Soda Springs Gulch				X			X
South Fork			X				X
South Fork Tributary #1				X			X
Anderson Gulch						X	X
East Railroad			X				X
Gunari Gulch							X
Winery Gulch						X	X

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within the Inland Subbasin?

Findings and Conclusions:

- Both historic and current data are limited on salmonid population trends, relative health, or diversity;
- Historic accounts and stream surveys from the 1960s by CDFG describe healthy populations of coho and steelhead trout;
- Current data indicate that the Inland Subbasin continues to maintain steelhead and coho populations;
- Based on MRC and CDFG presence surveys since the 1960s, the range of coho salmon and steelhead trout have not changed;
- Coho salmon continue to be observed more frequently than steelhead trout;
- Little specific, scientific data are available on population abundance trends, relative health, or diversity. NOAA Fisheries listing investigations suggest that populations of salmonids have probably decreased in the Albion Basin as they have elsewhere along the Pacific Coast.

What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?

Findings and Conclusions:

- **Erosion/Sediment**
  - Limited data collected in 1998 and 2001 at sites on the middle mainstem and lower South Fork Albion River indicate unsuitable levels of instream fine sediment (<6.4mm, which are above the TMDL target); while fine sediment <0.85 mm at sites throughout this subbasin were below the target (suitability undetermined) ;
  - Roads are listed in the Total Maximum Daily Loads as a major source of human-related sediment into streams;
  - There are erosion problems associated with the County road drainage system;
- **Riparian/Water Temperature**
  - Water temperatures at sites on the middle and upper mainstem, South Fork Albion, Marsh Creek, Anderson, Gunari, and East Railroad gulches are suitable for salmonids;
- **Instream Habitat**
  - In general, a high incidence of shallow pools, and a lack of cover and large woody debris have contributed to a simplification of instream salmonid habitat, with the exception of the mainstem;
  - Canopy cover was fully suitable within this subbasin;
- **Gravel Substrate**
  - Some of the streams are dominated by bedrock, indicating ongoing scouring of the channel;
  - Available data from sites on the middle and upper mainstem and lower North and South Fork Albion rivers reflect a limited amount and distribution of high quality spawning gravels for salmonids;
  - Gravel permeability at the location monitored on the South Fork Albion was low;
  - Instream substrate particle size (D50) is generally small at monitoring locations on the middle mainstem, East Railroad Gulch, Little North Fork, and the North and South Fork Albion rivers;
- **Refugia Areas**
  - The middle mainstem has the best refugia conditions in the basin. The North Fork, Upper mainstem, Bull Team Gulch, Little North Fork, South Fork, and East Railroad Gulch also provide refugia areas;
- **Other**
  - County culverts located where Flynn Creek Road crosses the Albion River and Marsh Creek have been identified as fish passage problems by a Mendocino County roads study;
  - Dissolved oxygen levels at the location monitored on the North Fork Albion may be unsuitable for salmonids;
  - Limited water quality data from the middle mainstem Albion site appear to be suitable, as are pH levels at the North Fork site;
  - The Dam on Marsh Creek is a total barrier to salmonids.

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

Findings and Conclusions:

- Summer and fall flows are usually less than 1 cfs in many upper stream reaches of this subbasin.
- Supply and distribution of instream sediment seems to be somewhat limited in several reaches of the subbasin.
- Hundreds of acres of dormant rockslides flank the northwest oriented slopes above the North and South Forks of the Albion River. Large deep-seated landslides comprise approximately 15% of the

land surface. Historically active landsliding has occurred more frequently in the vicinity of the large dormant rockslides. Slopes along the eastern edge of the basin are steep and have been the locus of historically active landsliding.

- The watershed has experienced a variety of natural disturbances that have impacted sediment conditions in stream channels. These natural disturbances occurred over the last century and include earthquakes, flooding, droughts, and decadal climate shifts. During the mid to late 1800s, a moderate earthquake originated about two miles south of the Albion Basin. In 1898, another strong earthquake originated near Fort Bragg (Toppozada and others 2000). These nearby earthquakes and the distant San Francisco earthquake in 1906 triggered landsliding throughout the Basin.
- Redwood and Douglas fir conifers have historically, and continue to dominate the basin. Additional tree species include tan oak, bay, madrone, bishop pine, and hardwood. Pre-European forests consisted of mostly large old-growth trees. Today, trees averaging 12-24 inches diameter at breast height (DBH) cover 61% of the watershed. Twenty-five percent of the area is covered by stands that average greater than 24-inch DBH trees, pole-sized trees cover another 3% 6-11 inches DBH, and sapling-sized trees 1-6 DBH.
- Poor fertility, and iron-rich hardpan layer and associated soil wetness restricts vegetation growth and has created pygmy forests in some areas with marine terrace deposits.
- A long history of wildfire has influenced the current vegetation of the Albion Basin, although the specifics of fire practices and history are unknown. However, fire was a natural and frequent occurrence. Prior to European settlement, the Mendocino Coast experienced a fire every 6-20 years during the last 200-400 hundred years (Brown 1999). In 1931, the Comptche fire swept across the eastern part of the basin, burning 10,733 acres, 39% of the basin.
- Photo mapping of channel fluvial features suggesting sediment sources or depositions showed a reduction in the number and total length of mapped features (such as sediment bars) from 1984 to 2000. This represents an approximate 57% reduction in length of mapped channel showing features suggesting sediment sources or sediment deposition. This apparent reduction may be due in part to decreased detection because of an increase in channel canopy cover.

How has land use affected these natural processes in this subbasin?

