Fluvial Geomorphology

The Mattole Basin contains about 692 miles of blue-line streams (CGS Geologic Report-Table 10). The blue-line streams were chosen because they are a consistent depiction of the major streams within the network and include perennial, ephemeral, and intermittent streams. The river system within the Mattole Basin is arranged in a contorted or irregular drainage pattern. The mainstem of the Mattole River flows in a general northwesterly direction, parallel to the structural grain of the Franciscan Complex. Tributaries to the mainstem flow generally to the northeast or southwest, perpendicular to the Mattole River, and often the larger tributaries branch upstream into channels that trend parallel to the mainstem.

Stream Density

Streams are about evenly distributed spatially throughout the subbasins of the study area. That is the cumulative lengths of streams within a subbasin, expressed, as a percentage of the total stream length for the study area, is similar to the area of each subbasin expressed as a percentage of the total study area. The stream density calculated for the entire Mattole Basin study area is 2.3 (miles/square mile). Stream density varies considerably between areas underlain by bedrock and alluvial terrains; these density values forms the point of comparison for portions of the study area. The results are presented in CGS Geologic Report-Table 10.

Within bedrock terrains, stream density across the entire study area is 1.9 and, dependant on subbasin, varies between 0.9, and 2.1 (miles/square mile). Stream density varies within the three bedrock terrains, with higher densities found in the harder terrains. Specifically, stream densities within the moderate and hard terrain average 1.9 and 2.0 respectively. Stream densities within the soft terrain average 1.7.

Stream density within the Quaternary deposits is 8.3 (miles/square mile), and ranges by subbasin from a low in the Northern Subbasin of 5.9 to a high in the Eastern Subbasin of 12.5. These relatively high stream densities in the Quaternary deposits are expected, because the relatively small area occupied by Quaternary deposits (7% of the study area) are preferentially located along the longer, larger streams, particularly the mainstem Mattole.

Rosgen Classification

The Rosgen (1996) classification system (CGS Geologic Report-Figure 6) was applied by CGS to all blue-line streams within the Mattole Basin study area using aerial photographs and topographic maps. Channel slope, derived from the DEM, was used to subdivide primary stream types into subcategories. The areal distribution of Rosgen stream classification is shown in CGS Geologic Report-Figure 19, and a histogram showing the prevalence of specific Rosgen stream types (Rosgen stream class versus percent of total stream length) within the study area is presented in CGS Geologic Report-Figure 20. The two most common mapped stream classes are the A and A+ types, which combined account for about 66% of all blue-line streams. In general, the majority of smaller, lower order tributaries are A and B types. Type A channels are typically relatively straight, high-gradient, narrow reaches in the tributary headwaters that flow through bedrock with little alluvium. B channels are commonly found in larger tributaries, G and Gc channels in lower tributary reaches, and the majority of the mainstem channel is classified as C type channel.

The Southern Subbasin is unique for its abundance of F type streams. This stream type is found along the mainstem Mattole where the river is entrenched within a broad alluvial valley from approximately Thorn Junction to Thompson Creek.

Predictably, the distribution of Rosgen classes mapped along inner gorges are typically those defined as moderately entrenched to entrenched (A, B and G classes) and these classes occur more frequently along inner gorges then generally along all of the streams throughout the study area.

Source, Transport and Response Reaches

The spatial distribution of source, transport, and response reaches governs the distribution of potential impacts and recovery times for the stream system. We used channel slope to classify stream sections as source (>20%), transport (4-20%) or response (<4%) reaches. Streams with gradients greater than 20 percent are considered source areas for sediment, while those with gradients less than four percent are considered areas of sediment deposition (Montgomery and Buffington, 1997). Figure 32 shows the distribution of these slope classes for the Mattole Basin study area.

Source and transport reaches are most common in the bedrock terrains, while response reaches are more common in the Quaternary deposits (Table 39. Virtually all (99%) of the source reaches are found in bedrock terrains and comprise 24% of the total length of blue-line streams. Most of the transport reaches (91%) are found in bedrock terrains and this reach type comprises approximately 36% of all blue-line streams. Response reaches predominate in Quaternary deposits and comprise the remaining 40% of blue-line streams throughout the study area. Whereas, the Quaternary deposits account for only 7% of the study area, 53% of all the response reaches were identified in this terrain. Approximately 86% of the streams within the Quaternary deposits are response reaches.

The areas of greatest susceptibility to sediment deposition are those where higher gradient reaches transition into low gradient reaches. For example, a given transport reach could have high velocity and streamflow, resulting in a large carrying capacity for sediment. If the gradient changes to a slow moving response reach, sediment can rapidly fall out and deposit in the channel or along the banks. Examples of this phenomenon can be found at major slope breaks along Lower and Upper North Forks of the Mattole River. A specific example is shown in CGS Geologic Report-Figure 22, which is a photograph showing a tributary fan at the confluence of Conklin Creek and the mainstem Mattole River. Response reaches are found primarily in the Quaternary alluvium; these are reaches where sedimentation is most likely to occur.

Negative Mapped Channel Characteristics

Stream characteristics that may indicate excess sediment production or transport were mapped and quantified for comparison between streams. These features are termed negative mapped channel characteristics (NMCCs) within this report. Comparison of what proportion of a stream is occupied by these features was used as an indicator of disturbance, sediment source, or stored sediment in the river system. Quantitative analyses of NMCCs were conducted only on data assigned to the primary characteristic field because this field represents the channel characteristic that best reflected conditions observed throughout the entire mapped channel reach. The areal distribution of NMCCs is shown in Figure 31. The measured lengths and the proportion of streams affected by NMCCs recorded from both 1984 and 2000 aerial photo sets are shown in CGS Geologic Report-Table 12.

Negative Mapped Channel Characteristics, 1984-2000

Negative mapped channel characteristics observed on the 1984 photos affected approximately 36% of all blue-line streams (Table 39). In the 2000 photos, the total affected length decreased to approximately 21%. The stream reaches affected by observed NMCCs during these two photo years is shown in Figure 33. In both photo years, the features observed were dominated by wide channels and, secondarily, by displaced riparian vegetation (CGS Geologic Report – Figure 24). Figure 34 and Figure 35 visually depict the occurrence of these two NMCCs, recorded as either primary or secondary characteristics for the two photo years.

The overall trend for the Mattole Basin shows improvement (i.e., reduction in the length of observed NMCCs and/or reduction in the percentage of streams affected by NMCCs) in channel conditions for every subbasin between 1984 and 2000 (Table 39). In this time, the total length of NMCCs decreased by a low of 7% in the Northern Subbasin to a high of 88% in the Southern Subbasin. The largest absolute (actual length) reduction in the length of NMCCs occurred in the Eastern Subbasin. Most of this improvement is seen as a reduction in the proportion of streams affected by displaced riparian vegetation and, to a lesser extent, wide channels (CGS Geologic Report-Figure 24).

Similarly, reductions were observed when evaluating the percentage changes in the length of blue-line streams affected by NMCCs. The greatest change was observed in the Southern and Eastern Subbasins (18% and 27%, respectively), while the Northern Subbasin showed the least amount of improvement (3%). For the entire Mattole Basin, there was a 42% reduction in the total length of observed NMCCs, and 15% reduction in the proportion of blue-line streams affected by NMCCs (Table 39 and CGS Geologic Report-Table 12).

Despite the overall reduction in length and proportion of streams affected by NMCCs, three segments of the Mattole Basin showed a small overall increase in these features. The total length of streams affected by negative NMCCs within the soft terrain in the Northern Subbasin and within the Quaternary deposits in the

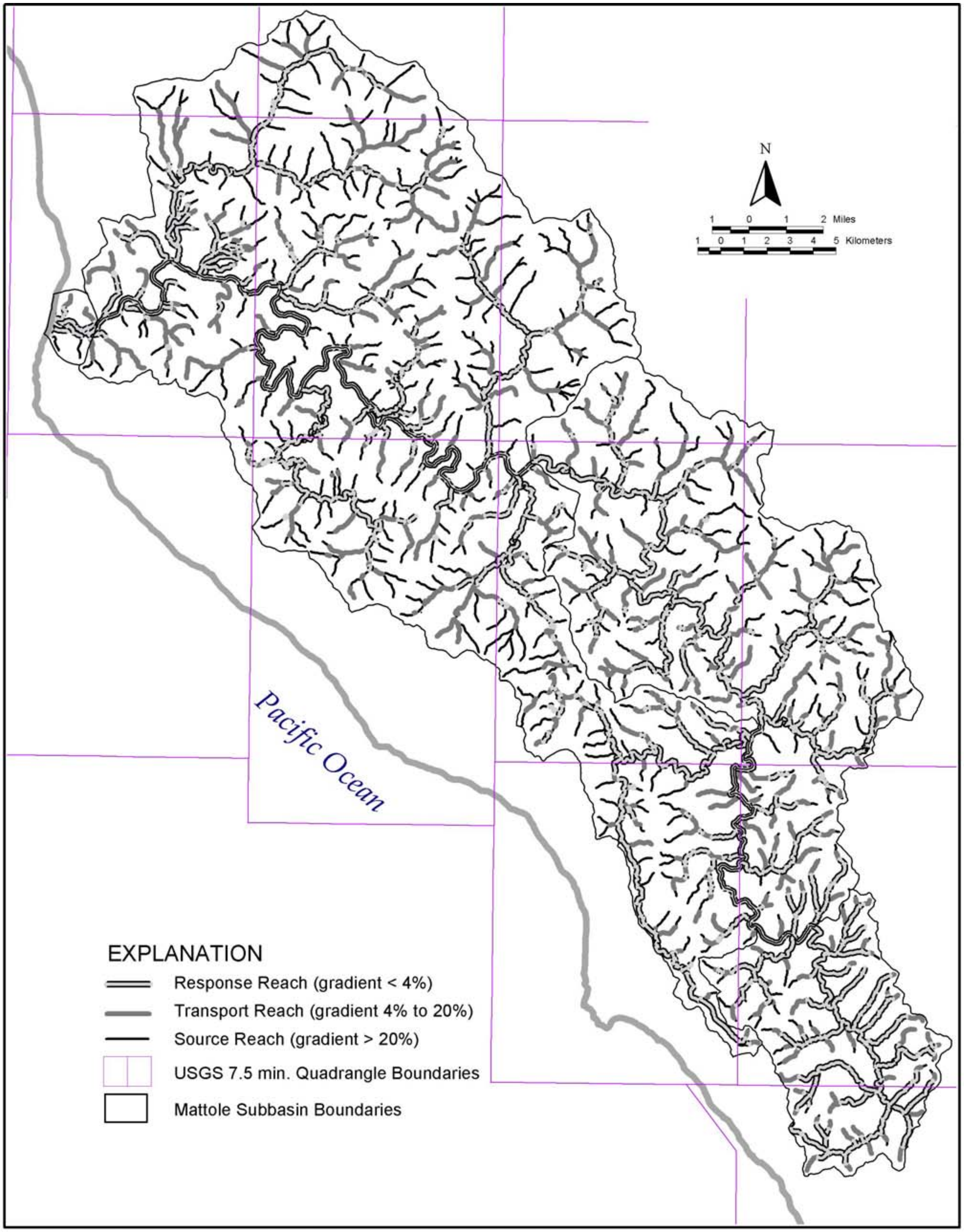

Figure 32. Distribution of stream reaches classified by gradient.

Eastern and Western Subbasins increased between 1% and 2%. These increases result primarily from a greater amount of wide channels, lateral bars, eroded banks and braided channels observed in the 2000 photos.

Improvements in channel conditions were greatest in the bedrock terrains, with the highest calculated values observed in the hard terrain, and the least amount of improvement recorded for the soft terrain. The total length of NMCCs within the Quaternary deposits remained nearly constant between 1984 and 2000 (Table 39 and CGS Geologic Report-Table 12). When compared to the percentage of total stream length within a terrain, these changes in the distribution of NMCCs result in features suggesting excess sediment being disproportionally observed in the bedrock in 1984 and distributed evenly across the entire study area in 2000.

We interpret the concentration and redistribution of NMCCs in streams within Quaternary deposits to suggest that the effects of historic excess sediment input are moving downstream through the river system. The spatial pattern of channel improvements within bedrock terrains implies that the rate of sediment input to the fluvial system has decreased since 1984.

Spatial Relationship to High Landslide Potential

To evaluate a potential linkage between delivery of sediment to streams resulting from slope instability and negative impacts to streams, correlations between NMCCs and streams adjacent to areas of high and very high landslide potential (landslide potential map (LPM) categories 4 and 5) were assessed. The LPM serves as a summary of our understanding of current and future hillslope instability, and therefore potential sediment sources. To facilitate this correlative analysis, NMCCs were represented by those occurring within 150 feet of LPM categories 4 and 5.

In this analysis, only streams and NMCCs within bedrock terrains were evaluated; those within Quaternary deposits were excluded. Streams in the Quaternary alluvium are commonly separated from the surrounding hillslopes by alluvial terraces and floodplains. Therefore, NMCCs observed in alluvial units do not directly result from input into the streams by landslides occurring on the surrounding hillslopes, but rather NMCCs within these alluvial reaches are likely derived from migration of upstream sediment.

Within the bedrock portions of the study area, 75% of the blue-line streams are adjacent to or within LPM categories 4 and 5 (CGS Geologic Report-Table 13). This value varies by subbasin according to the proportion of high to very high landslide potential in each subbasin. Within this subset of streams, 47% of streams were affected by NMCCs in 1984, and 26% were affected by NMCCs in 2000 (CGS Geologic Report-Table 14).

Throughout the study area, and in both sets of air photos evaluated, the NMCCs within LPM categories 4 and 5 represent between 98% and 100% of all the NMCCs mapped within bedrock terrains (CGS Geologic Report-Table 14 and Table 39). Stated another way, for both photo years (1984 and 2000); NMCCs in bedrock terrains have occurred almost exclusively in streams adjacent to or within LPM categories 4 and 5. Conversely, this indicates that only a very small proportion of NMCCs observed in bedrock (0% to 2%) occur in bedrock streams not within 150 feet of LPM categories 4 and 5. Our mapping indicates that LPM categories 4 and 5 are in close proximity to categories 1, 2, and 3 throughout the bedrock terrains of the study area. Therefore, it appears that only a very small proportion of the sediment currently or recently delivered to streams has been transported any great distance downstream along stream reaches in bedrock terrains. However, sediment has clearly been delivered to the downstream alluvial response reaches in the past, and the measured affected stream length within the Quaternary deposits has remained about constant from 1984 to 2000. These last observations suggest that much of the sediment currently impacting the lower reaches of the mainstem of the Mattole River was delivered some time ago (i.e., prior to 1984), perhaps during major flood events.

Additionally, our mapping indicates that virtually all NMCCs within bedrock terrains of the Mattole Basin study area occur on only 26% (2000) to 47% (1984) of streams adjacent to or within LPM categories 4 and 5. This information indicates that even within LPM category 4 and 5, only a portion of the adjacent streams have been impacted by NMCCs.

Based on the above findings, it appears that in the Mattole Basin study area there is a clear linkage (relationship) between areas of slope instability and portions of streams with negative sediment impacts. This investigation indicates that some portion of hillslopes with a high landslide potential (represented by

LPM categories 4 and 5) have delivered sediment to the adjacent streams (such effects being represented by NMCCs). The fact that NMCCs are not ubiquitous in bedrock streams adjacent to or within LPM categories 4 and 5 indicates that although the entire length of the streams have potentially unstable slopes above them, only a portion of LPM category 4 and 5 is delivering sediment to the streams, and therefore only portions of streams are being affected by sediment delivered by landslides. Furthermore, that portion with NMCCs is declining through time. Areas for further research should include evaluations of which portions of hillslopes in LPM category 4 and 5 are most likely to deliver sediment to streams, which portions are not, and what measurable attributes could be identified to discern this difference.

Despite this, hillslopes in LPM category 4 and 5 are clearly the most likely areas for landslides to occur and these landslides have a high potential to be a source of excess sediment to the streams. The clear linkage (relationship) between these areas of slope instability and features indicating excess sediment production/transport in the adjacent streams provides the opportunity to identify which portions of bedrock uplands are most likely to negatively impact streams. For these reasons, hillslopes in LPM category 4 and 5 need to be identified as areas of special concern. Further refinements in our ability to identify areas of high landslide potential, will allow us in the future to more closely define these areas of special concern.

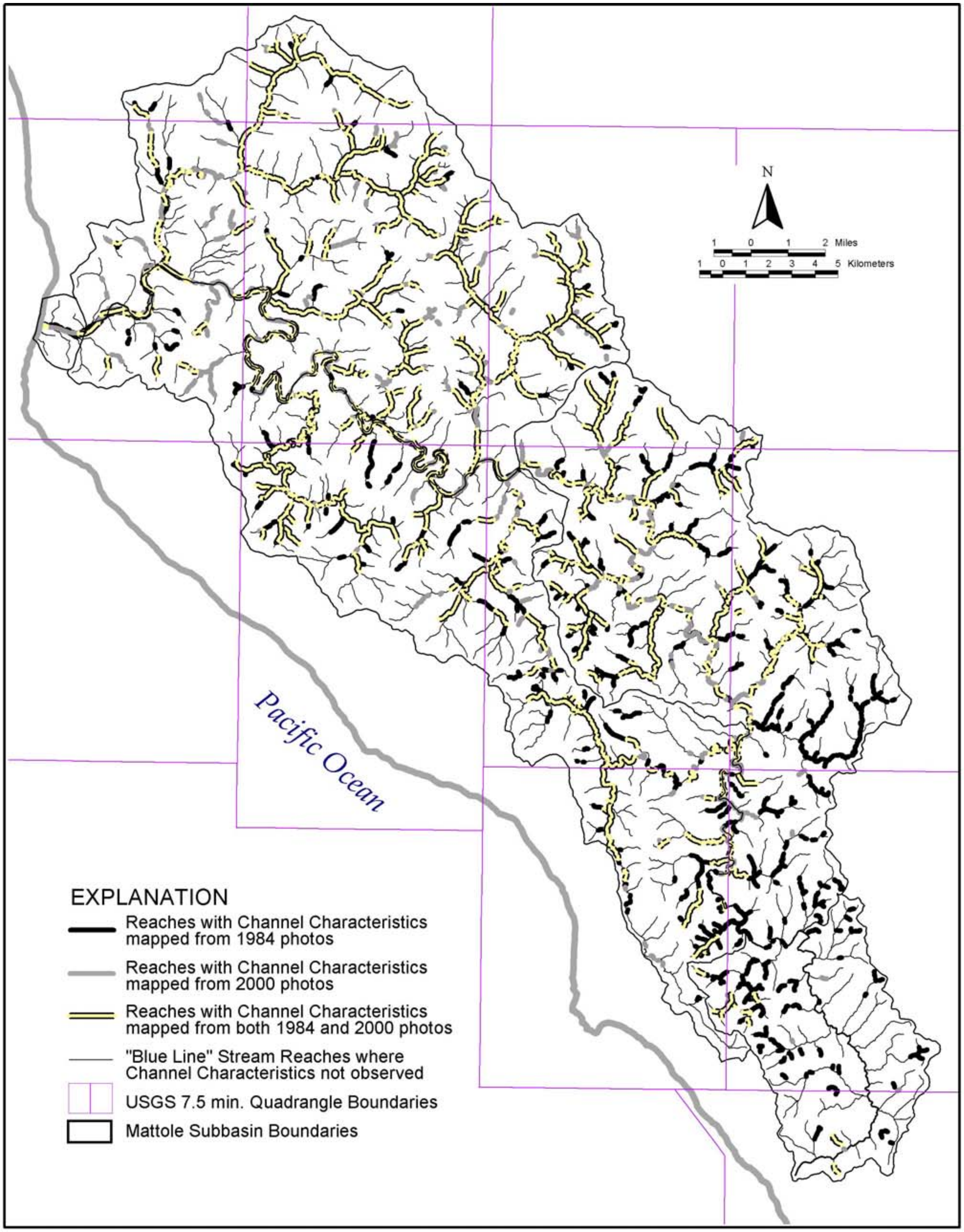

Figure 33. Compilation of mapped stream channel characteristics that may indicate excess sediment production, transport, and/or deposition.

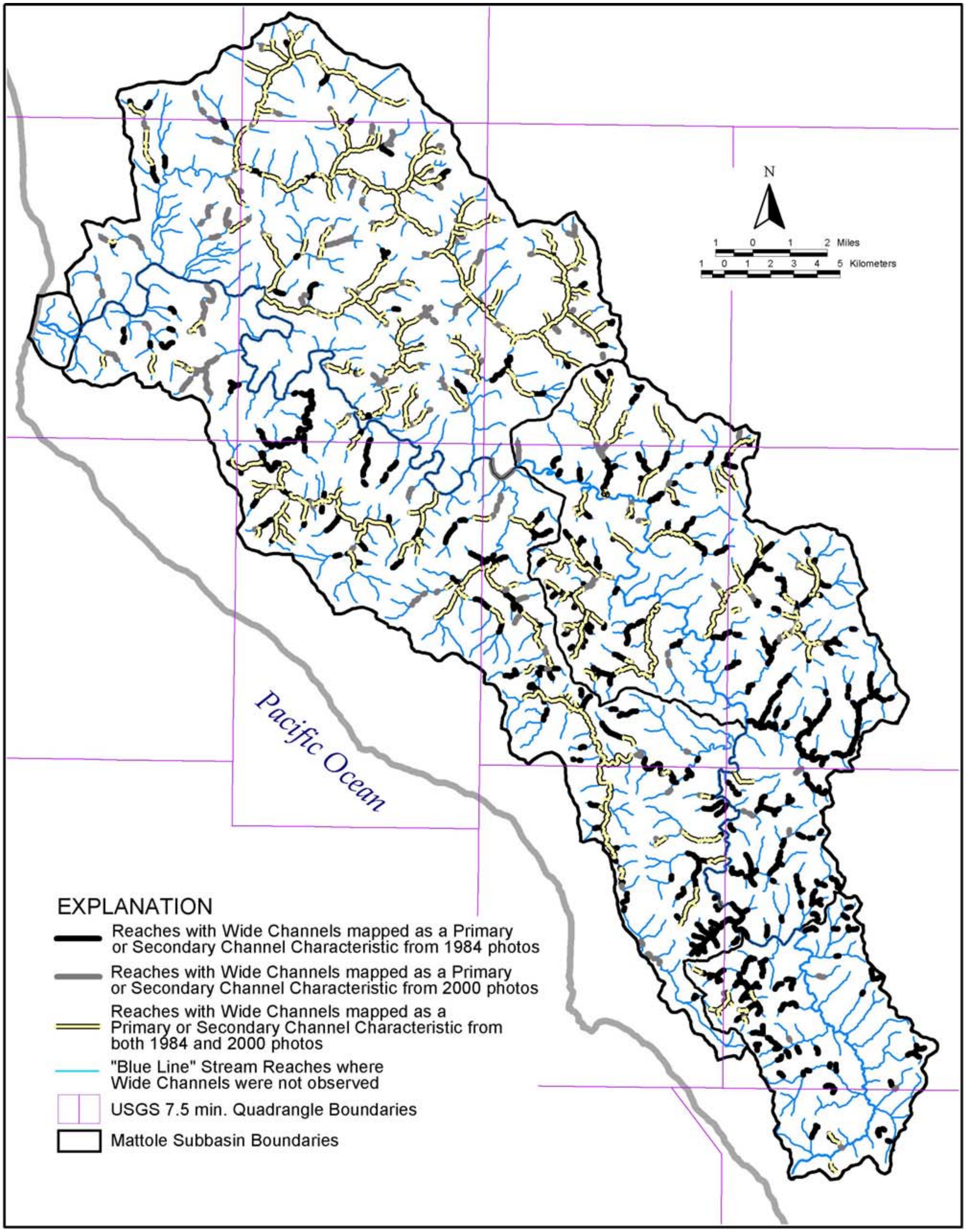

Figure 34. Stream reaches along which wide channel was mapped as a primary or secondary channel characteristic.

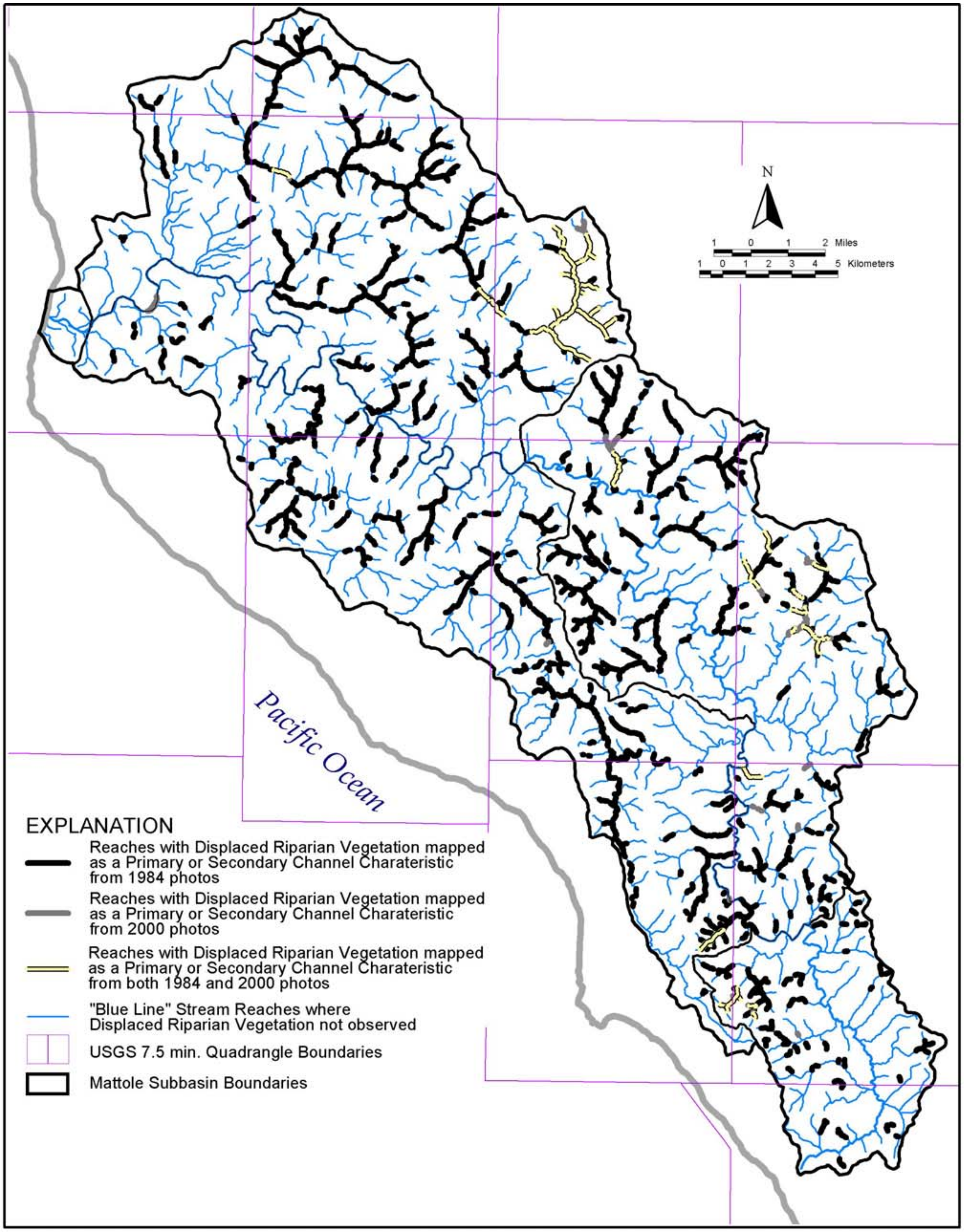

Figure 35. Stream reaches along which displaced riparian vegetation was mapped as either a primary or secondary channel characteristic.

Water Quality

The Mattole River has been placed on a list of water bodies for impairment or the threat of impairment by sediment and temperature 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 beneficial use and water quality. The listing of the Mattole River will eventually result in numeric targets for sediment and temperature allocations being developed by the North Coast Regional Water Quality Control Board (Regional Board) that are expressed as a total maximum daily load (TMDL) for each pollutant.

At the time of the listing sediment and temperature were judged to be impacting the cold (COLD) water fishery and associated beneficial uses, described in the Water Quality Control Plan, North Coast Region, Region 1 (Basin Plan, 1996). Nearly all aspects of the cold water fishery are presumed affected by sediment and temperature 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 Mattole River include municipal, agricultural, industrial, 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 Mattole River is also foreseen as a potential beneficial use in the Basin Plan.

The Basin Plan also describes specific water quality objectives for the Mattole River that include limitations for in stream specific conductance, total dissolved solids, dissolved oxygen, and pH or hydrogen ion concentration. If exceedences to specific water quality objectives are discovered during NCWAP data gathering, collection, and analysis they will be elucidated and addressed in pertinent report sections. It should be noted that data was not available or not analyzed for all the Basin Plan objectives.

Although numeric targets for a sediment and temperature TMDL have not yet been developed for the Mattole River, much of the following discussion focuses on issues of concern relative to their adoption. Brief references are made to numeric targets adopted for the Garcia River sediment TMDL and, at this time, should not be construed as regulatory targets applicable to the Mattole River.

Key Regional Water Board findings, summarized below, disclosed that the following may be affecting the Mattole River and many of its tributaries:

Temperature

For temperature, the NCWAP team proposed the following 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:

- Fully suitable = 50-60°F
- Moderately suitable = 61-62°F
- Somewhat suitable = 63°F
- Between somewhat suitable and somewhat unsuitable = 64°F
- Somewhat unsuitable = 65-66°F
- Moderately unsuitable = 67°F
- Unsuitable ≥ 68°F
- The instantaneous maximum that may lead to salmonid lethality ≥ 75 °F

MWATs were fully unsuitable (≥68°F) and likely impacting the salmonid fisheries and other beneficial uses of water in the estuary and the mainstem up to the Southern Subbasin near RM 50. Maximum temperatures that may lead to salmonid mortality (≥75 °F) were also prevalent downstream from approximately RM 50; however, there are isolated yearly maximums that did drop below the 75°F threshold. Table 11 and Table 12 contain the minimum and maximum MWATs and peak maximum temperatures for available sample years along the mainstem of the Mattole River and various tributaries. If applicable to the following tables, a single temperature entry at a particular station indicates that records were not analyzed or available for more than one year. Most of the stations have temperature records for multiple years; however, for the sake of brevity, individual yearly temperatures are not included. Refer to the Water Quality Appendix E for more detailed discussions.

Table 11. Minimum and maximum MWATs and peak maximum temperatures for all available sample years for the mainstem Mattole River from the estuary to the headwaters.

Nearest "Upstream" Watercourse	River Mile*	MWAT (Minimum / Maximum)	Seasonal Maximum Temperature (Minimum/Maximum)
Estuary	0.1	68.2 / 73.4	73.0 / 83.0
Mill Creek	1.0	69.4 / 71.5	79.0 / 83.0
North Fork Mattole River	3.5	69.9 / 72.3	78.0 / 86.0
Conklin Creek	6.2	71.5 / 72.4	80.0 / 81.0
Pritchett Creek	15.5	73.6 / 73.9	80.0 / 85.0
Honeydew Creek	26.4	69.8 / 71.7	78.0 / 81.0
Big Finley Creek	43.0	70.0 / 74.4	72.0 / 82.0
Bridge Creek	50.7	66.6 / 68.7	65.0 / 76.0
Gibson Creek	56.5	62.4 / 64.1	62.0 / 65.7
Ancestor Creek	60.8	58.5 / 64.1	62.0 / 68.0
"Headwaters"	61.0	52.7 / 55.4	53.0 / 64.0

*Indicates the distance upstream along the mainstem from the Pacific Ocean.

Although seasonal maximum temperatures and MWATs along the mainstem were generally elevated at locations where thermographs were placed, a helicopter flyover employing thermal infrared imaging technology (thermal imaging) added additional information useful in evaluating water temperature characteristics in the Mattole Basin.

Thermal imaging is capable of discerning median surface water temperatures in a continuous path above watercourses. Thermal imaging revealed several tributaries with visible plumes of cooler water flowing into the mainstem that persisted for short distances downstream that could have furnished thermal refugia for salmonids (Watershed Sciences, 2002). For example, Bear, Squaw, Honeydew, and Grindstone Creeks all had median surface temperatures between 71-72°F, entering a much warmer mainstem that ranged between 76-78°F. Within the mainstem, and also several of the tributaries, thermal imaging also detected that feeder springs and intragravel flow were additional sources of colder water that, at times, were as much as 6-8°F cooler than their receiving waters. These isolated pockets of cool water, in all likelihood, also provide critical thermal refugia during low flow, late summer conditions when stream and river temperatures become extremely elevated and stressful to salmonids.

Temperature extremes as MWATs and instantaneous maximums detrimental to salmonids are affecting the lower gradient, downstream reaches of nearly all of the larger tributaries to the Mattole River. This includes the North Fork (NFK) and Upper North Fork (UNFK) Mattole Rivers, Honeydew, Blue Slide, Bear, Mattole Canyon, and Squaw Creeks. The following table shows that the aforementioned larger tributaries all exceeded the fully unsuitable MWAT extreme of 68°F within a maximum of two miles upstream from the mainstem. Average maximum temperatures in the largest streams, except Bear and Squaw Creeks, exceeded the 75°F range deemed unsuitable for salmonid survival. The remaining tributaries in the following table are, in general, smaller in stream length and basin size than the previously cited streams, and most had MWATs and instantaneous maximum temperatures that were within varying degrees of suitability for salmonids. The only exception was an MWAT of 67.9°F at Westlund Creek, a temperature considered moderately unsuitable for salmonids.

Table 12. Minimum and maximum MWATS and peak maximum temperatures, lower to mid-reaches of various basin tributaries.

Watercourse	NCWAP Subbasin	River Mile*	MWAT Minimum / Maximum	Seasonal Maximum Temperature Minimum / Maximum
Mattole Canyon Creek	Eastern	41.1 + 0.1	70.8 / 73.3	80.0 / 88.0
Upper North Fork Mattole River	Northern	25 + 2.0	69.8 / 71.1	72.0 / 82.0
Bear Creek	Western	42.8 + 0.1-0.6	67.8 / 71.5	68.0 / 78.0
Honeydew Creek	Western	26.6 + 0.5	68.9 / 71.9	76.0 / 80.0
North Fork Mattole River	Northern	4.7 + 0.5	69.7	74.0 / 81.0
Blue Slide Creek	Eastern	42.0 + 0.1	68.2 / 70.8	74.4 / 79.0
Squaw Creek	Western	15.0 + 0.1	69.1 / 70.0	72.0 / 77.0
Westlund Creek	Eastern	37.1 + 0.1	62.5 / 67.9	67.0 / 69.5
Bridge Creek	Southern	52.1 + 0.2	59.8 / 65.0	62.0 / 72.0
Thompson Creek	Southern	58.4 + 0.6	60.6 / 62.5	64.0 / 68.7
Baker Creek	Southern	57.6 + 0.1	58.6 / 61.3	63.0 / 68.7
Eubanks Creek	Eastern	47.7 + 0.1	59.7 / 61.1	67.0 / 70.0
Vanaukin Creek	Southern	54 + 0.1	58.9 / 60.8	62.2 / 64.5
Lost River Creek	Southern	58.8 + 0.5	58.4 / 60.3	59.0 / 65.0
Yew Creek	Southern	58.4 + 0.4	57.6 / 61.5	61.6 / 66.0
Big Finley Creek	Western	47.4 + 0.1	59.2 / 60.3	61.0 / 63.0
Mill Creek-Lower	Western	2.8 + 0.1	57.7 / 58.4	57.0 / 68.0
Ancestor Creek	Southern	60.8 + 0.2	56.7	57.0 / 60.1

*Indicates locations of the confluence of the tributary from the Mattole River mouth, the + indicates distance upstream the thermograph is located in the tributary.

In contrast to the borderline suitable and unsuitable MWATs and maximum temperatures mentioned above, median surface temperatures derived from a single day, thermal imaging flyover showed that only the NFK and UNFK Mattole Rivers, and Oil Creek, tributary to the UNFK Mattole, exceeded the 75°F lethal maximum temperature for salmonid survival. Caution is urged, though, in trying to draw analogies between surface derived median temperatures from thermal imaging and those of seasonally deployed thermographs.

Thermographs, unless measuring air temperatures, are always placed below the water surface and because of this placement can provide information not visible to thermal imaging of the water's surface. For example, thermographs can indicate areas of deep water thermal refugia where salmonids often escape to during times of heat stress, such as from reaches or habitat units where sparse or non existent riparian canopy shelter allow excess inputs of solar energy to elevate stream water temperatures.

MWATs and instantaneous maximum temperatures are mostly within suitable to somewhat suitable conditions for salmonids in the upper reaches of many of the larger tributaries. summarizes minimum and maximum temperature conditions, where available, in many of the upper reaches of the same tributaries previously discussed.

Table 13 summarizes temperatures found in select upstream reaches shows that, except for Mattole Canyon Creek, NFK and UNFK Mattole Rivers, and Sulphur Creek, tributary to the NFK Mattole River, MWATs are grouped slightly above and below the 63 °F range considered somewhat suitable for salmonids. Temperatures in the same tributaries that are somewhat suitable as MWATs are also below the 75°F instantaneous maximum considered lethal to salmonids. CGS's NCWAP analysis and the thermal imaging video revealed that the upstream reaches of Mattole Canyon Creek, and the NFK and UNFK Mattole Rivers, including Sulphur Creek, have open, widened, and disturbed alluvial flood plains providing very little effective shade canopy over their wetted channels. These watercourses also had average maximum temperatures above the 75°F threshold of lethality for salmonids.

Table 13. Minimum and maximum MWATs and peak maximum temperatures, middle to upper reaches of various Mattole Basin tributaries.

Watercourse	NCWAP Subbasin	River Mile*	MWAT (Minimum / Maximum)	Maximum Temperature (Minimum / Maximum)
Mattole Canyon Creek	Eastern	41.1 + 3.1	70.8 / 73.3	81.6
Upper North Fork Mattole River	Northern	25 + 4.5	69.4 / 67.8	76.9 / 78.3
North Fork Mattole River	Northern	4.7 + 9.0	65.0	74.6
Sulphur Creek	Northern	4.7 + 10.5	64.4 / 65.5	75.0 / 76.0
Bear Creek -upstream	Western	26.5 + 4.8	60.5 / 64.7	71.0 / 72.0
Honeydew Creek	Western	26.5 + 3.2-4.8	62.9 / 63.9	N/A
South Fork Bear Creek	Western	42.8 + 5.1	60.9 / 64.2	65.4 / 69.0
North Fork Bear Creek -	Western	42.8 + 5.1	60.0 / 61.5	66.6 / 74.0

*Indicates locations of the confluence of the tributary from the Mattole River mouth, the + indicates distance upstream the thermograph is located in the tributary.

Temperature may currently be impacting the salmonid fisheries and other beneficial uses of water in some isolated tributaries for an unknown distance upstream from their confluences with the mainstem, such as Bridge, Squaw, Westlund, and Dry Creeks. Presently there is insufficient data to properly assess the upstream reaches of these tributaries. The latter tributaries had thermographs placed only within 0.1miles upstream from their confluences with the mainstem. Except Bridge Creek, with an average temperature of 62.4°F, all had average MWATS over 65°F that are presumed representative of a thermal reach for some distance upstream. In all likelihood, the same tributaries probably had temperatures for an unknown distance upstream that may have been between 64-66°F, the ranges determined to be between somewhat suitable, somewhat unsuitable, and fully unsuitable for salmonids. Bridge Creek's 62.4°F average MWAT for all record years did have individual MWATs of 63.9°F and 65.0°F during 1996 and 1998, respectively, but during 1999 and 2001, fluctuated near the upper 60°F range considered suitable for salmonids. Additional monitoring would be necessary at the mid- and upstream reaches of these particular watercourses to determine if MWATs remain elevated, stabilize, and/or decrease over prolonged sampling periods.

Sediment

Available evidence indicates that sediment is likely currently impacting the salmonid fisheries and other beneficial uses of water in the estuary, the mainstem up to the Southern Subbasin, and the lower gradient, downstream reaches of Lower North Fork and Upper North Fork Mattole Rivers, Lower Bear, Mattole Canyon, and Squaw Creeks. Observations by professionals, local residents, and time sequenced aerial photographs, and CGS's NCWAP analysis show that the low gradient, downstream reaches of nearly all of the preceding watercourses have open alluvial floodplains with numerous mid- and side channel gravel bars, and shallow pools filled to varying degrees with fine sediment. Recent eyewitness accounts and videos from the thermal imaging overflight during 2001 show Mattole Canyon Creek with extensive sedimentation at its mouth that resulted in the stream drying up, possibly flowing subsurface before reaching the Mattole River.

During 2000 in the Mattole mainstem the MSG collected and calculated V* = 0.31 near Petrolia at mile 1.3. V* measures the percent sediment filling of a streams pool with deposits such as silt, sand, and gravel compared to the total pool volume. Lower V* values may indicate relatively low watershed disturbances. Some ranges for V*, and also D50, a measure of the median sizes of particles deposited on riffles, that can be useful as indicators of upslope disturbances and/or in-channel pool and riffle sediment deposition and transport characteristics, respectively, are:

- 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 (excessive) rates of pool filling; correlates well with high upslope disturbance.
- *Garcia River TMDL maximum V* = 0.21.
- *Garcia River TMDL minimum D50 = 0.69.

*The Garcia River TMDL is used for discussion purposes only and is not a regulatory target for the Mattole River.

The V* = 0.31 at Petrolia is an average value for ten individual pools that were measured, and varied from a high V* per pool = 0.49, to a low V* per pool = 0.17. The average V* = 0.31, as referenced above, indicate moderate rates of pool filling, but would not be protective of the beneficial uses of water for this metric only if adopted as a TMDL numeric target for the Mattole River.

In Squaw Creek the MSG, for seven pools, calculated a reach averaged V* = 0.24, indicating a low rate of pool filling, but still exceeding the Garcia River TMDL threshold of V* = 0.21, considered protective of the beneficial uses of water. The CGS's NCWAP analysis calculated that the Squaw Creek planning watershed has the largest total length of eroding banks, approximately 5700 lineal feet, than all other planning watersheds in the Western Subbasin. Channel characteristics mapped by the CGS, some considered detrimental and others not to salmonid habitat, are also prevalent along almost the entire length of Squaw Creek. Although there is a paucity of verifiable scientific data collected, recent information gathered and analyzed strongly suggests that excess sediment is probably impairing the beneficial uses of water of Squaw Creek.

The Lower North Fork and Upper North Fork Mattole Rivers, and Lower Bear Creek were mapped, analyzed, and found, in all likelihood, to be impacted with excess sediment from a combination of natural and anthropogenic sources. CGS's NCWAP analysis, previously referred to, show the lower reaches of each stream flowing through open, widened, alluvial floodplains with a number of mapped channel characteristics indicative of excess sediment deposition. CGS's assessment also agrees with low altitude, live video footage from recent thermal imaging profiles flown along the three watercourses. The profiles photographed all three-stream systems with features, such as elevated alluvial terraces, mid- and side channel sand and gravel bars, and displaced riparian vegetation indicating excess sediment may be impairing the beneficial uses of water in their lower reaches (Watershed Sciences, 2002). The observations of residents and others familiar with these stream systems also corroborate the various agencies' conclusions that excess sediment has accumulated in the lower reaches of these streams (MSG, 1997). Field observations by Regional Board staff during 2000 and 2001 indicate that all three watercourses are slowly downcutting through many of the historically aggraded flood terraces and steam channels. However, the lower gradient reaches of these watercourses still possess characteristics of simplified riverine systems in a state of succession from past disturbances, lacking complex habitat features preferable to most salmonid species, such as regularly spaced deep pools and riffles, large woody debris, and riparian cover.

In mainstem Honeydew Creek a V* = 0.10, and a D50 (or median particles size) = 105.9 mm were collected and calculated during 1992; both values are within the adopted numeric target of V* = 0.21, and D50 = 0.69 established for the Garcia River Sediment TMDL. A V* = 0.22 was also collected by the MSG in 2000, which exceeds the Garcia River Sediment TMDL target for V* by only 0.01. All three data sets appear to indicate efficient sediment transport and/or low rates of pool filling through the lower Honeydew Creek system. More thorough and recent sediment collection and analysis would be desirable in other locations, preferably upstream, in Honeydew Creek to ascertain if there are spatially and temporally differentiated trends between the two sediment metrics. For this metric only, the eight-year span between the two V* results tend to indicate a system that is in a relative state of isostasy between sediment transport and deposition.

Elevated temperatures associated with a widened, open alluvial floodplain often combine to impair the beneficial uses of water in the lower reaches of most of the larger tributaries to the Mattole River. However, in Honeydew Creek, even though temperatures analyzed from thermographs are mostly unsuitable for salmonids, the two sediment metrics gathered to this point in time are protective of the beneficial uses of water and would meet or exceed these numeric targets established for the Garcia River Sediment TMDL. However, like the Garcia River Sediment TMDL, a suite of parameters, including spawning gravel embeddedness, maximum pool depths and widths, and percent fines in different size classes, may also be applied to the future Mattole River sediment TMDL before it can be stated to what degree that Honeydew Creek, and other stream systems in the Mattole Basin are impacted by excess sediment depositions.

Physical-Chemical Water Quality

Although data were gathered inconsistently spatially, temporally, and volumetrically it does not appear that water chemistry and basic physical parameters, such as pH, specific conductance (conductance), and dissolved oxygen are impacting the salmonid fisheries, other vertebrate species, macroinvertebrates, and floral constituents in the Mattole River. The most consistent sampling was conducted in the mainstem Mattole River by the Dept. of Water Rights from 1974-1988 at the USGS gaging station near Petrolia. The Dept. of Water Rights collected basic water quality physical parameters that included pH, dissolved oxygen, and conductance during that time frame. Table 14 summarizes minimum and maximum results for all three parameters. Of the three metrics only one, a single pH = 8.6 collected during September 1979, exceeded the Basin Plan numeric standard of pH = 8.5 by 0.1 pH units. This single exceedance would only be cause for alarm if continuous sampling over time revealed a trend of maximum pH results that consistently violate the Basin Plan numeric targets.

Table 14. Summary of physical parameters collected at USGS Petrolia gage by DWR, 1974-1988.

Physical Parameter	No. of Samples	Maximum / Date	Minimum / Date
pH (standard units)	25	8.6 / Sept, 1979	7.4 / Feb, 1987
Dissolved Oxygen (mg/l)	26	13.2 / Feb, 1977	9.2 / Sept, 1975
Conductivity(micromhos)	23	282 / Feb, 1978	100 / Feb, 1978

There were three additional, single day sampling events conducted by the Regional Board in the mainstem. Two isolated sampling events took place at the Mattole-Petrolia Bridge, the Honeydew Bridge, near Ettersburg, and in the NFK Mattole River. Results from the Regional Board sampling at these locations were all within Basin Plan targets. The third sampling event was conducted on October 29, 2002, at eleven sample points in nine pools along the mainstem in the Southern Subbasin. Except for one sample point at 8.4 mg/l dissolved oxygen, the other ten sample points had dissolved oxygen levels ranging from 6.8 mg/l down to 0.2 mg/l, all levels that would be considered stressful to salmonids. All other physical parameters were within the beneficial use targets in the Basin Plan for the Mattole River. Sampling has not taken place in a systematic manner in any of the other NCWAP subbasins.