Findings and Conclusions:

- Water diversions of at least 0.5 cfs for irrigation and domestic uses are currently permitted in areas upstream of the site of the former USGS gage, mostly in the vicinity of Comptche and with a few diversions in the North Fork (GMA 2001);
- Splash dams were used in at least five locations in the Inland Subbasin. This practice straightened the stream banks and removed anything that could obstruct flow or logs all the way downstream to the mill located near the mouth of the Albion. Barrier removal projects cleared the stream of timber-related woody debris. The lack of instream complexity seen today likely results from these past practices;
- Land use, including road construction and use, timber harvesting, and grazing, have added excess sediment to the fluvial system. Many of the effects from these activities are spatially and temporally removed from their upland sources;
- County culverts located where Flynn Creek Road crosses the Albion River and Marsh Creek have been identified as fish passage problems by a Mendocino County roads study.
- Roads are a major contributor of sediment (U.S. EPA 2001).

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

Findings and Conclusions:

- Lack of shelter/cover, available and appropriately sized spawning substrate, pool frequency, and pool depth are limiting salmon and steelhead health and production;

- Summer flows on parts of the upper mainstem are limiting salmon and steelhead health and production;
- The barriers located on the mainstem and Marsh Creek are limiting salmon and steelhead health and production.

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

Recommendations

- Encourage reducing any unnecessary use of water to improve summer stream surface flows and fish habitat;
- Increase the use of water storage and catchment systems that collect rainwater in the winter for use during the dry summer and fall seasons;
- Support efforts to educate landowners about water storage and catchment systems, and to find ways to subsidize development of these systems;
- Continue water temperature monitoring at current locations and sustain conditions that are leading to suitable temperatures;
- Install LWD or other structures in the mainstem, South Fork and North Fork Albion rivers to retain gravel and create habitat;
- Investigate the suitability and feasibility of introducing appropriate, local substrate to spawning reaches if studies show instream structures to fail to retain gravel due to short supply from the system;
- Support stream gage installation and maintenance to establish a long term record of Albion hydrologic conditions;
- Support and encourage existing and active road management programs undertaken by MRC and the large percentage of small landowners with NTMPs to improve road standards throughout the basin, specifically in the middle and upper mainstem Albion River, North and South Fork Albion rivers, and Marsh Creek;
- Continue existing and develop new monitoring sites for in-channel sediment in this subbasin, with emphasis on the upper mainstem Albion River, the South Fork Albion and its tributaries;
- Investigate the affects to anadromous salmonids, other fish and wildlife, and the Albion community, as well as the feasibility of the removal of the earthen dam on Marsh Creek. Charlotte Ambrose from NOAA fisheries states that "NOAA Fisheries is in strong support of collaborative efforts to remove the Marsh Creek dam on the Albion River. Any restoration activities in this watershed are extremely important to the recovery of our listed salmonids, especially coho salmon. There are several funding sources for this type of activity through NOAA. We would be happy to facilitate discussions to procure funds and necessary permits to expedite dam removal."
- There is a minor problem with cattle trampling of the riparian zone in the areas of the North Fork Albion, upper mainstem Albion River, and Marsh Creek. Containment options should be explored with the landowner/manager;
- Conduct salmonid surveys of the mainstem Albion River, South and North Forks;
- Determine the cause of low gravel permeability at the location monitored on the South Fork Albion;
- Investigate the North Fork Albion River to determine whether dissolved oxygen levels are suitable for salmonids;
- Support progress of CDFG/Mendocino County fish passage improvement projects. Replace two county road culverts on the upper mainstem Albion River and Marsh Creek to allow unimpeded fish passage;
- Support upgrade and maintenance of the county road drainage system associated with the upper mainstem;

- Establish long-term water chemistry monitoring stations in the middle and upper mainstem Albion. If there are indications of problems, implement monitoring in tributaries as necessary to determine the source of the issue.

Subbasin Conclusions

The Inland Subbasin contains some pockets of human population concentrations. Consequently, the dewatering of streams for human uses in the summer and fall months is a potential problem for rearing salmonids. This subbasin also has a comparatively dense network of unpaved roads located near streams and road crossings that provide potential sources of fine sediment to streams. The subbasin is largely composed of naturally unstable and erosive terrain.

In this fragile environment, land use project planning must include consideration of appropriate BMPs. These should be prescribed and followed during the planning and implementation of any land use project to minimize soil disturbance and fine sediment delivery to streams, and to prevent vegetation removal near streams. Residents, landowners, and land managers can help maintain and improve stream habitat by learning methods to conserve water, reduce road related erosion, and identify fish passage barriers. They should enlist the support of appropriate agencies' technology, experience, and funding in accomplishing these goals.

Albion Basin in the Regional Context

Introduction

The Albion Basin is remotely located and very rural. The nearest urban center of Santa Rosa is a two hour drive. The 2000 census indicated a residential population of 912 people. These factors have made local residents self-sufficient, independent, and adaptive, with a strong sense of place. Historic and current land uses involve the primary production industries of forestry, fishing, and agriculture. Specific land uses include private industrial and non-industrial timber management, small cattle ranches, coastal salmon and crab fishing, and vineyards. Albion River freshwater fishery resources include coho salmon and winter-run steelhead trout. Traditionally, these fishery resources have been important food and recreation items to local residents as well as visitors.

Summary of Basin Conditions and Recommendations

Geology

- The watershed has three physiographic sub-regions: western, central, and eastern;
    - In the western sub-region, marine terraces are distinctive;
    - In the central sub-region, large relic landslides are distinctive;
    - In the eastern sub-region, broad areas of alluvium are distinctive.
- In the western portion of the basin, volcanic rocks predominantly composed on greenstone form several northwest/southeast trending lenses that are aligned with a regional structural grain of the northern Coast Ranges;
- The rocks of the Coastal Belt of the Franciscan Complex comprise the bedrock of the majority of the basin;
- During the last century, a suite of natural disturbances including earthquakes, flooding, droughts, and decadal climate shifts has occurred in the Albion Basin;
- Historic natural disturbances and land uses have likely impacted sediment conditions in the stream channels;
- At low tide, the estuary is reduced to a central channel thread that appears to be stable and shows little change from imagery of 1984 and 2000, and its location remains similar to 1936 imagery;
- Photo mapping of the central sub-region indicates a 57% reduction in the total length of mapped channel fluvial features such as sediment sources or depositions from 1984 to 2000;
- Most of the channel features mapped outside the estuary were in the eastern sub-region and their length showed a significant reduction from 1984 to 2000.

Land Use Impacts

- There are three general land uses that exacerbate sediment delivery to the stream system above natural erosion rates:
    - Erosion from poor road location, construction methods, and winter use;
    - Soil disturbance related to timber harvesting;
    - Topsoil, streambank, and riparian vegetation disturbance from grazing.
- Many of the in channel impacts from these activities are spatially and temporally removed from their upland sources;
- Currently, roads are a major, but controllable contributor of sediment to streams (CDF 2003).

Water Quality

- Limited data collected in 1998 and 2001 reflect unsuitable levels of fine sediment <6.4mm that are above TMDL targets in some areas of the basin, while fine sediment <0.85 mm at sample locations throughout the basin are below the TMDL target and therefore their suitability cannot be determined at this time;
- Instream substrate particle size (D50) is generally small at monitoring locations throughout the basin;

- Water temperatures are suitable at monitoring locations above tidal influence in the mainstem and all locations surveyed on tributaries;
- Summer water temperatures may be deleterious for salmonids in areas of the tidal estuary;
- Samples collected at sites in the estuary and the North Fork indicate dissolved oxygen levels deleterious to salmonids that are potentially limiting, although further study is necessary;
- Limited water quality data for mainstem Albion sites above tidal influence appear to be suitable, as are pH levels at the North Fork site.

Salmonid Populations

- The Albion Basin historically supported healthy populations of coho salmon and steelhead trout;
- Recent biological stream surveys indicate the presence of coho salmon and steelhead trout throughout the basin and detected no change in the salmonid range over the past 30 years;
- One population estimate based on limited data from 2002 estimated that the coho spawner population ranged from 386-1,753 with a 95% confidence interval;
- Albion basin-wide population estimates indicate reduced meta-populations of coho salmon and steelhead trout.

Salmonid Habitat

- Instream fine sedimentation in several low gradient stream reaches throughout the basin may be approaching or exceeding levels considered suitable for salmonid populations;
- In general, flow, pool depth, habitat complexity, and escape/ambush cover are unsuitable for salmonids in several mainstem and tributary stream reaches in the Albion Basin;
- In the Inland Subbasin summer flow is inadequate or non-existent in some reaches;
- Large woody debris recruitment potential is poor in the Inland Subbasin. Instream habitat improvement is the top recommendation category in the Inland Subbasin;
- Available data from sampled streams suggest that suitable, high quality spawning gravel for salmonids is limited in most of streams in both subbasins;
- Gravel permeability at the location monitored on the South Fork Albion was low;
- Salmonid habitat conditions in the Albion Basin are generally best in the Inland Subbasin and mixed in the Coastal Subbasin.

Limiting Factors Analysis Conclusions

Based on available information for the Albion Basin, the team believes that current negative salmonid habitat conditions include:

- Poor summer flows and shallow depths in some reaches of the Inland Subbasin;
- Summer water temperatures may be deleterious for salmonids in the estuary;
- Fine sediment accumulations in some locations;
- Lack of available, appropriately-sized spawning substrate;
- General basin-wide lack of habitat complexity;
- Reduced basin-wide coho and possibly steelhead meta-populations.

Refugia Rating

Based on this assessment of watershed processes and conditions, fishery status, and current salmonid habitat, the Albion Basin has medium potential as refugia for salmon and steelhead trout.

Recommendations

Flow and Water Quality Improvement Activities

- Encourage water conservation during summer low flow periods to improve stream surface flows and fish habitat in the Inland Subbasin;
- Increase the use of water storage and catchment systems that collect rainwater in the winter for use during the drier summer season.

Erosion and Sediment Delivery Reduction Activities

- Encourage the use of Best Management Practices for all land use development activities to minimize erosion and fine sediment delivery to streams;
- Expand road assessment efforts because of the potential for further fine sediment delivery from active and abandoned roads, many of which are in close proximity to stream channels;
- Encourage restricted access to unpaved roads in winter to reduce road degradation and fine sediment release. Where restricted access is not feasible, encourage rocking and other measures to decrease fine sediment production from roads;
- Inventory and map sources of streambank erosion and prioritize them according to present and potential fine sediment yield. Identified sites should then be treated to reduce the amount of fine sediments entering the stream;
- Provide technical assistance and incentives to landowners/managers in developing and implementing fine sediment reduction plans to meet requirements of the TMDL.

Riparian and Habitat Improvement Activities

- Ensure that stream reaches with high quality habitat and refugia are protected;
- Support progress of CDFG/Mendocino County fish passage improvement projects;
- Work with landowners and managers to increase large organic debris and shelter structures in streams in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids;
- Improve gravel retention and recruitment by adding instream structures where appropriate/feasible;
- Encourage use of exclusion fencing where there is evidence of streambank erosion caused by grazing livestock;
- Where feasible, design and engineer pool enhancement structures to increase the number of pools. This must be done where the banks are stable or in conjunction with streambank armor to prevent erosion;
- Investigate the suitability and feasibility of introducing appropriate, local substrate to spawning reaches if studies show instream structures fail to retain gravel due to short supply from the system.