There is anecdotal evidence that dissolved oxygen may approach anoxia in deeper pools in the estuary but there has been no recent sampling to confirm or refute this conclusion. Past sampling conducted in the lagoon/estuary from 1987-1990 by Humboldt State University students and faculty obtained results for dissolved oxygen that varied between 8.7-10.4 mg/l, well within limits necessary to support aquatic life and other beneficial uses of water (Zedonis, 1992). It was not stated at what depths dissolved oxygen was measured but, in all likelihood, it was probably at, or slightly below the waters surface if handheld devices were used.

Limited depth integrated sampling was also conducted in the lower mainstem during lagoon conditions from September through November, 1987. At one sample location approximately 1.7 feet from the bottom dissolved oxygen levels were measured at 2.8 and 4.7 mg/l, and, at another location a dissolved oxygen level of 5.2 mg/l was reported (Busby, et al., 1988). These data for dissolved oxygen are stressful to salmonids but are not considered true anoxia where dissolved oxygen levels approach 0.0 mg/l. However, the low oxygen levels observed during 1987 would induce salmonids, and most other fauna capable of movement, to escape from locations where those conditions exist. Additional depth integrated sampling would be necessary in any deeper pools to determine if true anoxic conditions do prevail during periods of low flow, lagoon conditions.

Herbicide and pesticide residues from commercial timber applications have been anecdotally linked to impacts to water quality. There have been no scientifically conducted sampling efforts and associated data collection in any of the Mattole subbasins to determine if chemical residues are affecting the beneficial uses of water on and from industrial timberlands to local watercourses.

Aquatic/Riparian Condition

The riparian zone is the area between a stream or other body of water and the adjacent upland and forms a vital link between terrestrial and aquatic ecosystems. It is identified by soil characteristics and distinctive vegetation. The riparian zone includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation. Riparian vegetation is the 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. The structure and composition of the riparian zone can be affected by the stream type and its active channel, as well as by geologic and topographic features. Functions of the riparian zone include:

- Controlling the amount of light reaching the stream;
- Providing litter and invertebrate fall;
- Providing stream bank cohesion;
- Buffering impacts from adjacent uplands;
- Providing large woody debris (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 fully supportive of 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 maintains prime salmonid habitat. Lastly, the large woody debris provided by riparian zones shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids (Murphy and Meehan 1991). Therefore, disruptions to the riparian zone can have serious impacts to the aquatic community, including anadromous salmonids.

Fish Habitat Relationship

Anadromous Salmonid Natural History

Anadromous fish migrate to the ocean early in their life, mature in the ocean, and return inland as adults to spawn in freshwater streams and rivers. Chinook salmon, coho salmon, and steelhead are the predominant anadromous fish using the waterways of the Mattole River. Habitat requirements of salmon and steelhead in the freshwater environment vary to some degree for each species but are generally similar.

Chinook Salmon

Mattole River Chinook salmon are fall-run, migrating into the river as adults from October through February and spawning during the same period. Shortly after fry emerge from redds, the gravel incubation nests built by spawning females, they begin to move downstream and arrive at the estuary throughout the spring. In California, most Chinook smolts enter the ocean during their first seven months of life. Chinook salmon generally mature at 3 to 4 years of age. Some precocious males mature at age two (commonly called jacks) and return to spawn and die along with the older, larger fish from earlier year classes.

Chinook salmon generally spawn in swift, relatively shallow riffles or along the edges of fast runs where there is an abundance of loose gravel. The females dig spawning redds in the gravel and deposit their eggs in the redd pocket. Eggs are immediately fertilized by a male and covered with gravel by the female. The adults die within a few days after spawning. Water flows through the gravel and supplies oxygen to the developing embryos. An average female Chinook salmon produces 3,000-6,000 eggs depending on the size of the fish.

Chinook salmon select spawning sites within narrow ranges of water velocity and depth. Spawning requires well oxygenated cool water. Velocity is generally regarded as a more important parameter than depth for determining the suitability of a particular spawning site. The velocity determines the amount of water which will pass over the incubating eggs. Depths fewer than 6 inches can be physically prohibitive for spawning activities. In general, optimum spawning velocity is 1.5 feet per second (fps), ranging from 1.0 to 3.5 fps. Mattole River fall-run Chinook typically spawn at depths ranging from 1-5 feet.

Substrate composition is another critical factor in determining the suitability of spawning site selection. For successful reproduction, Chinook salmon require clean and loose gravel that will remain stable during incubation and emergence. Average size of Chinook salmon redds ranges from 75 to 100 square feet. In areas where spawning activity is high, redds of later spawners may be dug adjacent to, or super-imposed upon, earlier redds and some egg disturbance may occur. The territory required for pre-mating activity has been estimated to be between 200 and 650 square feet for a pair of salmon but this varies widely according to population density. Where spawning occurs throughout a protracted spawning season, as many as three or four redds may be dug in the area equivalent to the territorial requirement of one pair.

In general, the substrate chosen by Chinook salmon for spawning is composed mostly of gravels from 0.5 to 5 inches in diameter with smaller percentages of coarser and finer materials with no more than about 5 percent fines. Although some spawning will occur in sub-optimal substrates, incubation success will be lower. Substrate composition must be low in sand and silt so that oxygenated water is allowed to freely permeate and flow through intra-gravel spaces, and to allow newly hatched salmon to move up through the gravel into the water column. Sediments deposited on redds can reduce water flow through the gravel and suffocation of eggs or newly hatched fry may occur. Gravel is completely unsatisfactory when it has been cemented with clays and other fines, or when sediments settle out and cover eggs during the spawning and incubation period.

The preferred temperature for Chinook salmon spawning is generally 52°F with lower and upper threshold temperatures of 42°F and 56°F. Holding adults prefer water temperatures less than 60°F, although, acceptable temperatures for upstream migration range from 57°F to 67°F.

In the Mattole River system, Chinook salmon eggs usually hatch in 40 to 60 days, and the young sac fry usually remain in the gravel for an additional 30 days until the yolk sac is nearly entirely absorbed. The rate of development is faster at higher water temperatures. Significant egg mortalities can occur at temperatures in excess of 57.5°F with total mortality normally occurring at 62°F.

After emergence, Chinook salmon fry attempt to hold position in the water column and feed in low velocity slack water and back eddies. They move to somewhat higher velocity areas as they grow larger and make their way to the estuary. In the Mattole River system Chinook salmon juveniles are detained in the estuary because of the creation of lagoon conditions early in the summer. This prevents them from going to the ocean until it reopens in the Fall. Unfortunately, conditions in the estuary through the summer are not hospitable and studies conducted by Humboldt State University within the past fifteen years have shown high, and perhaps total, mortality in some years. Juveniles that enter the ocean and survive to adulthood, usually return to the system after their third or fourth year at sea.

Coho Salmon

Coho salmon adults enter the Mattole River from October through December and reach the upper spawning reaches in November and January. In the shorter California coastal streams, most return from mid-November through mid-January. Spawning commences shortly after arriving at the spawning sites provided that water conditions, including flow and temperature are satisfactory.

Redd construction behavior is similar to that displayed by other salmonid species, with the female excavating a depression in the gravel by turning on her side and using her body and tail to displace gravel downstream. The number of eggs produced by the female is directly related to her size. Four-pound and ten-pound females produce about 2,000 and 2,700 eggs, respectively.

The amount of time required for the incubation of coho eggs varies primarily with water temperature. Normally, four to eight weeks are required for incubation. Another two to seven weeks are required from hatching to emergence from the gravels (Shapovalov and Taft, 1954). Mortalities during this period can vary substantially. Under optimum conditions, mortalities can be as small as ten percent. However, under very adverse conditions such as scouring flows or heavy siltation, close to a complete loss may occur. Shapovalov and Taft (1954) estimated that under favorable conditions (in the absence of heavy silting) survival to emergence in Waddell Creek (Santa Cruz) was between 65 and 85%of the eggs deposited.

Juvenile coho will normally attempt to remain in the stream, in the vicinity where hatched, for one year. However, environmental factors, such as low summer flows or high water temperatures, or population pressures due to limited rearing space and food, will force the smaller, weaker individuals to relocate. Most of this movement is manifested in a downstream migration of fry during the first spring and summer.

Smoltification, the physiological change adapting young anadromous salmonids for survival in saltwater, normally occurs in California coho during the spring of the fish's second year. In recent downstream migrant studies on several Mendocino County streams and on Lagunitas Creek, juvenile coho emigrating from the streams ranged in size from 2.5 to 8 inches fork length indicating age 0+ and age 1, and averaged approximately 4.5 inches (Bratovich and Kelley, 1988; W. Jones, personal comm.).

Coho typically spend two growing seasons in the ocean and return to spawn near the end of their third year of life. However, some males return to spawn near the end of their second year. Nearly all are precocious males (jacks) which, like their adult counterparts, die after spawning. Murphy (1952) estimated that the percentage of jacks returning to the South Fork Eel River above Benbow Dam from 1939-40 through 1950-51 ranged from 6.9% to 33.8%, with a mean of 18%.

Steelhead Trout

Steelhead trout are an anadromous strain of rainbow trout that migrate to sea and later return to inland rivers as adults to spawn. In contrast to all Pacific salmon, not all steelhead die after spawning. In the Mattole River, upstream migration occurs from November through May with the peak run occurring in January-February. Mattole River steelhead spawners are typically age four or five years and weigh 2 to 12 pounds or more. Female steelhead carry an average of 3,500 eggs, with a range of 1,500-4,500.

Like other salmonids, steelhead prefer to spawn in clean, loose gravel and swift, shallow water. Gravel from the redd excavation forms a mound or tail-spill on the downstream side of the pit. Eggs deposited along the downstream margin of the pit are buried in the gravel as excavation proceeds. An average of 550-1,300 eggs are deposited in each pit. The males fertilize the eggs as they are deposited. Water flowing through the gravel supplies oxygen to the developing embryos.

Water depth and velocity criteria for spawning and rearing steelhead differ slightly from those for salmon. Spawning velocity appears to be about the same as for Chinook salmon, 1.5 fps, but depth is slightly less, to about 0.75 foot. Gravel particle sizes selected by steelhead vary from about 0.25-3.0 inches in diameter, somewhat smaller than those selected by Chinook salmon.

Steelhead eggs seem less tolerant of fine sediment than Chinook salmon, probably because eggs are smaller and oxygen requirements for developing embryos are higher. A positive correlation has been demonstrated between steelhead egg and embryo survival and the rate of water flow through the gravel. Egg survival is highly dependent upon the flow of well oxygenated water. The average size of a steelhead redd is smaller than that of a Chinook salmon. Redd sizes range from 22.5 to 121 square feet and average 56 square feet.

All freshwater life stages of steelhead, except rearing, require lower temperatures than Chinook salmon. The preferred temperatures for steelhead are between 50EF and 58EF, although they will tolerate temperatures as low as 45EF. Studies show that the upper preferred temperature limit for rainbow trout in Sierra Nevada streams is 65EF. The temperature range for spawning is somewhat lower, ranging from 39 to 55°F, and the preferred incubation and hatching temperature is 50EF. During the egg's tender stage, which may last for the first half of the incubation period, a sudden change in water temperature may result in increased mortality.

Egg incubation in the Mattole River system takes place from December through April. The rate of embryo development is a function of temperature with higher temperatures contributing to faster development. At 50EF, hatching occurs in 31 days; at 55°F, hatching occurs in 24 days.

Newly hatched steelhead sac fry remain in the gravel until the yolk sac is completely absorbed, a period of 4-8 weeks. Emergence is followed by a period of active feeding and accelerated growth. The diet of newly emergent fry consists primarily of small insects and invertebrate drift. As they grow, fry move from the shallow, quiet margins of streams to deeper, faster water.

Unlike juvenile fall-run Chinook salmon, which typically emigrate within 3 to 4 months after emerging from the gravel, juvenile steelhead usually remain in fresh water for two years. Because rearing steelhead are present in fresh water all year, adequate flow and temperatures are important to the population at all times.

Generally, throughout their range in California, steelhead that are most successful in surviving to adulthood spend at least two years in fresh water before migrating downstream. In the Mattole River, steelhead generally migrate downstream as 2-year old smolts during spring and early summer months. Emigration appears to be more closely associated with size than age, 6-8 inches being the size of most downstream migrants. Downstream migration in unregulated streams has been correlated with spring freshets.

Summer Steelhead Trout

Summer steelhead enter the Mattole River between March and June. Fish remain in clear, cool, deep pools until late winter and spring of the following year before spawning. Mattole River summer steelhead can be large in size, averaging 26 inches and 24 inches, or more for males and females respectively. Egg deposition occurs in early spring with the young hatching about 50 days later. Generally, young summer steelhead will remain in the Mattole River for two years followed by another one to three years of ocean life before returning to complete their life cycle. Ninety percent of the returning adults are three and four year old fish. (Adapted from Jones and Ekman, 1980.)

Fish Passage Barriers

Stream connectivity is essential for juvenile and adult anadromous fish. Stream connectivity describes the absence of barriers to the free instream movement of adult and juvenile salmonids. Free movement in well-connected 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 stream connectivity. Culverts are one potential fish passage barrier that has been examined in the Mattole Basin.

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 15, Taylor 2000/2001). Passage barriers that can be created by culverts include an excessive drop at the culvert outlet (too high of entry jump 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 (Taylor, 2001). Inventories and fish passage evaluations of culverts within the Humboldt County and the coastal Mendocino County road systems 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 (Taylor, 2000, 2001). These inventories included 67 and 26 stream crossings in Humboldt and Mendocino Counties, respectively, of which 18 were in the Mattole Basin.

Table 15. Definition of barrier types and their potential impacts to salmonids.

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 lifestages 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 culverted 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, watershed groups and/or timber companies.

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, and 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 Region One Headquarters.

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

Fish History and Status

Fishery resources of the Mattole Basin include fall-run Chinook salmon, coho salmon, winter-run steelhead trout, and summer -run steelhead trout. Other fish present in the Mattole Basin include sticklebacks, lampreys, and sculpins (Table 16). Two notable fish species that have apparently been extirpated in the Mattole Basin are spring-run Chinook salmon (CDFG 1972) and green sturgeon (Moyle et al. 1989).

Table 16. Fish species in the Mattole Basin.

Common Name:	Scientific Name:
Anadromous	
Chinook salmon	*Oncorhynchus tshawytscha*
Coho salmon	*Oncorhynchus kisutch*
Rainbow trout	*Oncorhynchus mykiss*
Pacific lamprey	*Lampetra tridentata*
Freshwater	
Coast Range sculpin	*Cottus aleuticus*
Prickly sculpin	*Cottus asper*
River lamprey	*Lampetra ayresi*
Western brook lamprey	*Lampetra richardsoni*
Sacramento sucker	*Catostomus occidentalis*
Threespine stickleback	*Gasterosteus aculeatus*
Marine or Estuarine Dependent	
Pacific staghorn sculpin	*Leptocottus armatus*
Shiner perch	*Cymatogaster aggregata*
Redtail surf perch	*Amphistichus rhodoterus*
Walleye surf perch	*Hyperprosopon argenteum*
Speckled sanddab	*Citharichthys stigmeus*
Starry flounder	*Platichthys stellatus*
Surf smelt	*Hypomesus pretiosus*
Topsmelt	*Atherinops affinis*

Many fish in the Mattole Basin use the estuary during some part of their life history. Anadromous salmonids and pacific lampreys pass through the estuary on migrations. Threespine stickleback (Busby et al. 1988), pacific staghorn sculpin, prickly sculpin, shiner perch, and topsmelt spawn within the estuary. Juvenile Chinook salmon, some steelhead trout, threespine stickleback (Busby et al. 1988), Coast Range sculpin, shiner perch, starry flounder, surf smelt, and topsmelt rear in the estuary.

Though anecdotal evidence provides a convincing case that anadromous salmonid runs in the Mattole Basin were large and have experienced a sharp decline since the mid 1950s, little quantitative historic data exists (BLM, 1996). Estimates of Chinook salmon, coho salmon, and steelhead trout populations in the Mattole Basin were made by the United States Fish and Wildlife Service (USFWS) in 1960. Existing population estimates were based on spawning gravel surveys and interviews with sportsmen and local residents. Potential population estimates were based on spawning gravel surveys. Existing populations of 2,000 Chinook salmon, 5,000 coho salmon and 12,000 steelhead trout were estimated, while potential populations of 7,900 pairs of Chinook salmon, 10,000 pairs of coho salmon and 10,000 pairs of steelhead trout were predicted (Figure 36).

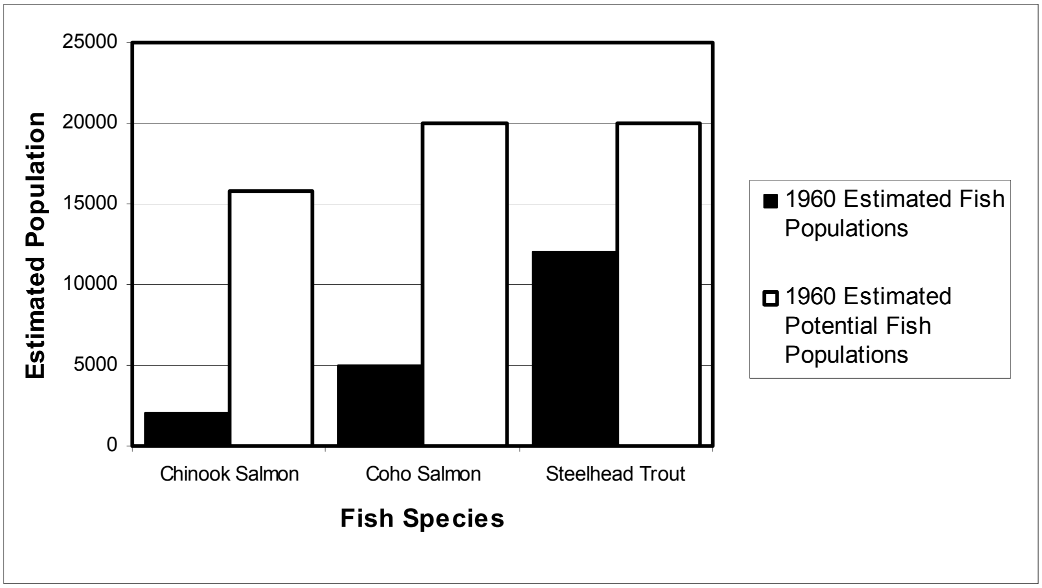

Figure 36. 1960 USFWS estimates of fish populations and potential fish populations in the Mattole Basin.

In 1965, the Department of Water Resources (DWR) reported that Chinook salmon were able to access the Mattole River for 45 miles, while coho salmon and steelhead trout used several more miles of the river. Chinook salmon spawned mostly on the mainstem according to DWR, though several tributaries such as the North Fork of the Mattole River, Squaw Creek, Honeydew Creek, and Bear Creek also provided suitable spawning areas. Coho salmon and steelhead trout were thought to spawn mostly in smaller tributaries throughout the basin. However, ongoing spawner surveys conducted by CDFG and MSG since 1981 have documented Chinook salmon, as well as coho salmon and steelhead trout, spawning clear to the Mattole River's headwaters (river mile (RM) 70).

Figure 37, Figure 38, and Figure 39 depict the estimated historic distributions of coho salmon, Chinook salmon, and steelhead trout, respectively. The limits of the estimated range of steelhead trout, the most athletic of the Mattole salmonids, was initially defined to be a stream reach of 1000 feet or more with a gradient in excess of 10%. The limits of the coho and Chinook salmon range estimates were defined as reaches of 1000 feet or more with a gradient in excess of 5%. These estimates were based on 10 meter digital elevation model (DEM) analyses. The preliminary range estimates were then reviewed by a team of CDFG and Bureau of Land Management (BLM) fishery biologists in collaboration with Mattole Salmon Group (MSG) biologists and Mattole Basin residents.

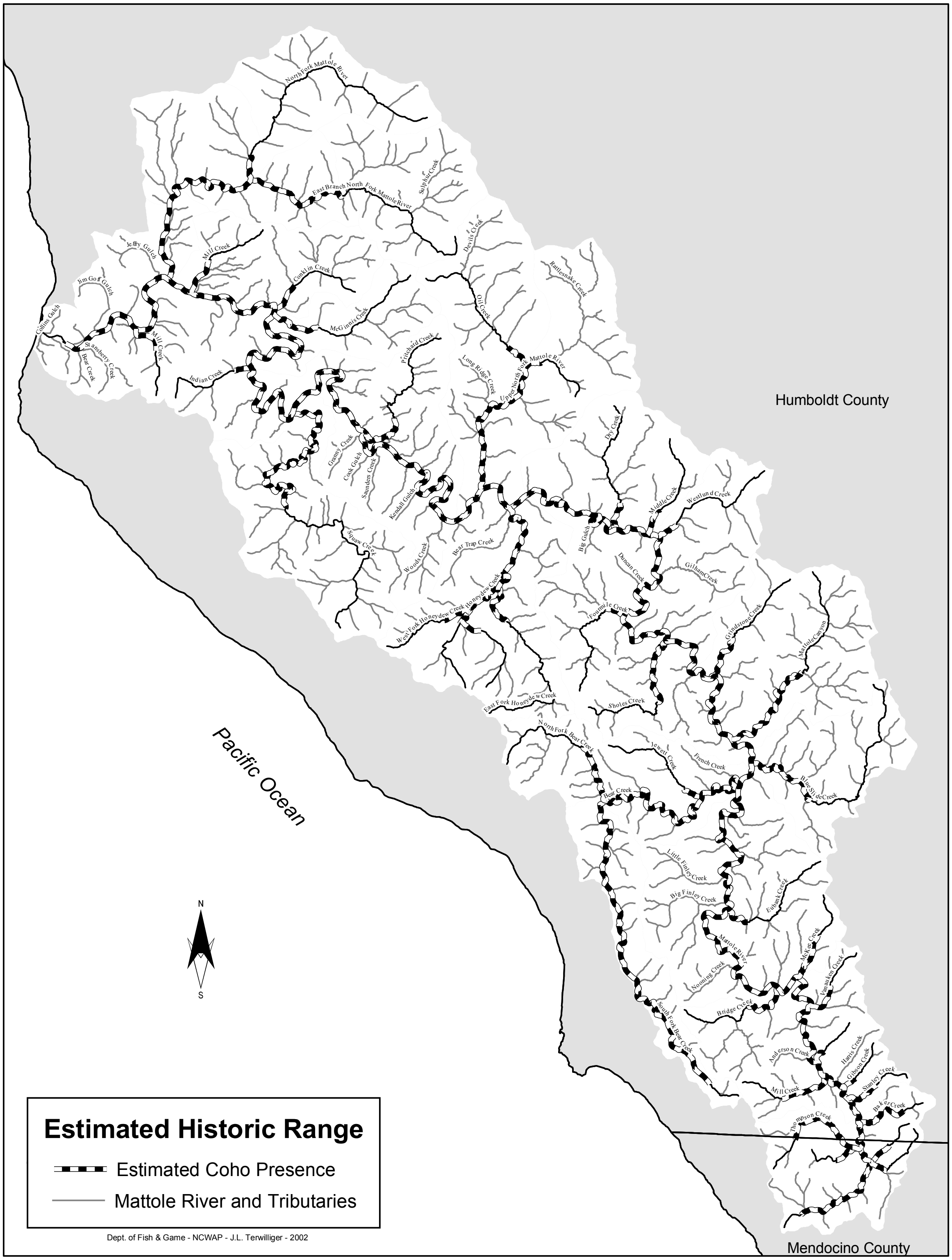

Figure 37. Mattole Basin estimated historic coho distribution.