Education, Research, and Monitoring Activities

- Conduct salmonid surveys to develop population estimates, which are needed to help evaluate the viability of habitat improvement activities;
- Develop and support local education efforts about water conservation and water catchment and storage systems;
- Support and expand ongoing efforts that monitor summer water and air temperatures on a continuous 24-hour basis to detect long-range trends and short-term effects on the aquatic/riparian community;
- Conduct studies in the estuary to determine conclusively whether water temperature and dissolved oxygen are suitable for salmonids;
- Encourage ongoing habitat inventories and fishery surveys of tributaries throughout the Albion Basin;
- Encourage macroinvertebrate surveys throughout the Albion Basin;
- Train local landowners throughout the basin to conduct stream and fishery surveys on their own lands;
- Continue long-term monitoring at current locations and establish new stations for water chemistry, thalweg, and in-channel sediment parameters;
- Determine the cause of low gravel permeabilities at the location monitored on the South Fork Albion;
- Investigate the North Fork Albion River to determine whether dissolved oxygen levels are suitable for salmonids;

- Establish a local cooperative group to help facilitate restoration funding efforts and monitoring activities;

Propensity for Improvement

Advantages

The Albion Basin has several advantages for planning and implementing successful salmonid habitat improvement activities that include:

- An expanding group of cooperative landowners that includes both public and private landowners from both subbasins in the Albion that are interested in improving watershed and fishery conditions. The effect of this is the ability to choose locations for projects where the best result can be achieved in the shortest time period;
- This assessment provides focus on watershed conditions and processes from the basin scale, through the subbasin scale, and down to the level of specific tributaries. This helps focus project design efforts so that local landowners can pursue the development of site specific improvement projects on an adaptive basis;
- Like most river systems, Albion coho salmon and steelhead trout meta-populations have evolved and adapted to the basin's unique conditions. Although these meta-populations are likely below historic levels, there remain local stocks that can take advantage of improved conditions.

Challenges

The Albion Basin also has some challenges confronting efforts to improve watershed and fish habitat conditions, and increase anadromous fish populations:

- Not all landowners are interested in salmonid habitat improvement efforts. Without a watershed wide cooperative land-base, treatment options are limited. In some cases this can remove some key areas from consideration of project development;
- Current levels of coho salmon and steelhead meta-populations could limit the amount of needed straying to rapidly colonize fish into improved or expanded habitat conditions.

Conclusion

The likelihood that any North Coast basin will react in a responsive manner to management improvements and restoration efforts is a function of existing watershed conditions. In addition, the status of processes influencing watershed condition will affect the success of watershed improvement activities. A good knowledge base of these current watershed conditions and processes is essential for successful watershed improvement.

Acquiring this knowledge requires property access. Access is a requirement to design, implement, monitor, and evaluate suitable improvement projects. Thus, systematic improvement project development is dependent upon the cooperative attitude of resource agencies, watershed groups and individuals, and landowners and managers.

The Albion assessment has considered a great deal of available information regarding watershed conditions and processes in the Albion Basin. This long assessment process has identified problems and made recommendations to address them while considering the advantages and challenges of conducting watershed improvement programs in the Albion Basin.

After considering these problems, recommendations, advantages and challenges, the Albion Basin appears to be an excellent candidate for a successful long-term, programmatic watershed improvement effort. According to the current refugia analysis, the Albion has medium potential to become a basin with high quality fishery refugia. Reaching that goal is dependent upon the formation of a well organized and thoughtful improvement program founded on broad based community support for the effort.

Limitations of this Assessment

This watershed assessment provides useful and valuable information and represents a considerable effort of the involved agencies, contractors, and public. It was limited in duration, scope, detail, and analysis level due to constraints in budget, time, access, and overall resources. Specific limitations are presented below to put the assessment in context.

- Data collected from individual stream reaches or point locations within them were described in relation to their streams or subbasins. As descriptions and inferences are extrapolated from those data to larger regional and basin scales, the certainty associated with those conclusions and inferences is reduced;
- CGS produced draft GIS data and maps. Preliminary interpretations based on geologic and geomorphic data are presented herein. Field verification of conditions was limited to drive-through reconnaissance. Finalized GIS data and maps will eventually be available as a CGS publication;
- The California Department of Fish and Game's habitat inventory surveys provided instream condition data to the EMDS Stream Reach Model, the Limiting Factors Analysis, and the Restoration Recommendations and Priorities. However, not all subbasin streams were surveyed. In the Coastal Subbasin 72% were surveyed and in the Inland Subbasin 84%. Basin wide 82% were surveyed;
- A lack of information on the suitability and/or use of the estuarine habitat for rearing and over-wintering by juvenile salmonids;
- Approximately 1.5 miles of the upper tidal portion of the estuary was not surveyed. Although this reach is unlikely to provide spawning habitat because of tidal flooding and fine sediment deposition, it may provide vital cover for migrating adult salmonids and seasonal rearing habitat for juveniles;
- California Department of Forestry and Fire Protection's land use analysis used aerial photos exclusively;
- The NCRWQCBs water chemistry analysis was limited to historic USEPA StoRet data for various years from 1976 to 1988 at three locations, and samples obtained by the NCRWQCB at three locations during sampling events in 2001. The sampling frequency was scattered and discontinuous and did not allow for much detailed temporal analysis;
- The temperature range used for "proposed fully suitable" of 50-60° F was developed as an average of the needs of several cold water fish species and life stages, including Chinook and coho salmon, and steelhead and cutthroat trout. As such, the range does not represent the slight variance of fully acceptable ranges for particular species;
- Temperature data received from MRC and MCWA reflect similar unusual features, where consecutive readings of constant temperature are apparent. The NCRWQCB performed side-by-side monitoring at two MCWA sites to determine whether placement of the probes within the water column or the sampling interval may be responsible for this observed "flat data." Results indicate that a smaller sampling interval and placement of the probes in a well mixed area result in the capture of more diurnal fluctuation in temperature, although "flat data" still appear and seem to be part of the naturally functioning system (see the Water Quality Appendix for further discussion);
- Temperature data received from MRC and MCWA reflect occasions where temperatures peaked twice in a 24-hour period, although both peaks were not necessarily at the same temperature. Potential explanations for this "double peaked" data are in the Water Quality Appendix. Daily maximum temperatures and MWATs were reported from data with "double peaks" because the factor of concern is the suitability of water temperatures for salmonids despite the timing or reason for these temperatures;
- Some temperature data was collected with continuous data recorders that were set to sample every 120 minutes. It is generally recommended that data recorders should be set to sample every 96 minutes to avoid missing instantaneous peak temperatures;
- Temperature files which did not cover the period from June 1 to September 30 may have missed the actual seasonal maximum temperature, and the MWAT may be underestimated (see Water Quality Appendix for further detail);

- All temperature monitoring sites were assumed to be in thermally well mixed locations and reflect representative stream conditions, with the exception of sites monitored by MCWA which were studying thermal refugia;
- Some in-channel sediment data were provided as summary statistics which did not allow for independent checks on the data quality. Additionally, the over all lack of sediment data available limited the analyses of temporal trends;
- The NCRWQCB V* value in this report is from sampling performed in one pool, while the TMDL target is based on a sample size of six pools. These data are useful as a snapshot of conditions at the time of the sample, although no recommendations are made based on this sample;
- The EMDS model used is preliminary; not all components of the model are currently in use due to data and modeling issues (i.e., stream temperature, fish passage, stream flow); not all data layers used in the model were fully subjected to quality control review.

Appendices

Glossary

AGGRADATION: The geologic process in which streambeds, floodplains, and the bottoms of other water bodies are raised in elevation by the deposition of material eroded and transported from other areas. It is the opposite of degradation.

ALEVIN: The life stages of salmonids that occurs after eggs have hatched but before young emerge from the gravel nests where they have incubated. Alevin still have yolk sacs attached to provide them with nutrition within the nest.

ALLUVIUM: A general term for all deposits resulting directly or indirectly from the sediment transport of streams, thus including the sediments lay down in riverbeds, floodplains, lakes, fans, and estuaries. ALLUVIAL *adj.*

ANADROMOUS: Fish that leave freshwater and migrate to the ocean to mature then return to freshwater to spawn. Salmon, steelhead, and shad are examples.

ANTHROPOGENIC: Caused by humans.

ARCINFO: ESRI (Environmental Systems Research Institute) proprietary software, which provides a complete GIS data creation, update, query, mapping, and analysis system.

AERIAL: Having to do with or done by aircraft. For example, aircraft equipped with cameras capture images of the earth in air photos.

BANKFULL DISCHARGE: The discharge corresponding to the stage at which the floodplain of a particular stream reach begins to be flooded; the point at which bank overflow begins.

BANKFULL WIDTH: The width of the channel at the point at which overbank flooding begins.

BASIN: see watershed.

BED SUBSTRATE: The materials composing the bottom of a stream.

BENTHIC: The collection of organisms living on or in sea, river, or lake bottoms.

BOULDER: Stream substrate particle larger than 10 inches (256 millimeters) in diameter.

CALWATER: A set of standardized watershed boundaries for California nested into larger previously standardized watersheds and meeting standardized delineation criteria.

CANOPY: The overhead branches and leaves of streamside vegetation.

CANOPY COVER: The vegetation that projects over the stream.

CANOPY DENSITY: The percentage of the sky above the stream screened by the canopy of plants, sometimes expressed by species.

CENTROID: The center of water mass of a flowing stream at any location. This location usually correlates well with the thalweg, or deepest portion of the stream. Sampling in the centroid is intended to provide a reasonably representative sample of the main stream.

CHANNEL: A natural or artificial waterway of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks, which serve to confine the water.

COAST RANGE: A string of mountain ranges along the Pacific Coast of North America from Southeastern Alaska to lower California.

COBBLE: Stream substrate particles between 2.5 and 10 inches (64 and 256 millimeters) in diameter.

COLLUVIUM: A general term for loose deposits of soil and rock moved by gravity; e.g. talus.

CONIFEROUS: Any of various mostly needle-leaved or scale-leaved, chiefly evergreen, cone-bearing gymnospermous trees, or shrubs such as pines, spruces, and firs.

CONSUMPTIVE USE OF WATER: Occurs when water is taken from a stream and not returned.

COVER: Anything that provides protection from predators or ameliorates adverse conditions of streamflow and/or seasonal changes in metabolic costs. May be instream cover, turbulence, and/or overhead cover, and may be for the purpose of escape, feeding, hiding, or resting.

DEBRIS: Material scattered about or accumulated by either natural processes or human influences.

DEBRIS JAM: Logjam. Accumulation of logs and other organic debris.

DEBRIS LOADING: The quantity of debris located within a specific reach of stream channel, due to natural processes or human activities.

DECIDUOUS: A plant (usually a tree or shrub) that sheds its leaves at the end of the growing season.

DEGRADATION: The geologic process in which stream beds and floodplains are lowered in elevation by the removal of material. It is the opposite of aggradation.