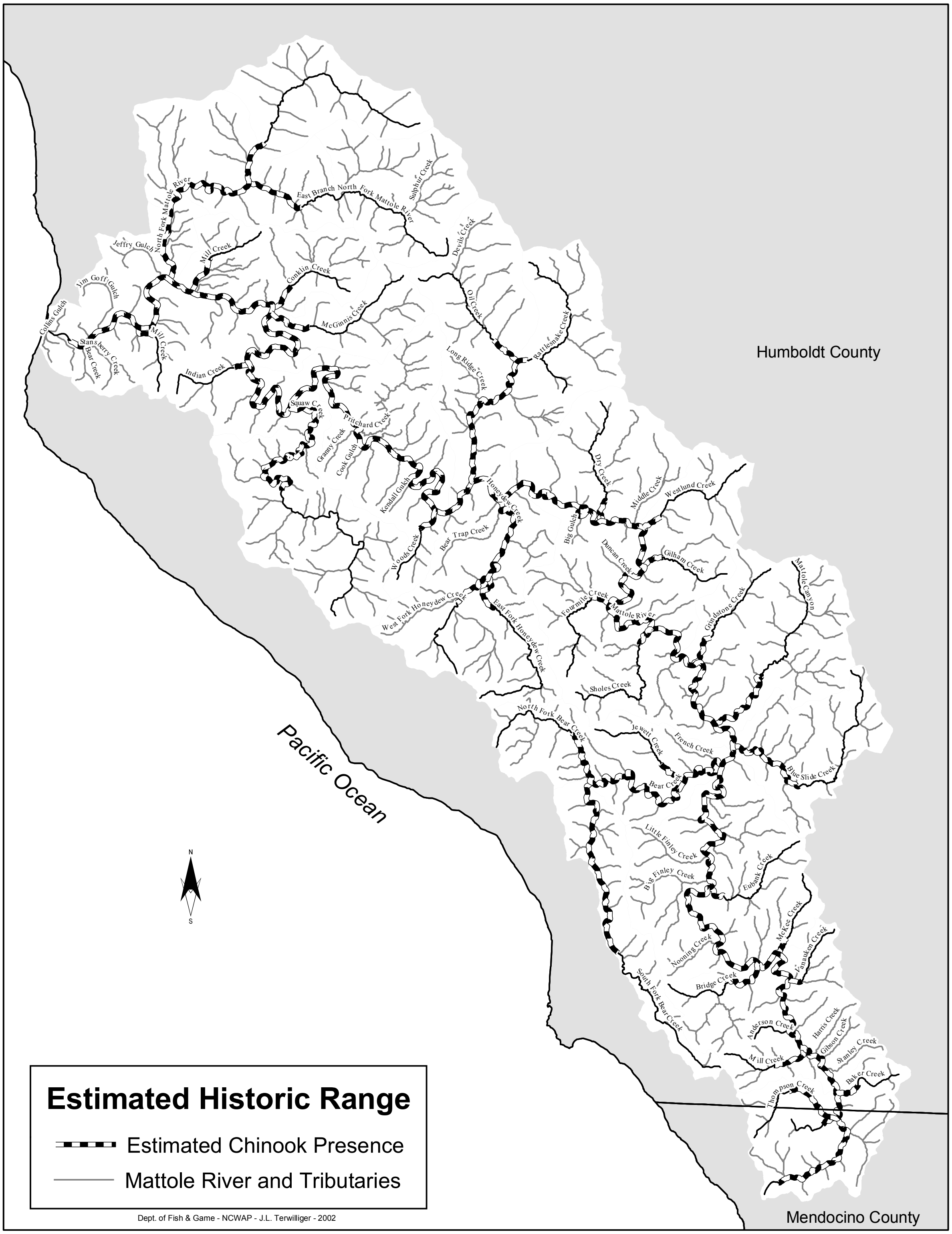

Figure 38. Mattole Basin estimated historic Chinook distribution.

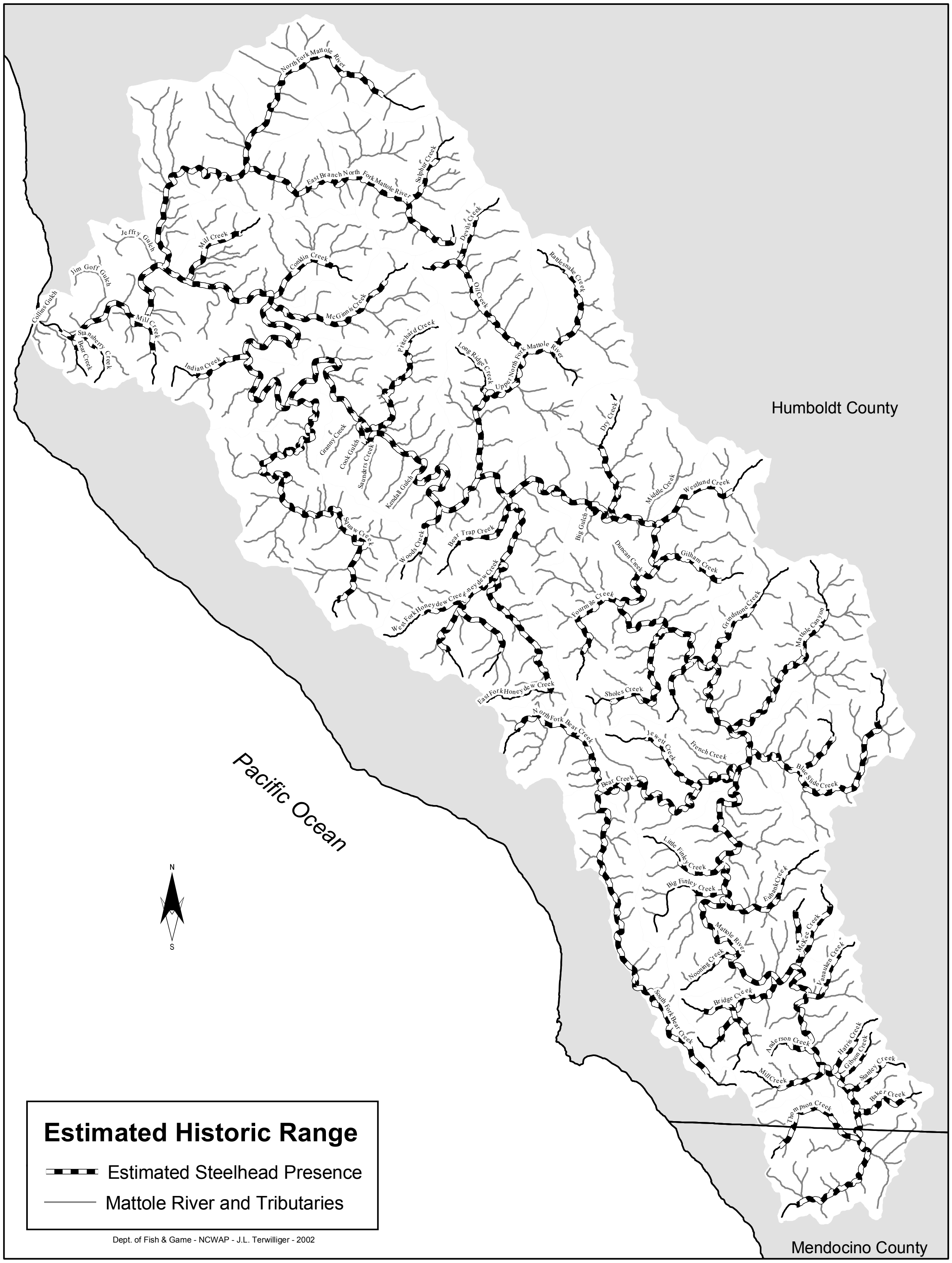

Figure 39. Mattole Basin estimated historic steelhead distribution.

DWR (1965) speculated that increases in siltation and debris jams following intensive logging that started in 1952 caused a significant reduction in the size of anadromous fish runs since 1955. Prior to 1954, the Mattole River had an exceptionally good winter steelhead trout fishery. The fishery had deteriorated seriously since the 1950s. In fact, DWR stated that:

> "It is sufficient to note here that the Mattole River was formerly one of the better king salmon (Chinook salmon), steelhead (trout), and silver salmon (coho salmon) producers of the entire coast. Since 1950, excessive logging operations have taken place in the drainage, which has severely damaged the stream, primarily from siltation. The stream is still considered to have the potential to again be the major fish producer that it was historically if improved logging and land management principles are followed."

Most of the Mattole Chinook salmon catch after 1954 was taken during November, although an occasional fish was caught in the estuary as early as October. Steelhead trout and an occasional coho salmon were taken whenever water conditions were favorable. USFWS surveys during 1956-1957 and 1957-1958 seasons indicated that an average of 4300 angler days were spent on the river, resulting in a catch of 400 salmon, 700 steelhead trout, and about 8000 juvenile steelhead trout. A need for better stream survey data was recognized in 1965, when it was recommended that thorough surveys of existing conditions be carried out so as to permit management of the resource by knowledge, not guesswork.

CDFG conducted 65 stream surveys on 58 Mattole River tributaries in the mid 1960s. Survey reports included drainage, stream condition, habitat suitability, stream obstruction, and fisheries descriptions. Salmonid presence and habitat characteristics were usually determined by direct stream bank observation. Survey reports concluded with recommendations for management. CDFG continued to survey streams in the Mattole Basin in the 1970s and 1980s with an emphasis on locating possible salmonid passage barriers. Coho salmon and steelhead trout presence was documented in tributaries throughout the Mattole Basin (Table 17).

Table 17. Coho salmon and steelhead trout presence reported in CDFG stream surveys from 1950-1989.

Subbasin	Number of Streams Surveyed	Number of Streams Where Coho Salmon Were Reported*	Number of Streams Where Steelhead Trout Were Reported *
Estuary Subbasin	NA	NA	NA
Northern Subbasin	14	2	13
Eastern Subbasin	16	3	8
Southern Subbasin	8	1	8
Western Subbasin	26	5	16

*These numbers do not include unidentified salmonid observations.

With the publication of the *California Salmonid Stream Habitat Restoration Manual* in 1991, stream survey methodologies used by CDFG became standardized and more quantitative. Sixty-two tributary reports were completed for the Mattole Basin in the 1990s. Biological inventories were conducted on 33 of the surveyed tributaries; coho salmon were detected in 11 surveyed tributaries and steelhead trout were detected in all 45 surveyed tributaries. More details about CDFG stream surveys and inventories are in the analyses and results by subbasin section of this report and the CDFG Appendix F.

The BLM also conducted 40 stream surveys in the Mattole Basin starting in the 1970s. BLM survey reports included access, drainage, stream conditions, habitat suitability, and fisheries descriptions. Salmonid presence and habitat characteristics were usually determined by direct observation. Survey reports concluded with recommendations for management. BLM surveys documented the presence of steelhead trout in tributaries throughout the Mattole Basin, but only document coho salmon in one(Table 18). More details about BLM stream surveys are in the analyses and results by subbasin section of this report and the CDFG Appendix F.

Table 18. Coho salmon and steelhead trout presence reported in BLM stream surveys.

Subbasin	Number of Streams Surveyed	Number of Streams where Coho Salmon Were Reported *	Number of Streams where Steelhead Trout Were Reported *
Estuary Subbasin	NA	NA	NA
Northern Subbasin	1	0	1
Eastern Subbasin	3	0	2
Southern Subbasin	3	0	1
Western Subbasin	18	1	6

*These numbers do not include unidentified salmonid observations.

C.J. Brown (1972, 1973a, 1973b) conducted a study of the downstream migrations of salmonids, a creel census and fisherman-use count, and an estimate of salmonid standing stocks for the Mattole River. Downstream outmigrant salmonids were trapped in the spring of 1972 to gain some insight into their distribution within the Mattole River and the timing of their outmigration (Brown 1972). Nets were set on the Mattole River 1.5 miles above the Petrolia Bridge, and 100 yards below the mouth of Bear Creek in between April and June. Results indicated that juvenile Chinook salmon outmigration in the Mattole River ceased by May, coho salmon outmigrants were present from April through June, and steelhead trout exhibited some downstream movement in May and June. Brown (1972) also speculated that the Mattole estuary may be an important rearing area for Chinook salmon and steelhead trout.

A census of angler use and catch was made in February 1972 and from September 1972 through February 1973 on the Mattole River downstream from Honeydew to determine the general nature of the fisheries and the number of fishable days occurring during a typical year (Brown 1973a). Two distinct groups of anglers were found to fish in the Mattole River: salmon anglers and steelhead anglers. Salmon anglers were characterized as local residents who fished from boats in the estuary from late September until winter storms allowed salmon to move upstream in early November. Fourteen anglers sampled in October 1972 had a catch per angler hour of 0.124.

Steelhead anglers were characterized as excellent fishermen who traveled long distances, put in long days fishing, and were frequently successful. An average angler-day was 7.1 hours, the average catch per angler day was 0.45, and the average catch per angler hour was 0.064 in February 1972.

The Mattole River was fishable for only 9 ½ days during February of 1972, though every day from May through August 1972 was fishable. Most of September and October were fishable, but turbid water limited fishing to only a few days per month by November 1972. Turbidity prevailed throughout most of the steelhead-fishing season (November 21, 1972 through February 28, 1973), though at least 28 days were fishable. The river had been fishable for 24 days during the 1971-72 steelhead-fishing season.

Estimates of the abundance and distribution of juvenile salmonids in the Mattole Basin were made in 1972 to determine the effect of a proposed dam on salmonid resources (Brown 1973b). The proposed dam was to be built at Nooning Creek (RM 50.2). Standing stocks of salmonids were estimated at 24 stations (18 stations above the proposed dam and six below the proposed dam) in the Mattole Basin using electrofishing surveys (Table 19). Salmonid populations on the mainstem Mattole River averaged 136 salmonids per 100 feet near Ettersburg and 61 salmonids per 100 feet in the headwaters above Bridge Creek (RM 52.1). Young-of-the-year steelhead trout predominated at these stations. Coho salmon fry were found at only one station on the mainstem Mattole River, at RM 58.6 in the Southern Subbasin.

Table 19. Mattole Basin steelhead trout and coho salmon population estimates, 1973 (after Brown 1973b).

Subbasin	Location	# of 100 ft Stations	Average Population Estimate for a 100 ft Stations (95% confidence intervals)		
			Steelhead Trout		Juvenile Coho Salmon
			Young-of-the-Year	Yearling and Older	
Mainstem	Mattole River near Ettersburg	2	131	5	0
Northern Subbasin	Lower North Fork of the Mattole River	2	172	14	0
Eastern Subbasin	Mattole Canyon Creek	1	596	6	6
	McKee Creek	2	124	15	0
Southern Subbasin	Upper Mattole River	7*	54	7	<1
	Vanauken Creek	2	74	<1	0
	Mill Creek (RM 56.2)	2	39	0	0
	Harris Creek	1	47	0	1
	Baker Creek	2	43	1	10
	Thompson Creek	2	59	3	6
Western Subbasin	Squaw Creek (near mouth)	1	74	0	0

* Juvenile steelhead not separated by age at one station so estimates taken from other six stations.

Average salmonid populations at 15 stations on tributaries to the Mattole River ranged from 39 to 596 salmonids per 100 feet. Young-of-the-year steelhead trout predominated at all tributary stations. Coho salmon were found at four stations on tributaries (Harris Creek, Baker Creek, Thompson Creek, and Mattole Canyon Creek). Sampling effort was not sufficient to accurately estimate the numbers of salmonids in the mainstem Mattole River above the proposed Nooning Creek dam site. Nevertheless, Brown (1973b) very roughly estimated that the proposed dam would eliminate nursery areas for 125,283 juvenile steelhead trout and 1,713 juvenile coho salmon.

The Coastal Headwaters Association surveyed just over 200 perennial stream miles in the Mattole Basin in the early 1980s under contract with CDFG. They conducted five different types of stream surveys: pre-inventory surveys, visual surveys, detailed habitat surveys, spot-checks, and high-water surveys.

Pre-inventory surveys consisted of obtaining land-owner permission to access streams, and obtaining and reviewing all available maps for an area, previous stream surveys, and historical information. Visual surveys provided a basic description of fish populations, habitat conditions, and rehabilitation needs but usually did not involve the collection of quantitative data. Detailed habitat surveys were similar to ocular surveys, but included actual measurements of habitat features such as pools, runs, and riffles. Spot-checks consisted of fish and habitat observations at point locations in easily accessible areas like bridges. Spot-checks often included the use of minnow-traps to sample juvenile salmonids. Lastly, high-water surveys were used to estimate spawning salmonid populations and followed procedures used by the Anadromous Fisheries Branch (1981).

Findings of the Coastal Headwaters Association's stream surveys were summarized in the First Annual Report of the Mattole Survey Program in 1982. Coastal Headwaters Association stream surveys document the presence of steelhead trout throughout the Mattole Basin, and coho salmon in every subbasin except the Northern Subbasin (Table 20). More details about stream surveys are in the analyses and results by subbasin section of this report and the CDFG Appendix F.

Table 20. Coho salmon and steelhead trout presence reported in Coastal Headwaters Association stream surveys

Subbasin	Number of Streams Surveyed	Number of Streams where Coho Salmon Were Reported *	Number of Streams where Steelhead Trout Were Reported*
Estuary Subbasin	NA	NA	NA
Northern Subbasin	6	0	5
Eastern Subbasin	8	3	6
Southern Subbasin	9	4	7
Western Subbasin	15	5	9

*These numbers do not include unidentified salmonid observations.

Recent CDFG surveys for coho salmon have determined coho presence in four tributaries in the Eastern Subbasin; seven tributaries and the upper mainstem Mattole River in the Southern Subbasin; and four tributaries in the Western Subbasin (Table 21). Steelhead trout were present at all sites.

Table 21. Recent coho salmon and steelhead trout presence surveys in the Mattole Basin

Subbasin	CDFG 2001 Coho Inventory			1990s CDFG Basin Planning Project		
	Number of Streams Surveyed	Number of Streams where Coho Salmon Were Reported	Number of Streams where Steelhead Trout Were Reported	Number of Streams Surveyed	Number of Streams where Coho Salmon Were Reported	Number of Streams where Steelhead Trout Were Reported
Estuary Subbasin	NA*	NA	NA	NA	NA	NA
Northern Subbasin	3	0	3	3	0	3
Eastern Subbasin	10	3	10	10	1	10
Southern Subbasin	7	5	7	10	5	10
Western Subbasin	11	3	11	10	2	10

*NA is not applicable as there are no fish bearing tributaries in the Estuary Subbasin.

Additional sources of information about anadromous salmonids in the Mattole Basin include watershed analyses, other studies of tributaries and salmonids, and stocking records. Detailed Watershed Analyses have been carried out by the BLM for Bear Creek (1995), Honeydew Creek (1996), and Mill Creek (lower) (2001), and Hamilton (1982) surveyed Nooning Creek as part of a research proposal. Additionally, Nehlsen et al. (1991) and Higgins et al. (1992) both mention Mattole salmonid runs in their overviews of the risk of extinction of salmon runs in the Pacific and Northern California, respectively. They postulated that fall-run Chinook salmon and coho salmon in the Mattole Basin had a high risk of extinction. More details are in the analyses and results by subbasin section of this report and the CDFG Appendix F.

The Mattole Basin was stocked by CDFG with steelhead trout, coho salmon and/or Chinook salmon from 1930 to 1981 (Table 21). The vast majority of fish released were steelhead.

Table. CDFG stocking records for the Mattole Basin from 1930 to 1981.

Year	Steelhead Trout	Coho Salmon	Chinook Salmon
1930	50,000		
1931	50,000		
1932	105,000		
1933	70,000		
1934	40,000		
1935	132,000		
1936	65,000		
1938	2,690	1,000	4,940
1961	187,000		
1972	30,065		
1973	19,067		
1975	30,012		
1981	100,000		

The Mattole Salmon Group (MSG) was formed in 1980 as a response to local citizen's concerns about declining salmonid populations. MSG represents a watershed-wide, entirely citizen-run effort to begin restoring native salmon runs. MSG promotes and operates a broad-based program aimed at restoring the native salmonid fishery in the Mattole Basin. Two important focus areas of the MSG program are monitoring fish populations, and maintaining and enhancing the remnant runs of native fall-run Chinook salmon and coho salmon (MSG 2000).

MSG monitors fish population in the Mattole Basin through spawning surveys and downstream migrant trapping. As a part of their activities, MSG has conducted annual spawning surveys since the 1981-1982 season to provide estimates of salmon escapement in specific index reaches and for extrapolation to basin-wide population levels. Estimated basin-wide populations of Chinook salmon and coho salmon for the 1999-2000 season were 700 and 300, respectively (Table 22). The coho salmon population has been estimated to be less than 1,000 since 1981 and below 100 from 1989 to 1992. Chinook salmon populations, although higher, also ranged to critically low levels- with only an estimated 100 to 400 adults in the years 1989-1993.

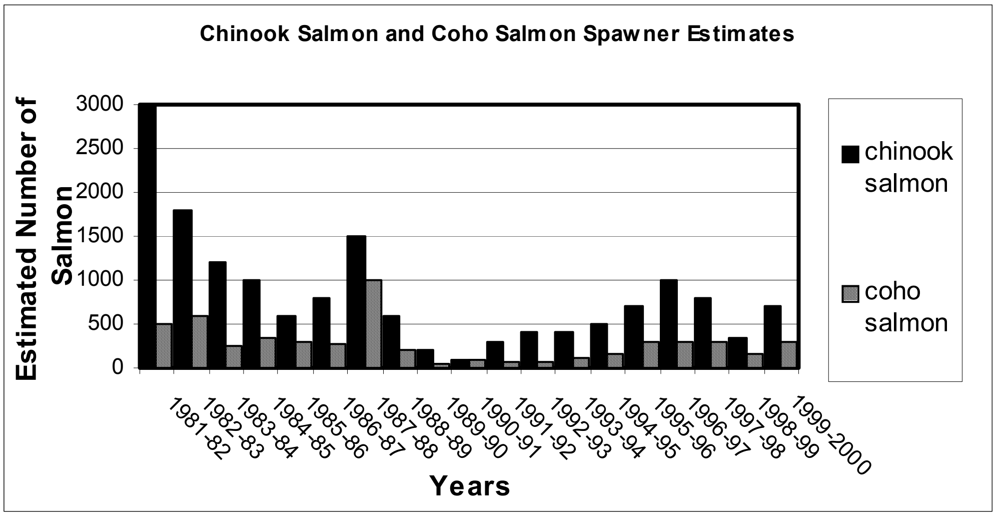

Table 22. Mattole Salmon Group estimates of returning adult Chinook and coho salmon spawners to the Mattole Basin from 1981-2000.

Data is based on annual synthesis of spawning surveys and counts at a temporary fish weir in the Mattole River near the confluence with Mill Creek. Data provided by the Mattole Salmon Group.

Small populations of organisms are at a greater risk of extinction from genetic problems, demographic fluctuations, and environmental fluctuations. A loss of genetic variability can be caused by inbreeding, loss of heterozygosity, and genetic drift. Demographic fluctuations are caused by random variations in birth and death rates. Environmental fluctuations include variation in predation, competition, disease, and food supply; and natural catastrophes resulting from single events that occur at irregular intervals, such as fires, floods, earthquakes, storms, or droughts (Primack 1993).