DEMOGRAPHY: The study of the characteristics of populations, such as size, growth, density, distribution, and vital statistics.
DEPOSITION: The settlement or accumulation of material out of the water column and onto the streambed. Occurs when the energy of flowing water is unable to support the load of suspended sediment.
DEPTH: The vertical distance from the water surface to the streambed.
DISCHARGE: Volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as cubic meters per second (m^3/sec), or cubic feet per second (cfs).
DISSOLVED OXYGEN (DO): The concentration of oxygen dissolved in water, expressed in mg/l or as percent saturation, where saturation is the maximum amount of oxygen that can theoretically be dissolved in water at a given altitude and temperature.
DIVERSION: A temporal removal of surface flow from the channel.
ECOTONE: A transition area between two distinct habitats that contains species from each area, as well as organisms unique to it.
EMBEDDEDNESS: The degree that larger particles (boulders, rubble, or gravel) are surrounded or covered by fine sediment. Usually measured in classes according to percentage of coverage of larger particles by fine sediments.
ECOLOGICAL MANAGEMENT DECISION SUPPORT (EMDS): An application framework for knowledge-based decision support of ecological landscape analysis at any geographic scale.
EMBRYO: An organism in its early stages of development, especially before it has reached a distinctively recognizable form.
ENDANGERED SPECIES: Any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man.
EROSION: The group of natural processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is worn away from the earth's surface. EROSIONAL *adj.*
ESTUARY: A water passage where the tide meets a river current.
EXTIRPATION: To destroy totally; exterminate.
EXTINCTION: The death of an entire species.
FILL: a) the localized deposition of material eroded and transported from other areas, resulting in a change in the bed elevation. This is the opposite of scour; b) the deliberate placement of (generally) inorganic materials in a stream, usually along the bank.
FINE SEDIMENT: The fine-grained particles in stream banks and substrate. Those are defined by diameter, varying downward from 0.24 inch (6 millimeters).
FISH HABITAT: The aquatic environment and the immediately surrounding terrestrial environment that, combined, afford the necessary biological and physical support systems required by fish species during various life history stages.
FLATWATERS: In relation to a stream, low velocity pool or run habitat.
FLOOD: Any flow that exceeds the bankfull capacity of a stream or channel and flows out of the floodplain; greater than bankfull discharge.
FLOODPLAIN: The area bordering a stream over which water spreads when the stream overflows its banks at flood stages.
FLOW: a) the movement of a stream of water and/or other mobile substances from place to place; b) the movement of water, and the moving water itself; c) the volume of water passing a given point per unit of time. Discharge.
FLUVIAL: Relating to or produced by a river or the action of a river. Situated in or near a river or stream.
FRESHETS: A sudden rise or overflowing of a small stream as a result of heavy rains or rapidly melting snow.
GENETIC DRIFT: The random change of the occurrence of a particular gene in a population.
GEOGRAPHIC INFORMATION SYSTEM (GIS): A computer system for capturing, storing, checking, integrating, manipulating, analyzing, and displaying data related to positions on the Earth's surface. Typically, a GIS is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature (e.g. roads). Each feature is linked to a position on the graphical image of a map.
GEOMORPHOLOGY: The study of surface forms on the earth and the processes by which these develop.

GRADIENT: The slope of a streambed or hillside. For streams, gradient is quantified as the vertical distance of descent over the horizontal distance the stream travels.

GRAVEL: Substrate particle size between 0.08 and 2.5 inches (2 and 64 millimeters) in diameter.

GULLY: A deep ditch or channel cut in the earth by running water after a prolonged downpour.

HABITAT: The place where a population lives and its surroundings, both living and nonliving; includes the provision of life requirements such as food and shelter.

HABITAT CONSERVATION PLAN: A document that describes how an agency or landowner will manage their activities to reduce effects on vulnerable species. An HCP discusses the applicant's proposed activities and describes the steps that will be taken to avoid, minimize, or mitigate the take of species that are covered by the plan.

HABITAT TYPE: A land or aquatic unit, consisting of an aggregation of habitats having equivalent structure, function, and responses to disturbance.

HETEROZYGOSITY: The presence of different alleles at one or more loci on homologous chromosomes.

HIERARCHY: A series of ordered groupings of people or things within a system.

HYDROGRAPH: A graph showing, for a given point on a stream, the discharge, stage, velocity, or other property of water with respect to time.

HYDROLOGY: The science of water, its properties, phenomena, and distribution over the earth's surface.

HYDROGRAPHIC UNIT: A watershed designation at the level below Hydrologic Region and above Hydrologic Sub-Area.

HYPOTHESIS: A tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation.

INBREEDING: The breeding of related individuals within an isolated or a closed group of organisms.

INBREEDING DEPRESSION: The exposure of individuals in a population to the effects of deleterious recessive genes through matings between close relatives.

INCUBATION: Maintaining something at the most favorable temperature for its development.

INSTREAM COVER: Areas of shelter in a stream channel that provide aquatic organisms protection from predators or competitors and/or a place in which to rest and conserve energy due to a reduction in the force of the current.

INTERMITTENT STREAM: A stream in contact with the ground water table that flows only at certain times of the year when the ground water table is high and/or when it receives water from springs or from some surface source such as melting snow in mountainous areas. It ceases to flow above the streambed when losses from evaporation or seepage exceed the available stream flow. Seasonal.

KNOWLEDGE BASE: An organized body of knowledge that provides a formal logical specification for the interpretation of information.

LAGOON: A shallow body of water, especially one separated from a sea by sandbars or coral reefs.

LIMITING FACTOR: Environmental factor that limits the growth or activities of an organism or that restricts the size of a population or its geographical range.

LARGE WOODY DEBRIS (LWD): A large piece of relatively stable woody material having a diameter greater than 12 inches (30 centimeters) and a length greater than 6 feet (2 meters) that intrudes into the stream channel. Large organic debris.

MACROINVERTEBRATE: An invertebrate animal (animal without a backbone) large enough to be seen without magnification.

MAINSTEM: The principal, largest, or dominating stream or channel of any given area or drainage system.

MELANGE: A mappable body of rock that includes fragments and blocks of all sizes, both exotic and native, embedded in a fragmented and generally sheared matrix.

MIGRATION: The periodic passage from one region to another for feeding or breeding.

NETWEAVER: A knowledge-based development system. A meta database that provides a specification for interpreting information.

NUTRIENT: A nourishing substance; food. The term *nutrient* is loosely used to describe a compound that is necessary for metabolism.

ONCORHYNCHUS: A genus of the family salmonidae (salmons and trouts). They are named for their hooked (onco) nose (rhynchus).

ORGANIC DEBRIS: Debris consisting of plant or animal material.

ORTHOPHOTOQUADS: A combined aerial photo and planimetric quad map (with no indication of contour) without image displacements and distortions.

PERMANENT STREAM: A stream that flows continuously throughout the year. Perennial.
pH: A measure of the hydrogen ion activity in a solution, expressed as the negative $\log_{10}$ of hydrogen ion concentration on a scale of 0 (highly acidic) to 14 (highly basic) with a pH of 7 being neutral.
PLATE TECTONICS: A theory in which the earth's crust is divided into mobile plates which are in constant motion causing earthquake faults, volcanic eruptions, and uplift of mountain ranges.
PHOTOGRAMMETRY: The process of making maps or scale drawings from photographs, especially aerial photographs.
PRODUCTIVITY: a) Rate of new tissue formation or energy utilization by one or more organisms; b) Capacity or ability of an environmental unit to produce organic material; c) The ability of a population to recruit new members by reproduction.
REDD: A spawning nest made by a fish, especially a salmon or trout.
REFERENCE CONDITIONS: Minimally impaired conditions that provide an estimate of natural variability in biological condition and habitat quality.
RIFFLE: A shallow area extending across a streambed, over which water rushes quickly and is broken into waves by obstructions under the water.
RILL: An erosion channel that typically forms where rainfall and surface runoff is concentrated on slopes. If the channel is larger than one square foot in size, it is called a gully.
RIPARIAN: Pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water.
RIPARIAN AREA: The area between a stream or other body of water and the adjacent upland identified by soil characteristics and distinctive vegetation. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.
RIPARIAN VEGETATION: Vegetation growing on or near the banks of a stream or other body of water on soils that exhibit some wetness characteristics during some portion of the growing season.
RUBBLE: Stream substrate particles between 2.5 and 10 inches (64 and 256 millimeters) in diameter.
SALMONID: Fish of the family *Salmonidae*, including salmon, trout, chars, whitefish, ciscoes, and graylings.
SCOUR: The localized removal of material from the stream bed by flowing water. This is the opposite of fill.
SEDIMENT: Fragmented material that originates from weathering of rocks and decomposition of organic material that is transported by, suspended in, and eventually deposited by water or air, or is accumulated in beds by other natural phenomena.
SERAL STAGES: The series of relatively transitory plant communities that develop during ecological succession from bare ground to the climax stage.
SHEAR: A deformation resulting from stresses that cause contiguous parts of a body to slide relatively to each other in a direction parallel to their plane of contact.
SILVICULTURE: The care and cultivation of forest trees; forestry.
SMOLT: Juvenile salmonid one or more years old that has undergone physiological changes to cope with a marine environment, the seaward migration stage of an anadromous salmonid.
SMOLTIFICATION: The physiological change adapting young anadromous salmonids for survival in saltwater.
SPAWNING: To produce or deposit eggs.
STADIA RODS: Graduated rods observed through a telescopic instrument while surveying to determine distances and elevation.
STAGE: The elevation of a water surface above or below an established datum or reference.
STREAM: (includes creeks and rivers): A body of water that flows at least periodically or intermittently through a bed or channel having banks and supports fish or other aquatic life. This includes watercourses having a surface or subsurface flow that supports or has supported riparian vegetation.
STREAM BANK: The portion of the channel cross section that restricts lateral movement of water at normal water levels. The bank often has a gradient steeper than 45 degrees and exhibits a distinct break in slope from the stream bottom. An obvious change in substrate may be a reliable delineation of the bank.
STREAM CLASSIFICATION: Various systems of grouping or identifying streams possessing similar features according to geomorphic structure (e.g. gradient, water source, spring, and creek), associated biota (e.g. trout zone), or other characteristics.
STREAM CORRIDOR: A stream corridor is usually defined by geomorphic formation, with the corridor occupying the continuous low profile of the valley. The corridor contains a perennial, intermittent, or ephemeral stream and adjacent vegetative fringe.

STREAM REACH: A section of a stream between two points.
SUBSTRATE: The material (silt, sand, gravel, cobble, etc.) that forms a stream or lakebed.
SUBWATERSHED: One of the smaller watersheds that combine to form a larger watershed.
TAKE: to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.
TERRACE: A former floodplain underlain by sediment deposited by a stream when the stream was flowing at a higher level; typically forming a relatively level bench along a valley side adjacent to a recent floodplain.
TERRAIN: A tract or region of the earth's surface considered as a physical feature, an ecological environment, or a site of some planned activity of man.
TERRANE: A term applied to a rock or group of rocks and to the area in which they crop out. The term is used in a general sense and does not imply a specific rock unit.
THALWEG: The line connecting the lowest or deepest points along a streambed.
THREATENED SPECIES: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
TOPOGRAPHY: The general configuration of a land surface, including its relief and the position of its natural and man-made features.
TRIBUTARY: A stream feeding, joining, or flowing into a larger stream. Feeder stream, side stream.
UNDERCUT BANK: A bank that has had its base cut away by the water action along man-made and natural overhangs in the stream.
VELOCITY: The time rate of motion; the distance traveled divided by the time required to travel that distance.
V*: Measures of percent sediment filling of a stream pool with deposits such as silt, sand, and gravel compared to the total volume.
WATER RIGHT: The right to draw water from a particular source, such as a lake, irrigation canal, or stream. Often used in the plural.
WATERSHED ASSESSMENT: An interdisciplinary process of information collection and analysis that characterizes current watershed conditions at a course scale.
WATERSHED: Total land area draining to any point in a stream, as measured on a map, aerial photograph or other horizontal plane. Also called catchment area, watershed, and basin.
WATERSHED MANAGEMENT AREA (WMA): In the context of the North Coast Regional Water Quality Control Board's Watershed Management Initiative, this represents a grouping of smaller watersheds into a larger area for identifying and addressing water quality problems, e.g., the Humboldt WMA includes all watersheds draining to the ocean or bays north of the Eel River to and including Redwood Creek.
WETLAND: An area subjected to periodic inundation, usually with soil and vegetative characteristics that separate it from adjoining non-inundated areas.