In general, populations of organisms need 50 individuals to avoid inbreeding depression (Franklin 1980), 500 individuals to avoid long-term loss of genetic variation (Franklin 1980, Lande and Barrowclough 1987), and 5,000 individuals to maintain potentially adaptive variation for the long term (Lande 1995). Various studies have investigated the minimum number of salmonids necessary to avoid the high risk of extinction associated with small populations. Allendorf et al. (1997) concluded that salmon populations below 2,500 individuals are at a high risk of extinction, and salmon populations below 250 are at an even greater risk. Given the current low population estimates of Chinook and coho salmon, Mattole Basin salmon populations are likely at a high risk of extinction.

MSG has also conducted downstream migrant trapping in the lower mainstem Mattole near Mill Creek, at RM 2.9, in the spring and early summer to monitor the timing of down-migration and to document the size of emigrating salmonid juveniles since 1985. The number of fish caught cannot be construed as a fish population estimate because of unknown trap efficiency and avoidance of the trap by fish at high flows. Data from 1995-2001 indicate that the majority of salmonids trapped were steelhead trout, followed by Chinook salmon and coho salmon (Figure 40 and Figure 41).

MSG started another downstream migrant trap on Bear Creek 300 ft upstream from its confluence with the Mattole River in 1997. The confluence of Bear Creek and the Mattole River is at RM 42.8. Data from the trap on Bear Creek also show that more steelhead trout are caught than Chinook salmon and coho salmon (Figure 42 and Figure 43). A third fish trap was placed on the mainstem Mattole River at Ettersburg in 2001 (RM 42.9). This trap caught 1,923 Chinook salmon, 6 coho salmon, 4,863 young-of-the-year steelhead trout, 541 steelhead trout 1+, and 33 steelhead trout smolts.

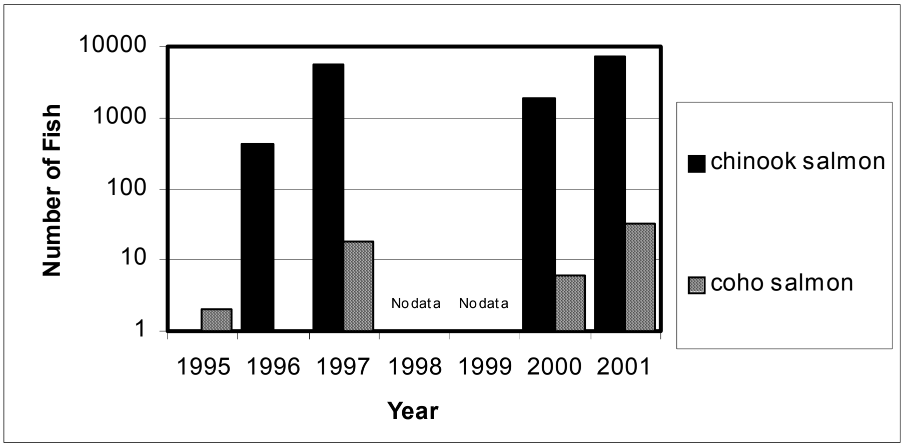

Figure 40. Outmigrant salmon trapped at Mill Creek (RM 2.9) from 1995-2001.
Data provided by the Mattole Salmon Group.

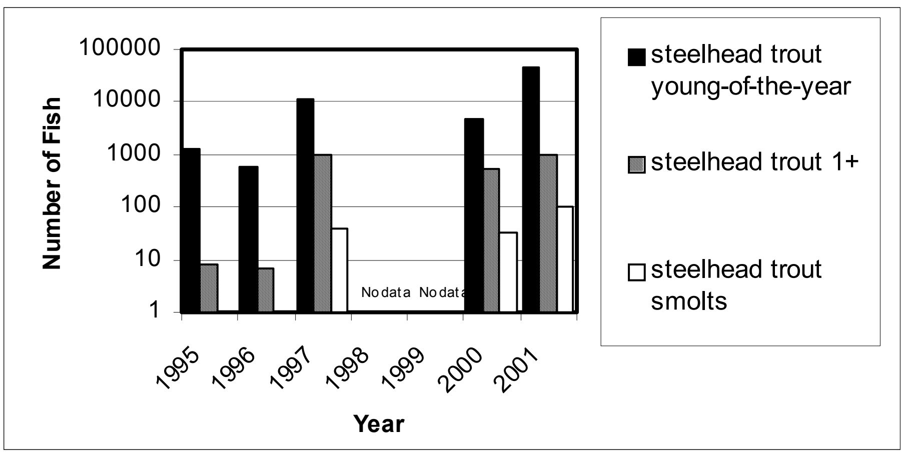

Figure 41. Outmigrant steelhead trout trapped by the Mattole Salmon Group
Spring and Early Summer in the Mattole River Near Mill Creek (RM 2.9) from 1995-2001
Steelhead were separated into young-of-the-year, 1+, and smolts. Data provided by the Mattole Salmon Group.

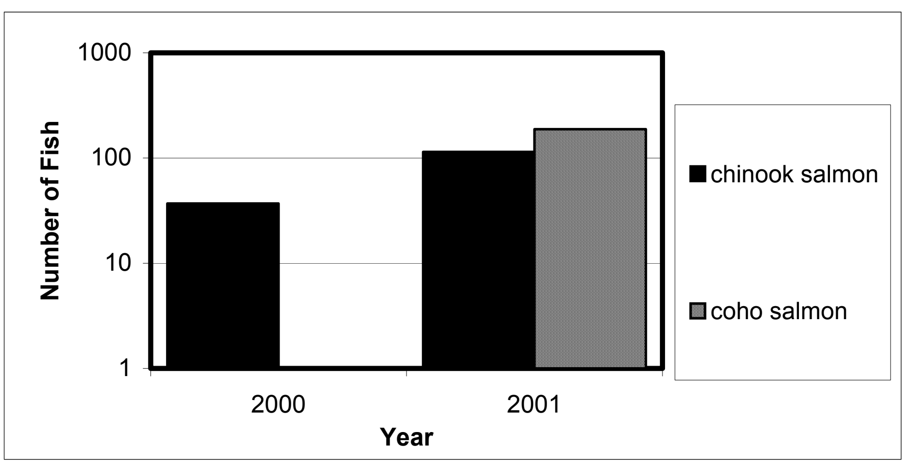

Figure 42. Outmigrant Chinook and coho salmon trapped by the Mattole Salmon Group.

Spring and Early Summer in Bear Creek 300 Ft From its Confluence with the Mattole River from 2000-2001. Data provided by the Mattole Salmon Group

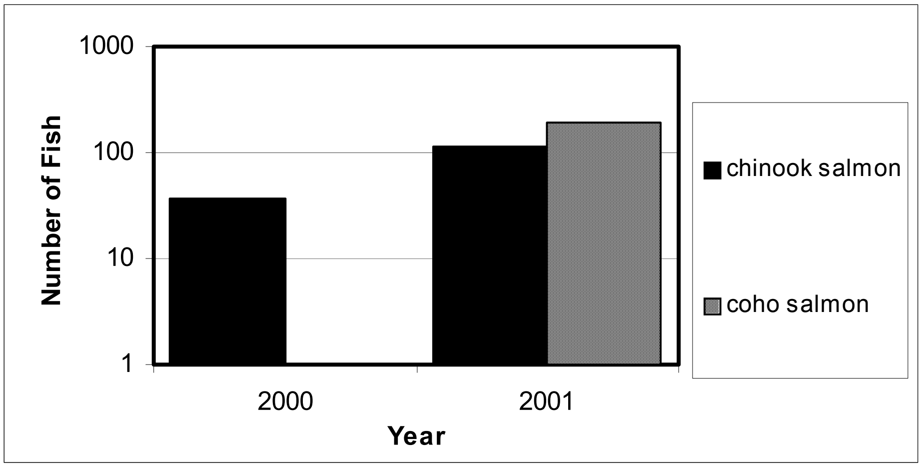

Figure 43. Outmigrant steelhead trout trapped by the Mattole Salmon Group.

Spring and early summer in Bear Creek, 300 feet from it confluence with the Mattole River from 2000-2001. Steelhead were separated into young-of-the-year, 1+, and smolts. Data provided by the Mattole Salmon Group.

MSG maintains and enhances the native fall-run Chinook salmon and coho salmon in the Mattole Basin through a hatchbox program and a rescue-rearing program. The goal of these programs is to restore native salmon runs to self-sustaining levels that can be maintained without artificial propagation or other significant human intervention. MSG is part of the CDFG Cooperative Fish Rearing Project.

Beginning in 1981, MSG has trapped wild adult Chinook and coho salmon in the Mattole Basin for use as broodstock. Eggs are obtained from females and fertilized. Fertilized eggs are incubated in hatchboxes. After hatching, fry are reared for 6 weeks before release. Over 350,000 hatchbox fish had been released by 1999 (Figure 44). All artificially propagated fish are marked, in order to provide estimates of hatchery-to-wild ratios. Adult trapping data from 1995 to 1999 suggest an overall hatchery-to-wild ratio of 1:10, and spawning ground surveys over the same time period suggest a hatchery-to-wild ratio of 1:33.

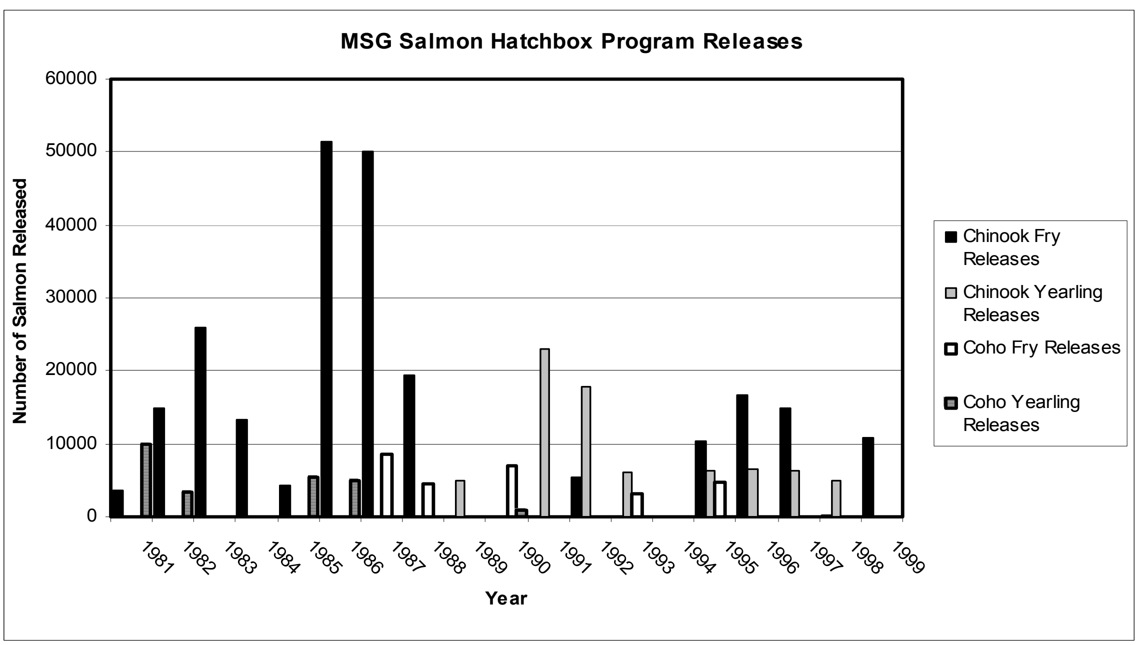

Figure 44. Mattole Salmon Group hatchbox program salmon releases from 1981-1999.

Data provided by the Mattole Salmon Group.

For the past several years in May and June, MSG has also trapped Chinook outmigrants just upstream of the estuary. Extensive studies from 1985-92, led by Humboldt State University, found that Chinook juveniles were suffering lethal impacts during summer rearing in the estuary. Therefore, MSG project personnel and volunteers net up to 6,000 naturally spawned outmigrant juvenile Chinook salmon each year and hold them in rearing ponds at Mill Creek. Volunteers rear the fish until water temperatures drop and/or the lagoon opens to the sea with fall rains. The combined number of Chinook salmon released from the MSG's hatchbox rearing program and their rescue-rearing program since 1981 is approximately 400,000.

Fishing Interests, Constituents

Historically, during the winter months sport fishing for salmon and steelhead has drawn anglers from throughout California and other states to the Mattole River, which has been an important contributor to both sport and commercial marine fisheries. Due to declining populations, Chinook and coho salmon, and steelhead are currently listed as threatened under the federal Endangered Species Act. The threatened status now restricts river sport fishing on Mattole Basin stocks. The Mattole Estuary, from the river mouth to 200 yards upstream, is closed to fishing all year. The winter salmon and steelhead fishery of the Mattole River is managed as a catch and release fishery from January 1 to March 31. Only artificial lures with barbless hooks may be used. This area consists of the Mattole mainstem from a point 200 yards upstream of the mouth to the confluence with Honeydew Creek. Additionally, the Mattole River mainstem from the confluence with Stansberry Creek to the confluence with Honeydew Creek is open from the fourth Saturday in May through August 31, for catch and release fishing using only artificial lures with barbless hooks.

The Mattole River is also subject to low-flow restrictions. From October 1 through January 31, the mainstem Mattole River from the mouth to Honeydew Creek shall be closed to all angling from Tuesday through Thursday when the flow on the previous Monday morning is less than 320 cfs at the Petrolia Bridge gauging station. Additionally, the river shall be closed to all angling from Friday through Monday when the flow on the previous Thursday morning falls below 320 cfs at the Petrolia Bridge gauging station.

These regulations were adapted from Department of Fish and Game's 2002 Freshwater Sport Fishing Regulations Booklet and are in effect March 1, 2002 through February 28, 2003. They are not presented here for use as official, current information. Anglers must rely upon the latest regulations booklet for official, current information. These are available free from:

Department of Fish and Game
Northern California & North Coast Region
619 Second Street
Eureka, CA 95501
(707) 445-6493

Fish Restoration Programs

Local watershed groups, the BLM, various state agencies such as CDFG, and local landowners have worked on numerous restoration projects throughout the Mattole Basin. The Mattole Restoration Council (MRC) and the Mattole Salmon Group (MSG) have obtained contracts for work on such diverse areas of restoration as stream surveys, road assessment, revegetation, instream habitat improvement, fish rearing, public education, and monitoring.

Stream surveys provide basic information about a stream and identify salmonid habitat problems. Examples of stream surveys done in the Mattole Basin include spawning surveys, habitat typing and channel typing surveys, and large woody debris surveys. Many of these surveys are conducted or funded by CDFG and BLM.

Road assessments help identify current and potential sources of erosion related to roads. One current road assessment project in the Mattole Basin is a Department of Water Resources funded assessment of roads in the Eastern Subbasin. CDFG is also funding erosion assessments in the Eastern Subbasin.

Revegetation is important both in riparian areas, to stabilize stream banks, provide cover for salmonids, and provide shade; and in upslope areas, to help stabilize hillslopes. Examples of revegetation activities in the Mattole Basin include tree planting in the Middle Creek headwaters in 1996 funded by Sunlaw

Cogeneration Partners, lower Mattole Basin riparian reforestation funded by CDFG in 1996, and willow planting in the estuary funded by CDFG in 1993.

The addition of instream improvement structures to a stream deficient in habitat diversity and complexity can provide escape and ambush cover needed by salmonids. These projects are most effective in watersheds in good health. The Mattole Salmon Group has added instream structures to the Mattole headwaters, the mainstem Mattole River, and various tributaries since 1980 with funding from CDFG.

Fish rearing projects can be a way to supplement salmonid populations before habitat restoration activities can improve conditions. Beginning in 1981, MSG has trapped and raised native Chinook and coho salmon in the Mattole Basin on a limited basis. In the upper reaches of the river system, the group has used hatch boxes placed instream to incubate fertilized eggs taken from locally trapped Chinook and coho broodstock. Extensive studies from 1985-92, led by Humboldt State University, found that Chinook juveniles were suffering lethal impacts during summer rearing in the estuary. For the past several years in May and June, the group has also trapped Chinook downstream migrants just upstream of the estuary / lagoon. Due to a combination of watershed factors, the estuary outlet closes in June or July in most years, preventing smolts from escaping very warm to lethal freshwater temperatures into the relative safety of the ocean. Project personnel and volunteers net up to 6,000 naturally spawned downstream Chinook migrants each year and then hold them in rearing ponds at Mill Creek (RM 2.8). Volunteers rear the fish until they are released to the estuary when river stream temperatures drop and/or the lagoon opens to the sea with fall rains. In the 14 years between 1981 and 1995, 338,000 Chinook salmon and 52,550 coho salmon have been released between the program's upstream and estuarine operations.

Public education programs are effective in expanding awareness about day-to-day activities that impact a watershed. Two important public education campaigns in the Mattole Basin are the MRC's *Good Roads, Clear Creeks* initiative, and the Mattole Salmon Group's campaign to encourage water conservation.

Stream monitoring is important for restoration work in the same way that stream surveys are important; however, monitoring also allows restoration workers to study stream conditions over time. USGS sponsored sediment sampling at the Petrolia Bridge by MSG since 2000 is an example of a monitoring program in the Mattole Basin.

For more information about the extent of restoration projects throughout the Mattole Basin, please see the CDFG Appendix F.

Special Status Species

Ten plant and animal species in the Mattole Basin have been found to have declining populations across their ranges and thus warrant special concern (Table 23). 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 F.

Table 23. Special status species of the Mattole Basin.

Major Group	Name	Scientific Name	Federal Listing	State Listing
Plants	Beach layia	*Layia carnosa*	Endangered	Endangered
	Leafy reed grass	*Calamagrostis foliosa*	None	Rare
Fish	Coho salmon	*Oncorhynchus kisutch*	Threatened	Threatened
	Chinook salmon	*Oncorhynchus tshawytscha*	Threatened	None
	Steelhead trout	*Oncorhynchus mykiss*	Threatened	None
Amphibians	Foothill yellow-legged frog	*Rana boylii*	Species of concern	Species of special concern
	Tailed frog	*Ascaphus truei*	Species of concern	Species of special concern
	Southern torrent salamander	*Rhyocotriton variegatus*	None	Species of special concern
Birds	Northern spotted owl	*Strix occidentalis caurina*	Threatened	None
	Marbled murrelet	*Brachyramphus marmoratus*	Threatened	Endangered

Amphibians of Interest

Southern torrent salamanders (*Rhyacotriton variegates*) and tailed frogs (*Ascaphus truei*) are two of the many amphibian species that inhabit the Mattole Basin. Like coho salmon, these two amphibians are sensitive to temperature and sediment. However, they live in small, lower order streams, upstream from coho salmon habitat. Therefore, torrent salamander and tailed frog populations can serve as indicators of environmental stressors such as increased water temperature and excessive fine sediment (Welsh and Ollivier 1998), which are also potential habitat problems for coho salmon.

Welsh et al. (2002) conducted a study to determine the linkages between landscape processes and torrent salamanders and tailed frogs in the Mattole Basin. They surveyed 49 stream reaches for amphibians from 1994-1996, eleven in the Northern Subbasin, six in the Eastern Subbasin, 15 in the Southern Subbasin, and 17 in the Western Subbasin (Figure 45). Torrent salamanders were found in eleven stream reaches and tailed frogs were found in15 stream reaches (Figure 46).

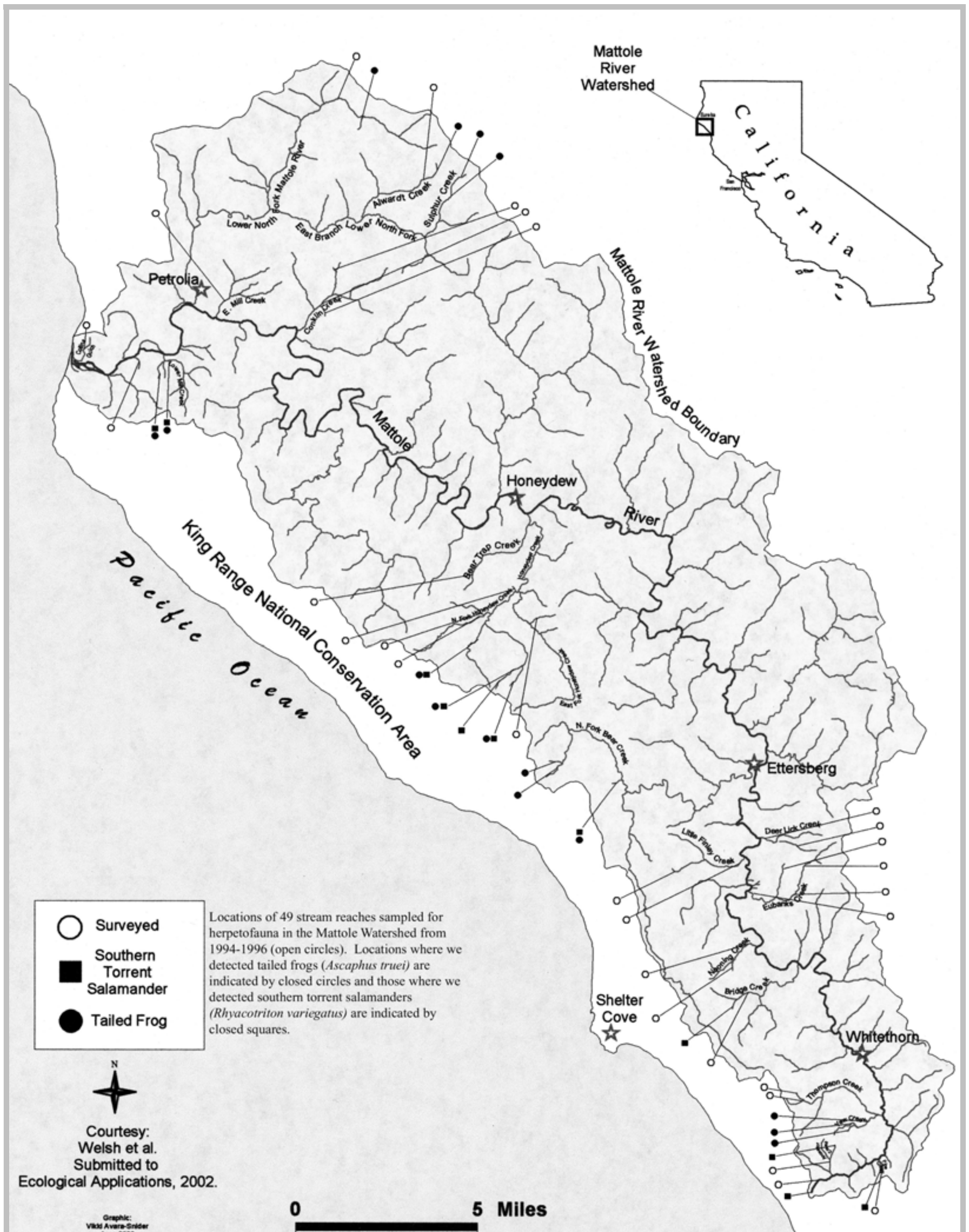

Figure 45. Amphibian survey (Welsh et al. 2002).

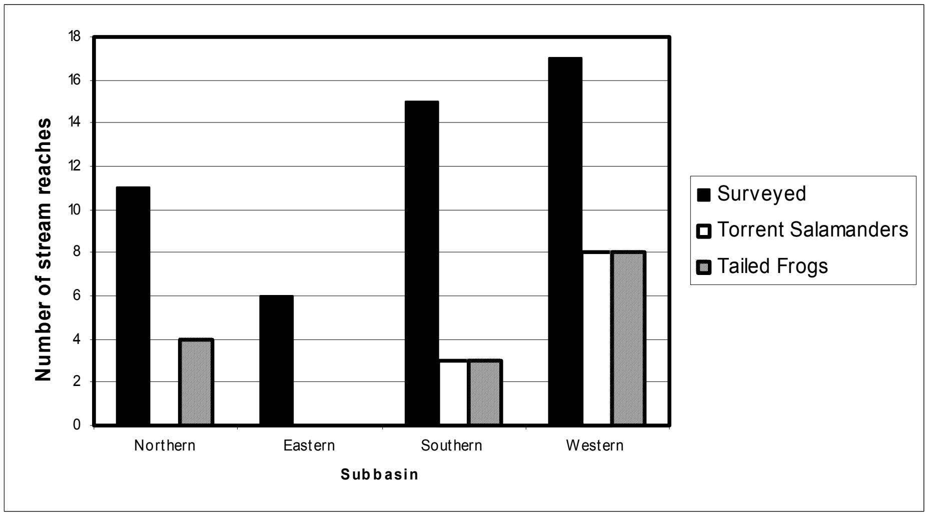

Figure 46. The number of surveyed stream reaches containing torrent salamanders and tailed frogs in each subbasin of the Mattole Basin (Data from Welsh et al. 2002).