List of Abbreviations

CalEPA	California Environmental Protection Agency
CDF	California Department of Forestry and Fire Protection
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFS	Cubic Feet per Second
CDFG	California Department of Fish and Game
DOC/CGS	California Department of Conservation-California Geological Survey
DWR	California Department of Water Resources
EMDS	Ecological Management Decision Support
EPA	Environmental Protection Agency
ESA	Federal Endangered Species Act
ESU	Evolutionarily Significant Units
FPA	Z'Berg-Nejedly Forest Practice Act
GIS	Geographic Information System
HA	Hydrologic Area
HCP	Habitat Conservation Plan
HR	North Coast Hydrologic Region
HSA	Hydrologic Sub-area
HU	Hydrologic Unit
LFA	Limiting Factor Analysis
L-P	Louisiana Pacific Lumber Company
LWD	Large Woody Debris
MOU	Memorandum of Understanding
MRC	Mendocino Redwood Company, LLC
MWAT	Maximum Weekly Average Temperature
NCRWQCB	North Coast Regional Water Quality Control Board
NCWAP	North Coast Watershed Assessment Program
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
PSA	Planning Sub Area
PWS	Planning Watershed
RM	River Mile
SPEWS	Super Planning Watershed
SRP	Scientific Review Panel
SWRCB	California State Water Resources Control Board
TMDL	Total Maximum Daily Load
TPZ	Timber Production Zone
USFS	United States Forest Service
USGS	United States Geologic Survey
WMA	Watershed Management Area
WQO	Water Quality Objectives

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Spatial Data Availability, Catalog, Standards and Analyses

Data Availability

GIS spatial data used and developed by the program is available to the public through the internet at: www.ncwatershed.ca.gov. Please navigate to the California Geospatial Information Library under other links.

Data Catalog

Source abbreviations
- CDF – California Department of Forestry and Fire Protection
- CGS – Department of Conservation, California Geological Survey
- CWMC – California Watershed Mapping Committee
- DFG – California Department of Fish and Game
- DOD – Department of Defense
- DWR – California Department of Water Resources
- FRAP – Forest Resource Assessment Program
- NCRWQCB – North Coast Regional Water Quality Control Board
- RNSP – Redwood National and State Parks
- SSRRCD – Sotoyome-Santa Rosa Resource Conservation District
- Teale – Stephen P. Teale data center, State of California
- USDA – United States Department of Agriculture
- USGS – United States Geological Survey

Spatial and Geographic Information Systems (GIS) Data Standards and Analyses

Data records were collected for synthesis and analysis purposes and most of these data were either created in a spatial context or converted to a spatial format. Effective use of these data between the five partner departments required establishing standards for data format, storage, management and dissemination. Early in the assessment process, we held a series of meetings designed to gain consensus on a common format for the often widely disparate data systems within each department. Our objective was to establish standards that could be easily used by each department, that were most useful and powerful for selected analysis, and would be most compatible with standards used by potential private and public sector stakeholders.

As a result, we agreed that spatial data and base information disseminated to the public through the program would be in the following format (See data catalog for a complete description of data sources and scale):

Data form: standard database format usually associated with a GIS shapefile© (ESRI) or coverage. Data were organized by watershed and distributed among watershed synthesis teams. Electronic images were retained in their current format.

Spatial Data Projection: spatial data were projected from their native format to both Teale albers, North American Datum (NAD) 1927 and Universal Transverse Mercator (UTM), Zone 10, NAD 1983. Both formats were used in data analysis and synthesis.

Scale: most data were created and analyzed at 1:24000 scale to 1) match the minimum analysis scale for planning watersheds, and 2) coincide with base information (e.g., stream networks) on USGS quadrangle maps (used as Digital Raster Graphics [DRG]).

Data Sources: data were obtained from a variety of sources including spatial data libraries with partner departments or were created by manually digitizing from 1:24000 DRG.

The metadata available for each spatial data set contain a complete description of how data were collected and attributed. Spatial data sets that formed the foundation of most analysis included the 1:24000 hydrography and the 10 meter scale Digital Elevation Models (DEM). Hydrography data were created by manually digitizing from a series of 1:24000 DRG then attributing with direction, routing, and distance information using a dynamic segmentation process (see http://arconline.esri.com/arconline/whitepapers/ao_/ArcGIS8.1.pdf for more information). The resulting routed hydrography allowed for precise alignment and display of stream habitat data and

other information along the stream network. The DEM was created from base contour data obtained form the USGS for the entire assessment region.
Source spatial data were often clipped to watershed, planning watershed, and subbasin units prior to use in analysis. Analysis often included creation of summary tables, tabulating areas, intersecting data based on selected attributes, or creation of derivative data based on analytical criteria. For more information regarding the approach to analysis and basis for selected analytical methods, see the integrated analyses section.