No torrent salamanders were found in Northern Subbasin surveyed stream reaches, while tailed frogs were found in four reaches. Neither species of amphibian was found in surveyed stream reaches in the Eastern Subbasin. The Southern Subbasin had torrent salamanders in three surveyed stream reaches and tailed frogs in three additional surveyed stream reaches. The Western Subbasin also had occurrences of both torrent salamanders and tailed frogs. Five surveyed stream reaches contained both species of amphibian, two reaches only contained torrent salamanders, and two reaches only contained tailed frogs.

The high number of surveyed stream reaches in the Western Subbasin with torrent salamanders and tailed frogs could be an indication of good habitat conditions for coho salmon in this subbasin. These amphibians were found in headwaters reaches of the North Fork of Bear Creek, the West Fork of Honeydew Creek, and Mill Creek (RM 2.8). In fact, coho salmon have been found in downstream reaches of these streams by CDFG stream inventories, the 2001 CDFG Coho Inventory, CDFG electro-fishing, and/or Welsh et al. (2001). Similarly, coho salmon have been found downstream from headwaters reaches of the Mattole River, Yew Creek, and upper Mill Creek (RM 56.2), where torrent salamanders or tailed frogs were detected in the Southern Subbasin.

When the occurrence of torrent salamanders and tailed frogs in stream reaches was examined in terms of the seral stage of the stream canopy, torrent salamanders and tailed frogs were abundant in late seral forests, less common in second growth forest habitats, and not found in mixed forest/grassland ecosystems in the Mattole Basin (Figure 47).

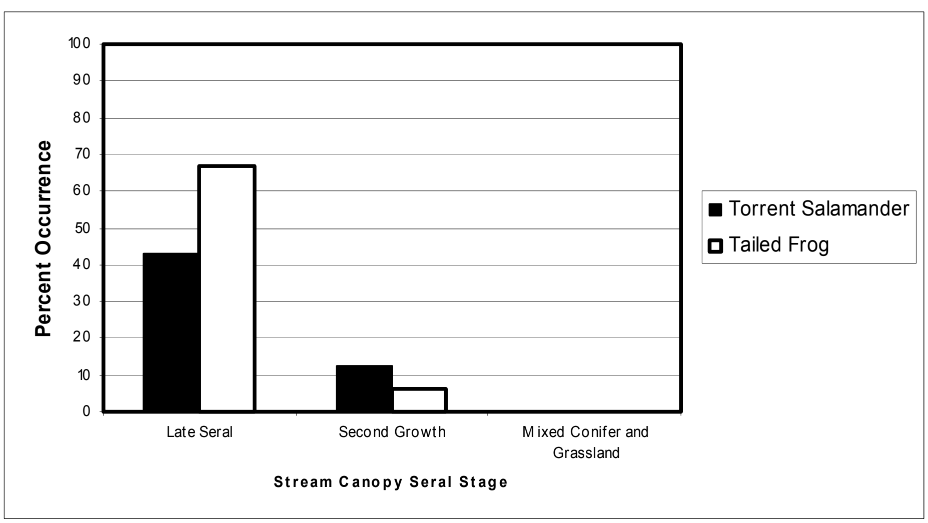

Figure 47. Percent occurrence of torrent salamanders and tailed frogs.
In Stream Reaches with Late Seral, Second Growth, and Mixed Conifer and Grassland Canopy in Surveyed Stream Reaches in the Mattole Basin (data from Welsh et al. 2002).

Mattole Synthesis

Integrated Analysis

The following tables provide a dynamic, spatial picture of watershed conditions for the freshwater lifestages salmon and steelhead. The tables' fields are organized to show the extent of watershed factors' conditions and their importance of function in the overall watershed dynamic. Finally a comment is presented on the impact or condition affected by the factor on the watershed, stream, or fishery. Especially at the tributary and subbasin levels, the dynamic, spatial nature of these processes provides a synthesis of the watershed conditions and indicates the quantity and quality of the freshwater habitat for salmon and steelhead.

Geology

Introduction

The potential for sediment production is strongly influenced by the underlying geology. The following IA tables compiled by CGS examine the influence of geology on sediment production by comparing the distribution of geomorphic terrains (hard, moderate, and soft bedrock terrains, and the separately grouped Quaternary surficial deposits) against the observation of landslides and geomorphic features related to mass wasting within the basin. Table 24 presents the proportions of the basin underlain by each of the terrains. Table 25 looks at hillside gradient, which is influenced by the type of underlying terrain and, in turn, has a variable influence on slope stability within the different terrains. Table 26 looks at distribution of small landslides (historically active and dormant), gullies, and inner gorges by terrain are then considered.

Table 24. Geomorphic terrains as a proportion of Mattole Basin.

Proportion of Mattole River Basin Underlain by the Different Geomorphic Terrains			
Feature/Function		Significance	Comments
Terrain Type	Proportion of basin Area	The geomorphic terrains represent groupings of geologic map units based on similarities in geology, geomorphic expression, and landslide occurrence. They provide a simplified division of the watershed useful in comparing the influence of bedrock geology to the distribution of other mapped features.	Soft terrain, where landslides and gully erosion are most abundant, is concentrated in the Northern Subbasin, and scattered through the Eastern and Western Subbasins. Quaternary units (primarily alluvium) occupy only a minor portion of the basin and are concentrated along valley bottoms.
Hard	40%		
Moderate	28%		
Soft	25%		
Quaternary[1]	7%		

1 Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, terrace deposits, active stream channel deposits, and other alluvial deposits.

Table 25. Hillside gradient by geomorphic terrain in the Mattole Basin.

Hillside Gradient by Geomorphic Terrain in the Mattole Basin								
Feature/Function							Significance	Comments
Terrain Type	Percentage of Watershed Area							
	Range in % slope							
	0-10	10-30	30-40	40-50	50-65	>65	Hillside slope is an important indicator of potential instability (steeper is generally less stable). The terrain type influences the degree to which hillside slope affects the slope stability.	High rates of tectonic uplift in the region are reflected in the rugged topography and relative abundance of steep to very steep slopes in the watershed. Steeper slopes are typically found in the hard, and to a lesser degree moderate terrains. More gentle slopes predominate in the soft terrain, as it is typically less able to support development of steep slopes without failing.
Hard	1	4	5	7	11	11		
Moderate	<1	5	6	6	7	5		
Soft	1	6	7	5	4	2		
Quaternary	4	3	<1	0	0	<1		
Total	6	18	18	18	22	18		

Table 26. Small historically-active landslides by terrain.

Distribution of Small Historically-Active Landslides by Terrain in the Mattole Basin				
Feature/Function			Significance	Comments
Terrain Type	Small Point Landslides[1] Mapped from year 1981[2], 1984, or 2000 Photographs			
	Point Count	Area[3] (acres)	The relative number of small point slides is used to evaluate which geomorphic terrains are more prone to small, localized slope failures.	The majority of small-localized failures occur in the hard and moderate terrains; these failures consist primarily of shallow debris slides associated with steep slopes. Significant portions of small failures in the soft terrain on less steep slopes are earthflows.
Hard	2,355	233		
Moderate	1,900	188		
Soft	1,346	133		
Quaternary	41	4		

1 Mapping was compiled at a 1:24,000 scale. Landslides smaller than approximately 100 feet in diameter were captured as points in the GIS database; larger features were captured as polygons.
2 Landslides included from year 1981 photographs are from previous mapping by Spittler (1983 and 1984) covering limited portions of the Mattole Basin.
3 Based on assumed average area of 400 square meters (roughly 1/10th acre) for small landslides.

Table 27. All historically-active landslides by terrain in the Mattole Basin.

Distribution of All Historically-Active Landslides by Terrain in the Mattole Basin				
Feature/Function			Significance	Comments
Terrain Type	Combined Area (acres) of All Historically-Active Landslides[1]	Proportion of Total Active Landslide Area within Basin	The relative percentage of area covered by historically-active slides identifies which geomorphic terrains are most prone to slope failures.	The soft terrain, despite underlying a smaller proportion of basin area and having relatively more gentle slopes, contains the majority of the area occupied by historically-active landslides. Most of the larger slope failures in the soft terrain are earthflows.
Hard	1,921	19%		
Moderate	2,553	25%		
Soft	5,586	55%		
Quaternary	69	1%		

1 Includes small point and larger polygon features mapped from year 1981, 1984 and 2000 photos. Where landslides overlapped (i.e., the same or similar features mapped from more than one photo set) the area of overlap was counted only once. Small landslides captured as points in the GIS database were assumed to have an average area of 400 square meters (roughly 1/10th acre).

Table 28. Distribution of dormant landslides by terrain in the Mattole Basin.

Distribution of Dormant Landslides by Terrain in the Mattole Basin				
Feature/Function			Significance	Comments
Terrain Type	Combined Area (acres) of All Dormant Landslides[1]	Proportion of Total Dormant Landslide Area within Basin	The relative percentage of area covered by dormant landslides identifies which geomorphic terrains have been most prone to the larger, more deep-seated types of slope failures.	The area of dormant landslides is somewhat more evenly distributed between soft and moderate terrains than are active landslides; however, the soft terrain is still substantially over represented when considering its smaller size. Over 85% of dormant landslides are rock slides, with the remainder being earthflows. Over half of the earthflows are found in soft terrain.
Hard	6,338	18%		
Moderate	12,276	35%		
Soft	16,145	46%		
Quaternary	238	1%		

1 Includes features mapped from year 1981, 1984, and 2000 photos. Where landslides overlapped (i.e., the same or similar features mapped from more than one photo set) the area of overlap was counted only once.

Table 29. Gullies and inner gorges by terrain in the Mattole Basin.

Distribution of Gullies and Inner Gorges by Terrain in the Mattole Basin				
Feature/Function			Significance	Comments
Terrain Type	Proportion of Total Mapped Gully Lengths[1] in Basin	Proportion of Total Mapped Inner Gorge Lengths[1] in Basin	Gullies and inner gorges are an important indicator of ongoing sources of sediment to the fluvial system.	The large majority of mapped gullies are located in soft terrain; gully erosion is a significant, on-going contributor of sediment load from soft terrain areas. Roughly half of all inner gorges were identified in hard terrain; inner gorges act as sediment source areas primarily through debris sliding.
Hard	5%	51%		
Moderate	11%	29%		
Soft	81%	18%		
Quaternary	3%	2%		

[1] Includes only those features mapped from year 2000 photographs.

Table 30. Landslide potential by terrain on of Mattole Basin.

Distribution of Landslide Potential Categories by Terrain as a Proportion of the Total Mattole Basin							
Feature/Function						Significance	Comments
Terrain Type	Landslide Potential Category[1]						
	1	2	3	4	5		
Hard	0.2%	6.5%	15.6%	6.2%	11.2%	Categories 4 and 5 represent the majority of unstable areas that are current or potential future sources of sediment.	Unstable soft terrain is disproportionably represented because of its inherent instability (over 4/5 of soft terrain is in LPM Category 4 and 5). Hard terrain has the largest proportion of area, steep slopes, and small slides in basin, yet has the lowest proportion of basin area occupied by LPM Category 4 and 5. Moderate terrain has an intermediate proportion of LPM Category 4 and 5, consistent with its intermediate nature of all slope related categories.
Moderate	0.2%	2.7%	13.8%	6.1%	5.7%		
Soft	0%	0.4%	4.3%	11.0%	9.0%		
Quaternary	4.0%	2.2%	0.6%	0.1%	0.3%		
Basin Total[2]	4.4%	11.8%	34.3%	23.4%	26.2%		

1 Categories represent ranges in estimated landslide potential, from very low (category 1) to very high (category 5); see Geologic Report, Plate 2.
2 Percentages are rounded to nearest 1/10 %; sum does not equal 100% due to rounding.

Discussion

As highlighted in the tables, areas of sediment production associated with landslides and gullies are concentrated in the soft terrain. Although soft terrain has more gentle slopes and occupies only 25% of the basin, over half of the area occupied by historically active landslides and over 80% of the total gully lengths observed in the basin are located in soft terrain. In addition, over 80% of the soft terrain falls into Landslide Potential Categories 4 or 5 (high or very high). Landslides in hard terrain, and to a lesser degree moderate terrain, are predominantly small debris slides associated with sleep slopes or inner gorges. In contrast, landslides in soft terrain include a significant proportion of larger earthflows on gentler slopes and more deep-seated rock slides.

Vegetation and Land Use

Introduction

CDF NCWAP developed a number of tables that are intended to help identify and highlight how current patterns of vegetation and land use are expressed in relation to the geology of the watershed. First, vegetation and land use are related to the underlying bedrock geology or terrain type. These patterns are then explored by examining the current vegetation and recent timber harvesting in relation to their occurrence in landslide potential classes, the product of a model that uses terrain type, vegetation, and landslides as variables. Landslide causality was not assigned and recent timber harvest activity has occurred in low percentages in most of the planning watersheds. The significance of the geologic characteristics in these tables is expressed as a relative rating and is not characterized numerically.

Table 31. Vegetation types associated with terrain types in the Mattole Basin.

Vegetative Condition in the Mattole Basin								
Feature/Function							Significance	Comments
Terrain Type	Vegetation Type							
	Conifer	Mixed	Hardwood	Grassland	Other	Total		
Hard	10%	68%	19%	3%	<1%	100%	The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use.	Basin-wide, 64 % of the grassland vegetation type is present on soft terrain. Grazing practices should consider the susceptibility of the soft terrain to surface erosion. Timber harvesting impacts in soft terrain may be higher risk than the THP required estimated surface soil erosion hazard rating (EHR) worksheet may indicate.
Moderate	10%	66%	15%	8%	1%	100%		
Soft	5%	38%	16%	38%	3%	100%		
Quaternary	3%	26%	13%	33%	25%	100%		

Table 32. Riparian (within 150 feet of streams) vegetation types associated with terrain types in the Mattole Basin.

<table>
<tr><th colspan="10">Riparian Vegetative Condition in the Mattole Basin</th></tr>
<tr><th colspan="8">Feature/Function</th><th>Significance</th><th>Comments</th></tr>
<tr><th rowspan="2">Terrain Type</th><th colspan="7">Riparian Vegetation Type</th><td rowspan="6">The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use. The riparian vegetation in this zone is the primary source of large woody debris. The species and size of large woody debris provided to the stream system over time is at least partially dependent upon the inherent slope stability of the underlying terrain type.</td><td rowspan="6">Riparian vegetation is in tree-type vegetation at a proportionately higher percentage than the overall subbasin landscape. Vegetation removal impacts in riparian soft terrain should consider the heightened susceptibility of soft terrain to gullying. The large percentage of barren ground in the quaternary terrain type includes areas of expansive stream channel.</td></tr>
<tr><th>Conifer</th><th>Mixed</th><th>Hardwood</th><th>Grassland</th><th>Barren</th><th>Other</th><th>Total</th></tr>
<tr><th>Hard</th><td>15%</td><td>70%</td><td>13%</td><td>1%</td><td>1%</td><td><1%</td><td>100 %</td></tr>
<tr><th>Moderate</th><td>12%</td><td>71%</td><td>13%</td><td>2%</td><td>1%</td><td>1%</td><td>100 %</td></tr>
<tr><th>Soft</th><td>7%</td><td>55%</td><td>21%</td><td>14%</td><td>1%</td><td>2%</td><td>100 %</td></tr>
<tr><th>Quaternary</th><td>4%</td><td>34%</td><td>15%</td><td>13%</td><td>27%</td><td>7%</td><td>100 %</td></tr>
</table>

Table 33. Land use associated with terrain types in the Mattole Basin.

<table>
<tr><th colspan="7">Land Use in the Mattole Basin</th></tr>
<tr><th colspan="5">Feature/Function</th><th>Significance</th><th>Comments</th></tr>
<tr><th rowspan="2">Terrain Type</th><th colspan="4">Landuse Type</th><td rowspan="6">The Public category consists mostly of the King Range National Conservation Area managed by the Bureau of Land Management, other parcels managed by BLM, and State Parks. The Agriculture/Timber category includes virtually all the grassland shown on the CalVeg 2000 data layer, and parcels that contain TPZ and timber as part of their zoning designation. The Other category contains parcels zoned unclassified or forest recreation (Humboldt Co.), and forest lands (Mendocino Co.). The Other category often includes housing and contains many parcels 160 acres or less in size.</td><td rowspan="6">Historic logging occurred across all ownership types, leaving a legacy of young vegetation and dirt-surfaced roads. Public lands within the Mattole are reserved for recreation and conservation. The primary economic use of the natural resources on private land is grazing and timber harvesting. While grazing is widespread, only 5% of the watershed has been harvested since 1990. Many of the current owners simply live on their property and do not derive substantial economic benefits from the land. Despite this, many residents are interested in restoration work if funding and assistance is provided.</td></tr>
<tr><th>Public</th><th>Ag/Timber</th><th>Other</th><th>Total</th></tr>
<tr><th>Hard</th><td>30%</td><td>49%</td><td>21%</td><td>100%</td></tr>
<tr><th>Moderate</th><td>13%</td><td>65%</td><td>22%</td><td>100%</td></tr>
<tr><th>Soft</th><td>4%</td><td>83%</td><td>13%</td><td>100%</td></tr>
<tr><th>Quaternary</th><td>10%</td><td>58%</td><td>32%</td><td>100%</td></tr>
</table>

Table 34. Road mileage and density associated with terrain types in the Mattole Basin.

<table>
<tr><th colspan="5">Roads in the Mattole Basin</th></tr>
<tr><th colspan="3">Feature/Function</th><th>Significance</th><th>Comments</th></tr>
<tr><th>Terrain Type</th><th>Miles (of road)</th><th>Road Density (miles per sq. mile)</th><td rowspan="6">Roads crossings on steep slopes in hard and moderate terrain may increase the potential for debris slides while roads within the soft terrain may increase the potential for small earthflows, gullies, and erosion. The alluvium terrain type tends to be relatively flat, but proximity to watercourses may allow for direct delivery of sediment from the roads to the streams.</td><td rowspan="6">While current practices locate roads on less environmentally sensitive locations, typically gentle ground high on the hillslope, the presence of soft terrain in these areas should be considered. A large, but not quantified, portion of the road mileage was constructed for logging purposes between about 1945 and 1974. While many of these roads are no longer in use, others are used as residential and parcel access roads</td></tr>
<tr><th>Hard</th><td>463</td><td>3.8</td></tr>
<tr><th>Moderate</th><td>341</td><td>4.0</td></tr>
<tr><th>Soft</th><td>305</td><td>4.1</td></tr>
<tr><th>Quaternary</th><td>154</td><td>8.3</td></tr>
<tr><th>Total</th><td>1,263</td><td>4.2</td></tr>
</table>

Table 35. Data summary table for the Mattole Basin.

Factor	Mattole Basin	
Timber Harvest 1990 -2000[1]	**Acres**	**% Area**
Silviculture Category 1		
Tractor	**1,166**	**0.6%**
Cable	**1,578**	**0.8%**
Helicopter	**285**	**0.2%**
TOTAL	**3,029**	**1.6%**
Silviculture Category 2		
Tractor	**1,571**	**0.8%**
Cable	**483**	**0.3%**
Helicopter	**30**	**0.0%**
TOTAL	**2,083**	**1.1%**
Silviculture Category 3		
Tractor	**1,270**	**0.7%**
Cable	**510**	**0.3%**
Helicopter	**268**	**0.1%**
TOTAL	**2,049**	**1.1%**
TOTAL	**7,161**	**3.8%**
Other Land Uses		
Grazing	**23,332**	**12.3%**
Agriculture	**990**	**0.5%**
Development	**34**	**0.0%**
Timberland, No Recent Harvest	**140,910**	**74.3%**
TOTAL	**165,266**	**87.2%**
Roads		
Road Density (miles/sq. mile)	**4.2**	
Density of Road Crossings (#/stream mile)	**0.6**	
Roads within 200 feet of Stream (miles/stream mile)	**0.1**	

Silvicultural Category 1 includes even-aged regeneration prescriptions: clear-cut, rehabilitation, seed tree step, and shelter wood seed step prescriptions. Category 2 includes prescriptions that remove most of the largest trees: shelter wood prep step, shelter wood removal step, and alternative prescriptions. Category 3 includes prescriptions that leave large amounts of vegetation after harvest: selection, commercial thin, sanitation salvage, transition, and seed tree removal step prescriptions.

Table 36. Land use and vegetation type associated with historically active landslides in the Mattole Basin.

Historically Active Landslide Feature[1]	Mattole Basin	Woodland and Grassland[2]	THPs 1990 - 2000[5]	Timberland, No Recent Harvest[3]	Roads[4]	
	% of Area	% of Area	% of Area	% of Area	Length (miles)	% of Total Length
Earthflow	2.6%	1.7%	0.1%	0.7%	27.5	2.2%
Rock Slide	0.4%	0.2%	0.0%	0.2%	6.0	0.5%
Debris Slide	2.0%	0.2%	0.1%	1.6%	14.9	1.2%
Debris Flow	0.0%	0.0%	0.0%	0.0%	0.3	0.0%
All Features	**5.0%**	**2.2%**	**0.1%**	**2.6%**	**48.7**	**3.9%**
The area occupied by slides is almost evenly divided between the timberland and woodland/grassland categories even though the timberland acreage combined is four times larger. Earthflows are the most significant type of slide in the woodland/grassland while debris slides occupy the majority of the slide acreage in the timberland vegetation type. Recent THPs occupy 4% percent of the basin acreage and have a low percentage of the slide acreage in their boundaries.						

1 This category includes only large polygon slides and does not include point slides.
2 Woodland and grassland includes areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Table 37. Land use and vegetation type associated with relative landslide potential in the Mattole Basin.

Relative Landslide Potential[1]	Mattole Basin	Woodland or Grassland[2]	THPs 1990 - 2000[5]	Timberland, No Recent Harvest[3]	Roads[4]	
	% of Area	% of Area	% of Area	% of Area	Length (miles)	% of Total Length
Very Low	4.4%	1.7%	0.1%	1.3%	82.4	6.7%
Low	11.8%	1.9%	0.7%	8.9%	185.9	15.0%
Moderate	34.3%	4.6%	1.4%	28.1%	455.5	36.8%
High	23.4%	6.0%	0.9%	16.2%	271.9	22.0%
Very High	26.2%	5.2%	0.7%	19.8%	239.4	19.4%
TOTAL	**100%**	**19%**	**4%**	**74%**	**1,235.1**	**100%**
Half of the Mattole Basin acreage is in the high and very high relative landslide potential categories. Recent THPs covered 4% of the basin and 40% of the harvest acres were in the two highest relative landslide potential classes. Since half of the basin is in the high and very high relative landslide potential classes well-distributed across the landscape, it is not surprising to find that THPs also contain a high percentage of acreage in these same categories. The Mattole Basin has about 1,235 miles of roads, with the proportion of road length in relative landslide potential categories similar to the percentage of total acres in each class, although there is a slight shift towards lower relative landslide potential classes.						

1 Refer to Plate 2 and California Geological Survey Appendix A.
2 Woodland and grassland include areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Discussion

The Mattole Basin as a whole has had widespread grazing on its grasslands and limited timber harvesting since 1990. While Mattole timber harvest plans have incorporated a zero net sediment discharge analysis since about 1994, only 4% of the basin was harvested between 1990 and 2000, almost entirely by industrial timberland owners. Of the harvest acres in the high or very high relative landslide potential categories, about 40% was harvested by even-aged regeneration silvicultural systems and 40% was tractor logged. It should be noted that although these landslide potential categories are part of a classification system that is not equivalent to the THP potential surface erosion hazard rating (EHR), both quantify potential sediment movement, although by different processes. The current Forest Practice Rules do not have a methodology for characterizing relative landslide potential.

Other current land uses include recreation on public lands and residential occupation. The legacy of dirt-surfaced roads throughout the watershed provides a chronic source of sediment to the Mattole River. The large number of individual owners provides challenges in evaluating road condition and status. Future road relocation and transportation network efficiencies are also encumbered by the existing ownership patterns and road infrastructure. Since most of the landscape is outside current regulatory processes, the development of site-specific best management practices for grazing, road construction, and road use, especially on soft terrain, is recommended. Education and economic incentives for road improvements and livestock management provide the greatest opportunities for near-term benefits for fisheries.

Fluvial Geomorphology

Introduction

Fluvial geomorphic mapping of channel characteristics was conducted along blue line streams in the Mattole Basin to document channel characteristics that are indicative of excess sediment production, transport, and/or response (deposition); these features are referred to as negative mapped channel characteristics (NMCCs). The following CGS Integrated Analysis (IA) Tables present some of the findings of this investigation. To understand the distribution of these NMCC's we present: the predominant NMCC's identified; the relative distribution of these features between the bedrock terrains and the Quaternary units; the changes in amount and distribution of NMCC's observed between 1984 and 2000; and the relationship between areas of projected slope instability and portions of streams with evidence of excess sediment.

Table 38. Steam reach gradient in the Mattole Basin.

Stream Reach Gradient by Terrain as a Proportion of Total Blue Line Stream Length in the Mattole Basin					
Feature/Function				Significance	Comments
Terrain Type	Source (Slope >20%)	Transport (Slope 4-20%)	Response (Slope <4%)	The spatial distribution of source, transport, and response reaches governs the distribution of potential impacts and recovery times for the system. The areas of greatest susceptibility to pulses of sediment are transitions from the highest gradient reaches into a low gradient reach.	Practically all of the source and transport reaches are in the bedrock terrains. Response reaches are more common in the Quaternary alluvium. In the bedrock terrains, response reaches are typically found in the lower portions of the main tributaries to the Mattole River.
Hard	9%	15%	8%		
Moderate	7%	11%	6%		
Soft	7%	7%	4%		
Quaternary	<1%	3%	22%		
Total Basin	24%	36%	40%		

Table 39. Negative mapped channel characteristics in the Mattole Basin

Negative Mapped Channel Characteristics in the Mattole Basin						
Feature/Function					**Significance**	**Comments**
		From 1984 Photos	**From 2000 Photos**	**Change 1984 to 2000**[4]	The reduction in the total length of NMCC's over time qualitatively reflects the degree of improvements within the blue line streams. These NMCC's were chosen to be highlighted in these figures because in both photo years, the NMCC's observed were dominated by wide channels and, secondarily, by displaced riparian vegetation. Most of this observed improvement results from reductions in the proportion of streams affected by displaced riparian vegetation and wide channels.	Whereas significant reductions in the occurrence of wide channels mapped as a primary feature has occurred, many of wide channels observed as primary or secondary features in 1984 were still present in 2000.
Blue Line Streams where Wide Channel (wc) Observed		See Figure 34				
Blue Line Streams where Displaced Riparian Vegetation (dr) Observed		See Figure 35				Those portions of the fluvial system observed to be affected by displaced riparian vegetation, mapped as primary or secondary features in 1984 had recovered extensively by 2000.
% of all Blue Line Stream Segments in Basin affected by NMCC's	**Total**	36%	21%	-15%	These values identify how much of the streams have been affected by NMCC's. Decreases in the length of stream affected by NMCC's quantitatively represents the degree of improvement within blue line stream reaches.	The fluvial system in almost all of the bedrock reaches have experienced significant improvements between 1984 and 2000, but still remains impacted by NMCC's. The proportion of the Quaternary unit reaches affected by NMCC's have remained unchanged.
	Bedrock	40%	20%	-20%		
	Alluvium	23%	23%	0%		
Percentage of all NMCC's found within bedrock[1]		83%	72%	-12%	Changes in the distribution of NMCC's between 1984 and 2000 show different patterns in the bedrock and Quaternary unit reaches. Therefore, it is important to understand what portion of NMCC's occur within bedrock or Quaternary unit reaches.	The bedrock reaches have experienced significant reductions in NMCC's between 1984 and 2000, whereas the Quaternary reaches have shown no measurable improvement. When compared to the distribution of streams by terrain, NMCC's are disproportionably observed in the bedrock in 1984 and distributed evenly across the entire watershed in 2000. The values in the Change 1984 to 2000 column result from redistribution of relative percentages of NMCC's between bedrock and Quaternary unit reaches caused by the reduction in the total length of NMCC's observed in bedrock reaches. These values do not represent a significant increase in NMCC's within the Quaternary units.
Percentage of all NMCC's found within Quaternary Units[2]		17%	28%	+12%		
Percentage of all Blue Line Stream segments in bedrock that are: 1) adjacent to or within LPM Categories 4 and 5[3] **and 2), affected by NMCC's**		52%	26%	-26%	The magnitude of decrease in affected streams quantitatively represents the degree of improvement within bedrock stream reaches adjacent to unstable areas. Because the streams in the Quaternary units are commonly separated from the surrounding hillsides by alluvial terraces and floodplains, the NMCCs observed there do not directly result from input into the streams from landslides that occur on the surrounding hillsides. Therefore, NMCC's in alluvial areas have been interpreted as having been transported from upstream bedrock reaches. For this reason, the analysis of NMCC's vs. LPM 4 and 5 excludes the NMCC's identified in the Quaternary units and only describes the relationship between these two features as it applies to the bedrock reaches.	The fact that NMCC's are not ubiquitous in bedrock streams adjacent to or within LPM categories 4 and 5 indicates that although entire reaches of the streams have potentially unstable slopes above them, only a portion of those slopes have delivered or transported sediment to the streams. Whereas, between roughly one quarter (2000) to one half (1984) of all blue line streams in the bedrock terrains that are adjacent to or within LPM categories 4 and 5 are affected by NMCC's, there has been an about 26% decrease in the total length of blue line streams adjacent to or within those potentially unstable slopes and affected by NMCC's.

Negative Mapped Channel Characteristics in the Mattole Basin (Continued)					
Feature/Function				**Significance**	**Comments**
	From 1984 Photos	**From 2000 Photos**	**Change 1984 to 2000[4]**	Percentage reflects likelihood that the presence of NMCC's in bedrock are related to LPM categories 4 and 5 and that these unstable areas represent current and future potential sources of sediment to streams.	Virtually all of the total NMCC's observed in bedrock terrains were found on blue line streams adjacent to or within LPM category 4 and 5. Therefore, we interpret a clear relationship between areas of projected slope instability and portions of streams with negative sediment impacts, and that some portion of hillsides with high landslide potential are delivering sediment to the adjacent streams.
Percent of total NMCC length in bedrock, within 150 feet of LPM Categories 4 and 5[2]	99%	100%	+1%		

1 Include all areas identified as hard, moderate, or soft geomorphic terrain.
2 Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.
3 Landslide Potential Map developed by CGS for the Mattole Basin; see California Geologic Report Appendix A and Plate 2.
4 Percentages are rounded to nearest 1%; sum of rounded values may not equal rounded totals or 100%.

Discussion

The results of our fluvial geomorphic mapping of channel characteristics that may indicate excess sediment accumulations (NMCC's) can be summarized as follows.

- Changes in the distribution of NMCC's between 1984 and 2000 show different patterns in the bedrock and Quaternary unit reaches.
- Channel conditions in bedrock streams have improved between 1984 and 2000.
- Channel conditions in the Quaternary unit reaches have remained unchanged between 1984 and 2000.
- Virtually all of the NMCC's in bedrock terrains were identified along portions of those streams that are near potentially unstable slopes and the total length of NMCC's in these areas has decreased between 1984 and 2000. Therefore, we conclude that portions, but not all, of the hillslopes in the high to very high landslide potential categories are delivering sediment to the adjacent streams.

Water Quality

Introduction

The following Water Quality Integrated Analysis table for the Mattole Basin is an attempt to compile and condense spatially and temporally varying data and information from all of the NCWAP subbasins into a more readily accessible format. The table headings are self-explanatory with the comment column used to briefly expand on the summary data and its significance affecting salmonids or other watershed processes. The seasonally derived maximum weekly average temperatures (MWATs) and maximum water temperature data have a consistent and reliable history of information gathering over time. Conclusions can be formulated about the relative conditions affecting salmonids and other aquatic species proximate to monitored locations. When the seasonal temperature results are viewed in conjunction with the single day, thermal imaging results, patterns of thermal distribution at the reach and watercourse scale become evident. Almost all of the sediment data were sporadically and inconsistently collected and analyzed, making it difficult to detect trends. The water chemistry and quality data in the mainstem Mattole at the USGS Petrolia gage were collected from 1973 through 1989, and are useful to extrapolate trends to the present. The Lower North Fork Mattole data, however, represents only two sampling events giving a quick snapshot of stream conditions. It becomes evident after reading the tables much information remains hidden, additional details can be more thoroughly explored in the NCRWQCB Appendix E and those of other participating NCWAP agencies.

Table 40. Mattole Basin summary water quality integrated analysis table

<table>
<tr><th colspan="2">Feature/Function</th><th>Significance</th><th>Comments</th></tr>
<tr><th colspan="4">Temperature</th></tr>
<tr><th colspan="2">MWATs (133 Thermograph Records for 77 stations)</th><td rowspan="3">Maximum weekly average temperature (MWAT) is the temperature range of 50-60°F considered fully suitable of the needs of several West Coast Salmonids.</td><td rowspan="3">Mostly unsuitable throughout subbasin but with a higher percentage of suitable locations in the Southern and Western Subbasins, and the headwater reach of the mainstem.</td></tr>
<tr><th>Suitable Records</th><th>Unsuitable Records</th></tr>
<tr><td>27</td><td>106</td></tr>
<tr><th colspan="2">Maximum Temperatures (176 Thermograph Records for 71 Stations)</th><td rowspan="3">A maximum-peak temperature of 75°F is the maximum temperature that may be lethal to salmonids if cool water refugia is unavailable.</td><td rowspan="3">Mostly suitable throughout subbasin but this result is driven by the large number of suitable locations in the Southern and Western Subbasins. Refer to individual subbasins for specific results. There were insufficient thermograph sampling locations in the upstream reaches of the Northern and Eastern Subbasins however, one-day, thermal imaging (below) indicates these reaches may also have maximum temperatures suitable for salmonid survival.</td></tr>
<tr><th>Suitable Records</th><th>Unsuitable Records</th></tr>
<tr><td>120</td><td>56</td></tr>
<tr><th colspan="2">Thermal Infrared Imaging Median Surface Temperature</th><td rowspan="7">Ability to assess surface water temperatures at the river-stream-reach level for a holistic picture of thermal distribution.</td><td rowspan="7">Basin wide median surface temperatures reflect subbasin results with cooler temperatures in the headwater-upstream reaches, gradually warming in a downstream direction. Except the Southern Subbasin, the above trend is symptomatic, and a reflection of fluvial geomorphology analyses disclosing, in a downstream direction, more sheltered narrow, and deeper inner gorges and canyons, that gradually widen to more open, disturbed floodplains, with little solar shelter. See below for data limitations of thermal imaging.
Data limitations: 1) Assessments generally performed on a specific day and time, 2) not comparable to seasonally assessed MWATs or maximum temperatures, 3) unable to assess below water surface. Note: Thermal imaged median surface temperatures are derived from the minimum and maximum imaged surface temperatures scaled to a particular point in a sample cell (cell approximately = 317 feet x stream width). Cell minimum and maximum temperatures rarely varied more than 1-3 °F.</td></tr>
<tr><th>Subbasin</th><th>Minimum/ Maximum (°F)</th></tr>
<tr><td>Estuary-Mainstem to Headwaters</td><td>58 / 80</td></tr>
<tr><td>Northern</td><td>55 / 80</td></tr>
<tr><td>Eastern</td><td>68 / 82</td></tr>
<tr><td>Southern</td><td>(no thermal imaging)</td></tr>
<tr><td>Western</td><td>56 / 74</td></tr>
</table>

Feature/Function		Significance	Comments
MWATs (133 Thermograph Records for 77 stations)		Maximum weekly average temperature (MWAT) is the temperature range of 50-60°F considered fully suitable of the needs of several West Coast Salmonids.	Mostly unsuitable throughout subbasin but with a higher percentage of suitable locations in the Southern and Western Subbasins, and the headwater reach of the mainstem.
Suitable Records	**Unsuitable Records**		
27	106		
Maximum Temperatures (176 Thermograph Records for 71 Stations)		A maximum-peak temperature of 75°F is the maximum temperature that may be lethal to salmonids if cool water refugia is unavailable.	Mostly suitable throughout subbasin but this result is driven by the large number of suitable locations in the Southern and Western Subbasins. Refer to individual subbasins for specific results. There were insufficient thermograph sampling locations in the upstream reaches of the Northern and Eastern Subbasins however, one-day, thermal imaging (below) indicates these reaches may also have maximum temperatures suitable for salmonid survival.
Suitable Records	**Unsuitable Records**		
120	56		
Thermal Infrared Imaging Median Surface Temperature		Ability to assess surface water temperatures at the river-stream-reach level for a holistic picture of thermal distribution.	Basin wide median surface temperatures reflect subbasin results with cooler temperatures in the headwater-upstream reaches, gradually warming in a downstream direction. Except the Southern Subbasin, the above trend is symptomatic, and a reflection of fluvial geomorphology analyses disclosing, in a downstream direction, more sheltered narrow, and deeper inner gorges and canyons, that gradually widen to more open, disturbed floodplains, with little solar shelter. See below for data limitations of thermal imaging. Data limitations: 1) Assessments generally performed on a specific day and time, 2) not comparable to seasonally assessed MWATs or maximum temperatures, 3) unable to assess below water surface. Note: Thermal imaged median surface temperatures are derived from the minimum and maximum imaged surface temperatures scaled to a particular point in a sample cell (cell approximately = 317 feet x stream width). Cell minimum and maximum temperatures rarely varied more than 1-3 °F.
Subbasin	**Minimum/ Maximum (°F)**		
Estuary-Mainstem to Headwaters	58 / 80		
Northern	55 / 80		
Eastern	68 / 82		
Southern	(no thermal imaging)		
Western	56 / 74		
Water Chemistry and Quality			
Subbasin	**Minimum / Maximum**		1973-1989 trend analyses and results for all three physical parameters are protective of the beneficial uses of water described in the North Coast Regional Water Board Basin Plan for the Mattole River. Limited, sporadic sampling results after 1989 are also protective of water quality goals and targets and presumed suitable throughout the basin.
pH (Standard units)		Beneficial pH ranges (~ph 6.5-8.5) controls/regulates chemical state of nutrients, such as CO_2, phosphates, ammonia, and some heavy metals (minimizes any possible toxic effects), etc.	
Estuary-Mainstem (1973-1989)	7.4 / 8.6		
Northern	8.3 / 8.9		
Dissolved Oxygen (mg/l)		By-product of plant photosynthesis/necessary for (life) respiration by aquatic plants and animals	
Estuary-Mainstem (1973-1989)	9.2 / 13.2		
Northern (2001)	8.9 / 9.3		
Conductivity (Micromhos)		Measure of ionic and dissolved constituents in aquatic systems; correlates well with salinity. Quantity/quality of dissolved solids-ions can determine abundance, variety, and distribution of plant/animals in aquatic environments. Osmoregulation efficiency largely dependent on salinity gradients. Estuary salinity essential to outmigrant smoltification.	
Estuary-Mainstem (1973-1989)	100 / 282		
Northern (2001)	255 / 281		

Feature/Function	Significance	Comments
Chemistry/Nutrients Chemical and nutrient sampling was inconsistently conducted from 1973-1989 and is limited spatially and temporally. Little, if any, data was available from 1989 to the present.	Quality and quantity of natural and introduced chemical and nutrient constituents in the aquatic environment can be toxic, beneficial, or neutral to organisms (whether terrestrial or aquatic), and their various life phases. Chemical composition, in part, influenced by rainfall, erosion and sedimentation (parent bedrock, overlying soils), solution, evaporation, and introduction of chemicals/nutrients through human and animal interactions.	Sample analysis results from 1973-1989 for various constituents were protective of the beneficial uses of water described in the North Coast Regional Water Board Basin Plan for the Mattole River. Limited sampling results after 1989 are also protective of water quality goals and targets.

References: Knopp, 1993; Mattole Salmon Group, 1996-200; PALCO, 2001; NCRWQCB Appendix E; Watershed Sciences, 2002

Discussion

In general, temperature conditions for salmonids in the Mattole Basin are unsuitable when MWATs are considered. However, maximum temperatures that may be lethal to salmonids are suitable at nearly twice the number of stations to those considered unsuitable. Though the thermal imaging was completed on a single day it represents temperature distributions over a thermal continuum. The thermal imaging reinforces point derived thermograph data that show cooler, surface water temperature in all of the Mattole Basin headwater reaches, gradually warming in a downstream direction. The sediment data in all of the subbasins varied widely but is inconclusive when attempting to extrapolate the limited results to long term trend analysis. For example, the Southern Subbasin has more sites with excessive sediment for the metrics sampled, but is also known to be the subbasin with some of the best fish habitat in the Mattole Basin. From 1973-1989, the mainstem at the USGS Petrolia Gage was suitable for all measured physical-chemical parameters and, even though very little recent information is available, probably continues to be so. The snapshot physical-chemical results for the NFK Mattole are inconclusive. Sufficient long-term physical-chemical data is unavailable for all of the other subbasins to attempt short or long-term predictions but, in all likelihood, are probably suitable.

Instream Habitat

Introduction

The products and effects of the watershed delivery processes examined in the geology, land use, fluvial geomorphology, and water quality 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 Mattole Basin are presented in the CDFG Instream Habitat Integrated Analysis. Data in this discussion are not sorted into the geologic terrain types since the channel and stream conditions are not necessarily exclusively linked to their immediate surrounding terrain, but may in fact be both spatially and temporally distanced from the sites of the processes and disturbance events that have been blended together over time to create the channel and stream's present conditions. Instream habitat data presented here were compiled from CDFG stream inventories of 61 tributaries and the headwaters of the Mattole River from 1991 to 2002, published research conducted in the Mattole Estuary by HSU, the MRC, and MSG in the 1980s and 1990s, and fish passage barrier evaluation reports conducted under contract to CDFG from 1998-2000. Details of these reports are presented in the CDFG Appendix F.

Pool Quantity and Quality

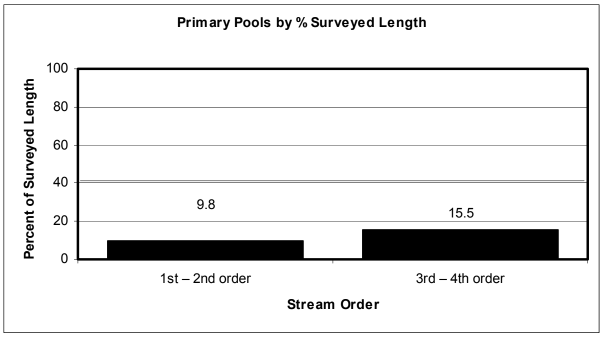

Figure 48. Primary pools in the Mattole Basin.

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 Mattole Basin is generally below target values for salmonids, and appears to be less suitable in lower order streams than in higher order streams.

Spawning Gravel Quality

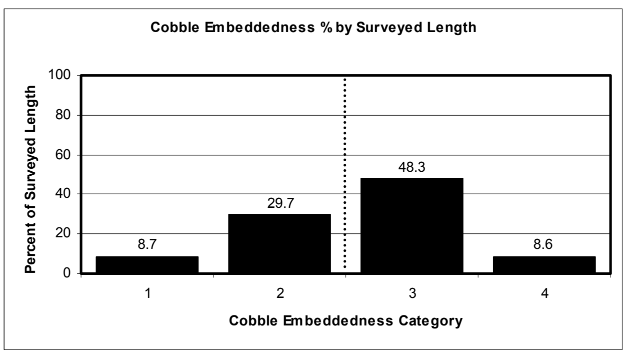

Figure 49. Cobble embeddedness in the Mattole Basin.

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 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 Mattole Basin have cobble embeddedness in excess of 50% in categories 3 and 4, which does not meet spawning gravel target values for salmonids.

Shade Canopy

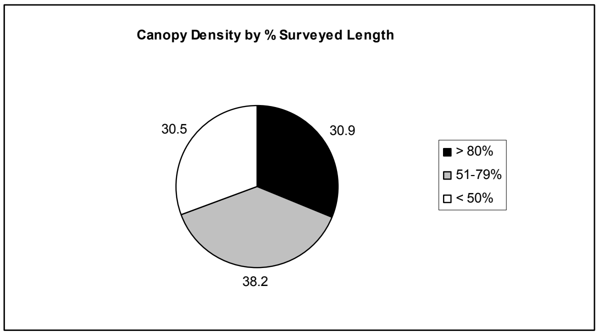

Figure 50. Canopy density in the Mattole Basin

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: More than one half of the surveyed stream lengths within the Mattole Basin have canopy densities greater than 50% and almost one third of the surveyed lengths have canopy densities greater than 80%. This is above the canopy density target values for salmonids

Fish Passage

Table 41. Salmonid habitat artificially obstructed for Fish Passage.*

Feature/Function		**Significance**	**Comments**
Type of Barrier	**% of Estimated Historic Coho Salmon Habitat Currently Inaccessible Due to Artificial Passage Barriers**	Free movement in well-connected 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 stream connectivity. 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	The percent of estimated historic coho salmon habitat that is currently blocked by all artificial barriers in the Mattole Basin varies from 10.2-11.2%. More salmonid habitat is blocked by total fish passage barriers in the Mattole Basin than by partial and temporary barriers. The CDFG North Coast Watershed Improvement Program funded an improvement of Clear Creek in 2001 and Mill Creek (RM 5.5), Ravasoni Creek (East Anderson Creek), and Mill Creek (RM 2.8) in 2002.
All Barriers	10.2-11.2		
Partial and Temporary Barriers	4.3-6.4		
Total Barriers	9.1-9.5		

*(N=18 Culverts) in the Mattole 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).

Table 42. Juvenile salmonid passage in the Mattole Basin (1991-2002 CDFG stream surveys, CDFG Appendix F).

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 Mattole Basin has the potential to disconnect tributaries from the mainstem Mattole River and disrupt the ability of juvenile salmonids to forage and escape predation. This condition is most common in streams in the Mattole headwaters in the Southern Subbasin, and in the Eastern 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.
1.2 Miles of Surveyed Channel Dry	No Data		
0.9% of Surveyed Channel Dry			

Large Woody Debris

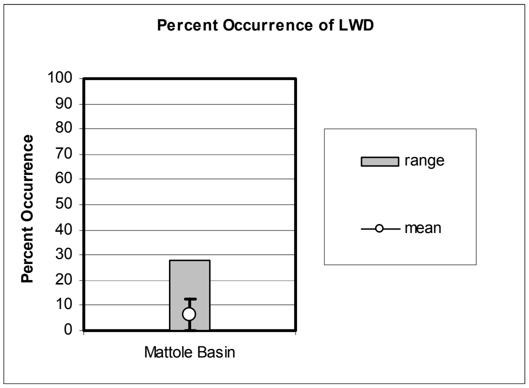

Figure 51. Large woody debris (LWD) in the Mattole Basin.

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 percent occurrence of LWD in a stream as calculated by CDFG in the Mattole Basin represents a measure of the amount of woody debris that was found in the wetted width of a stream channel during stream surveys that can be used by fish for cover as compared to other types of fish cover present. The average percent occurrence of LWD for the Mattole Basin is only 6.6%, as the dominant shelter type recorded in most stream reaches was boulders. This average percent occurrence of LWD is lower than that found in surveys in the Gualala River (average = 11.3 ± 13.6) and Redwood Creek (average = 8.9± 9.5) Basins, two basins for which CDFG has good records.

Discussion

Although instream habitat conditions for salmonids varied a great deal across the 304 square mile Mattole Basin, several generalities can be made. Canopy density was generally greater than 50% across the basin. Additionally, 0.9 miles of surveyed stream (less than 1% of surveyed stream channel) were dry and less than 5% of estimated historic coho habitat was inaccessible due to artificial passage barriers. However, across the Mattole Basin the percent of primary pools by survey length and cobble embeddedness values were both below target values found in CDFGs *California Salmonid Stream Habitat Restoration Manual* and calculated by the EMDS system. In two other North Coast California watersheds currently being assessed by the NCWAP, Redwood Creek near Orick and the Gualala River, have a higher percent occurrence of large woody debris than the Mattole Basin.

Draft Sediment Production EMDS

The draft sediment EMDS is currently under review. Preliminary results for the Mattole Basin are presented in the EMDS Appendix C.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the conditions 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 Stream Inventories. Currently, data exist in the Mattole Basin to evaluate overall reach, 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 C. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual survey.

EMDS stream reach scores were weighted by stream length to obtain overall scores for subbasins and the entire Mattole Basin. Weighted average reach conditions on surveyed streams in the Mattole Basin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 43). Suitable conditions exist for canopy in the Eastern, Southern, and Western Subbasins; and for pool quality and pool depth in the Southern Subbasin. Moderately unsuitable conditions exist for embeddedness in all four subbasins evaluated.

Table 43. EMDS anadromous reach condition model results for the Mattole Basin.

Subbasin	Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Northern Subbasin	-	U	- -	U	-	- -	- -	- -	- -
Eastern Subbasin	-	U	+	U	-	- -	- -	- -	- -
Southern Subbasin	-	U	++	U	-	+	+	-	- -
Western Subbasin	-	U	+	U	-	-	-	-	- -
Mattole Basin	-	U	+	U	-	-	-	-	- -

Key:

+++	Fully Suitable	U	Undetermined
++	Moderately Suitable	+	Somewhat Suitable
-	Somewhat Unsuitable	- -	Moderately Unsuitable
- - -	Fully Unsuitable		

Analysis of Tributary Recommendations

In order to compare the occurrence of recommendations between the four subbasins in the Mattole 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 five subbasin sections of this report.

The top three improvement recommendations in each tributary were summed for each subbasin (Table 44). In terms of the most frequently given recommendations in each subbasin, the Northern Subbasin had Bank, Canopy, and Pool recommendations for seven out of ten tributaries surveyed, the Eastern Subbasin had a Bank recommendation for 12 out of 18 tributaries surveyed, the Southern Subbasin had a Cover recommendation for 12 out of 14 tributaries surveyed, and the Western Subbasin had a Cover recommendations for 13 out of 17 tributaries surveyed.

Table 44. Occurrence of improvement recommendations in first three ranks in surveyed streams.

Subbasin	# of Surveyed Tributaries	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Live-stock	Fish Passage
Northern	10	20.9	7	4	7	2	7	3	0	0	0	0
Eastern	18	34.9	12	7	9	6	9	8	1	2	0	0
Southern	14	25.7	10	5	0	0	11	12	1	5	0	1
Western	18	49.9	11	2	6	3	11	13	0	2	0	3
Mattole Basin	60	131.4	40	18	22	11	38	36	2	9	0	4

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 45). When examining recommendation categories by number of tributaries, the most important Recommendation Category in the Northern and Eastern subbasins is Erosion/Sediment and in the Southern and Western subbasins is Instream Habitat, Table 46.

Table 45. How Improvement recommendations were collapsed into recommendation categories

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 46. *Distribution of basin-wide recommendation categories in the Mattole subbasins.*

Subbasin	Erosion/Sediment	Riparian/Water Temperature	Instream Habitat	Gravel/Substrate	Other
Northern	11	9	10	0	0
Eastern	19	15	17	3	0
Southern	15	0	23	6	1
Western	13	9	24	2	3
Mattole Basin	54	31	74	11	4

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 59 tributaries and the Upper Mattole River surveyed in the Mattole Basin, 21 stream miles were in the Northern Subbasin, 35 in the Eastern Subbasin, 26 in the Southern Subbasin, and 50 in the Western 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 the Southern and Western subbasins, while Riparian/Water Temperature is most important in the Northern Subbasin and Erosion/Sediment is most important in the Eastern Subbasin (Figure 52). In the Mattole Basin as a whole, the most important recommendation category is Instream Habitat, followed by Erosion/Sediment, Riparian Water Temp, Gravel/Substrate, and Other. Therefore, the number one priority rankings remained the same for the Eastern, Southern, and Western subbasins, whether assessed by the number of tributaries or the percentage of stream miles. Additionally, the overall rankings of Recommendation Categories in the Mattole Basin as a whole remained the same in both analyses. However, the number one priority in the Northern Subbasin changed from Erosion/Sediment to Riparian/Water Temperature when assessed by percentage of stream miles rather than number of tributaries.

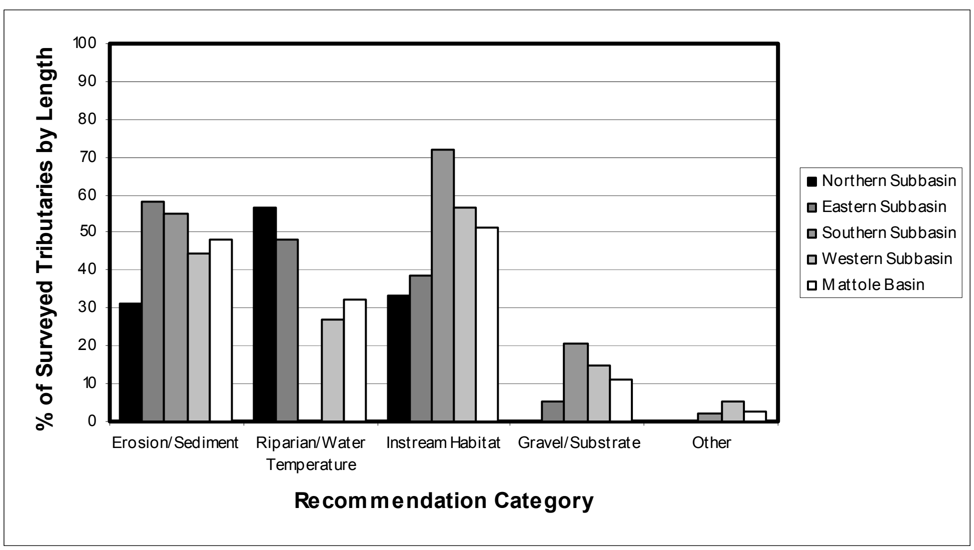

Figure 52. The Frequency of recommendation categories in Mattole Basin surveyed streams.

The high number of Instream Habitat, Erosion/Sediment, and Riparian/Water Temperature Recommendations across the Mattole Basin indicates that high priority should be given to restoration projects emphasizing pools, cover, sediment reduction, and riparian replanting.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Mattole Basin 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, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by NCWAP's EMDS at the stream reach and planning watershed/subbasin scales.

The most complete data available in the Mattole Basin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Mattole Basin are generally best in the Southern and Western subbasins, mixed in the Eastern subbasin, and worst in the Estuary and Northern subbasins. The following refugia area rating table summarizes subbasin salmonid refugia conditions:

Subbasin Recommendation Categories For Potential Watershed Improvements

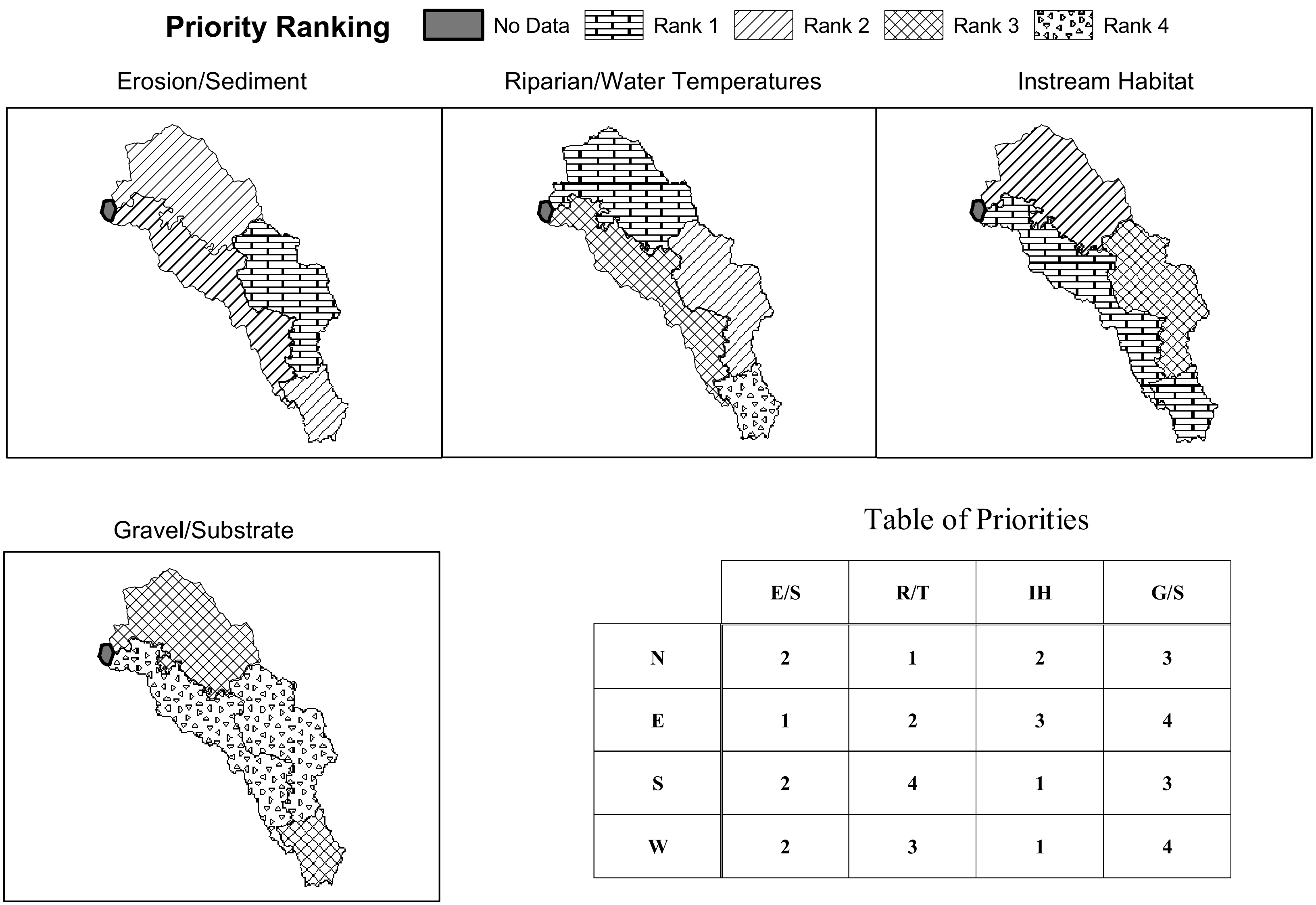

Table of Priorities

	E/S	R/T	IH	G/S
N	2	1	2	3
E	1	2	3	4
S	2	4	1	3
W	2	3	1	4

Figure 53. Prioritized recommendations by subbasin.

Table 47. Subbasin salmonid refugia area ratings in the Mattole Basin.

Subbasin	Refugia Categories:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Estuary Subbasin			X			X	X
Northern Subbasin			X				X
Eastern Subbasin			X				X
Southern Subbasin		X					X
Western Subbasin			X				X

*Ratings in this table are done on a sliding scale from best to worst. Subbasin refugia ratings are aggregated from their tributary ratings. See page 71 for a discussion of refugia criteria.

Mattole River Tributaries by Refugia Category:

High Quality Habitat, High Quality Refugia Tributaries:

Western Subbasin
Bear Creek (RM 42.8)

High Potential Refugia Tributaries:

Eastern Subbasin
Gilham Creek
Harrow Creek
Eubank Creek
McKee Creek
Painter Creek

Southern Subbasin
Bridge Creek
West Fork Bridge Creek
South Branch West Fork Bridge Creek
Vanauken Creek
Mill Creek (RM 56.2)
Upper Mattole River (> RM 56.2)
Baker Creek
Thompson Creek
Yew Creek
Lost Man Creek
Lost Man Creek Tributary

Western Subbasin
Mill Creek (RM 2.8)
North Fork Bear Creek
North Fork Bear Creek Tributary
South Fork Bear Creek
Big Finley Creek
South Fork Big Finley Creek

Medium Potential Refugia Tributaries:

Northern Subbasin
North Fork Mattole River
Sulphur Creek
Sulphur Creek Tributary #1
Sulphur Creek Tributary #2
Conklin Creek
McGinnis Creek
Oil Creek
Devils Creek
Rattlesnake Creek

Eastern Subbasin
Westlund Creek
Gilham Creek Tributary
Sholes Creek
Grindstone Creek
Little Grindstone Creek
Blue Slide Creek
Fire Creek
Box Canyon Creek
McKee Creek Tributary

Southern Subbasin
Anderson Creek
Stanley Creek
Helen Barnum Creek

Western Subbasin
Mill Creek (RM 2.8) Tributary #1
Mill Creek (RM 2.8) Tributary #2
Squaw Creek
Woods Creek
Honeydew Creek
Bear Trap Creek
East Fork Honeydew Creek
Upper East Fork Honeydew Creek
West Fork Honeydew Creek
Jewett Creek
Nooning Creek

Low Quality Habitat, Low Potential Refugia Tributaries:

Northern Subbasin	Eastern Subbasin
Green Ridge Creek	Dry Creek Middle Creek Fourmile Creek North Fork Fourmile Creek

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

Potential Future Refugia (Non-anadromous)

None Identified

Critical Contributing Tributaries:

Northern Subbasin
North Fork Mattole River

Data Limited:

Individual streams were all missing data that would have provided a more complete data set for use in the refugia analysis. In all streams rated, this involved only one or two of the factors used in the rating process and did not prevent refugia determination from being estimated.

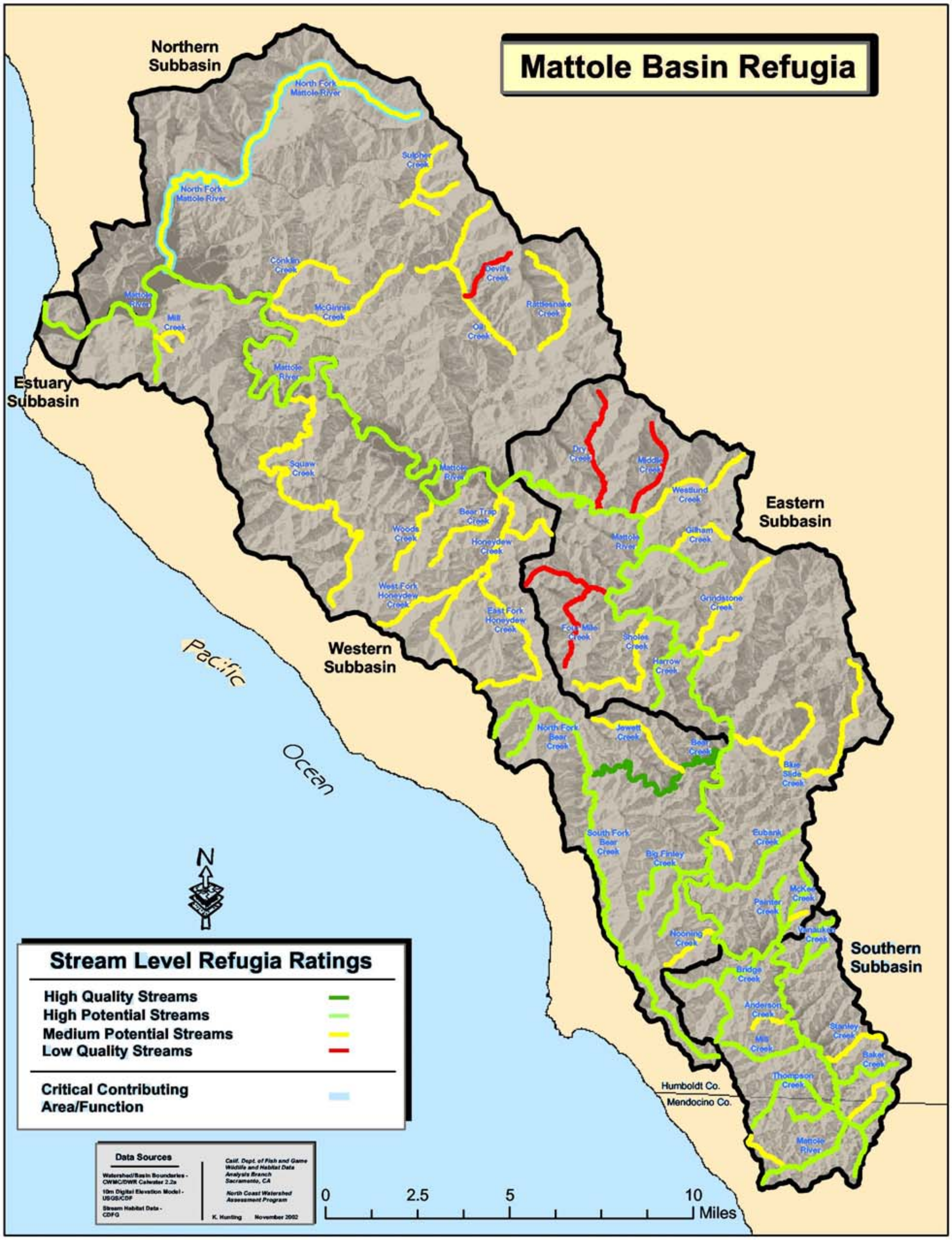

Figure 54. Refugia categories for Mattole Basin surveyed tributaries.

Responses to Assessment Questions

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

Conclusions:

- Historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the Mattole Basin historically supported relatively robust populations of Chinook salmon, coho salmon, and steelhead trout. Fishery surveys have been conducted on many tributaries throughout the Mattole Basin in the last ten years. These biological stream surveys indicate the presence of Chinook salmon and steelhead trout in all five Mattole subbasins and the presence of coho salmon in the Eastern, Southern, and Western Subbasins. Coho salmon also utilize the Estuary Subbasin on their migrations; however, in limited surveys conducted in the Northern Subbasin since the 1980s, coho salmon have not been detected. No studies have been conducted to estimate subbasin or tributary specific population levels of coho salmon or Chinook salmon. However, a nine-year intensive study of three tributaries within the Northern Subbasin indicated stable age classes of steelhead trout. Intensive studies of the Estuary Subbasin have shown depressed populations of over-summering Chinook salmon and steelhead trout, and no coho have been detected. Mattole Basin-wide population estimates indicate depressed meta-populations of Chinook and coho salmon. A metapopulation is a "regional (Mattole Basin) population consisting of semi-isolated local (stream/subbasin) populations" (Levins 1970).

Supporting Evidence:

- The United States Fish and Wildlife Service (USFWS) estimated existing populations of 2,000 Chinook salmon, 5,000 coho salmon and 12,000 steelhead and potential populations of 7,900 pairs of Chinook salmon, 10,000 pairs of coho salmon and 10,000 pairs of steelhead trout in the Mattole Basin in 1960 (USFWS 1960, CDFG Appendix F.
- CDFG conducted 65 stream surveys on Mattole River tributaries in the mid 1960s. CDFG continued to survey streams in the Mattole Basin in the 1970s and 1980s. Coho salmon and steelhead trout presence was documented in tributaries throughout the Mattole Basin. Coho salmon were detected in eleven tributaries, and steelhead trout were detected in 45 (CDFG Appendix F).
- Stream surveys throughout the 1970s, 1980s, and 1990s by CDFG, BLM, Coastal Headwaters Association, and the Redwood Sciences Laboratory continued to document the presence of steelhead trout throughout the Mattole Basin (CDFG Appendix F).
- Surveys also continued to document the presence of coho salmon in the Mattole Basin except for in the Northern Subbasin (CDFG Appendix F).
- Thirty-three of the 58 tributaries (and the upper Mattole River) surveyed by CDFG in the Mattole Basin from 1990-2000 included a biological survey. Steelhead trout were found in these 33 streams, but coho salmon were only found in eight. Coho salmon were not detected in the Northern Subbasin (CDFG Appendix F).
- Thirty-one tributaries in the Mattole Basin were also surveyed as a part of the CDFG 2001 Coho Inventory. Steelhead trout were found in these 31 streams, but coho salmon were only found in eleven streams. Coho salmon were not detected in the Northern Subbasin (CDFG Appendix F).
- Three tributaries in the Northern Subbasin were sampled intensively by CDFG for their salmonid populations from 1991 through 1999, Oil, Rattlesnake Creek, and Green Ridge creeks. Stable population structures of steelhead trout were found in these three streams, but coho salmon were not detected (CDFG Appendix F).
- Snorkel surveys in summers after 1987 have detected very low numbers of juvenile Chinook salmon in the estuary (MRC 1995, MSG 2000).
- Estimated populations of Chinook salmon or coho salmon in the entire Mattole Basin have not exceeded 1000 since the 1987-88 season. Mattole Basin Chinook salmon and coho salmon population estimates for the 1999-2000 season were 700 and 300, respectively (MSG 2000).

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

Conclusions:

- Erosion/Sediment
  - Instream sedimentation in several stream reaches throughout the basin may be approaching or exceeding levels considered unsuitable for salmonid populations. Currently, the estuary is very shallow and lacks channel complexity. Erosion/sediment reduction is the top recommendation category for the Eastern and Estuary subbasins;
- Riparian/Water Temperature
  - High summer water temperatures in many surveyed tributaries are deleterious to summer rearing salmonid populations in the Estuary, Northern, Eastern, and Western Subbasins. Riparian/water temperature improvements is the top recommendation category in the Northern Subbasin;
- Instream Habitat
  - In general, pool habitat, escape and ambush cover, and water depth are unsuitable for salmonids in many mainstem and tributary stream reaches in the Mattole Basin. In the Southern Subbasin summer flow is inadequate or non-existent in many reaches. Large woody debris recruitment potential is poor in the Northern, Eastern, and Western subbasins. Instream habitat improvement is the top recommendation category in the Southern and Western subbasins;
- Gravel/Substrate
  - Available data from sampled streams suggest that suitable, high quality spawning gravel for salmonids is limited in some streams in all subbasins;
- Refugia Areas
  - Salmonid habitat conditions in the Mattole Basin are generally best in the Southern and Western Subbasins, mixed in the Eastern Subbasin, and worst in the Estuary and Northern subbasins.

Supporting Evidence:

- Three of 61 tributaries (and the upper Mattole River) surveyed by CDFG in the Mattole Basin were found to have 40% or more of their survey lengths in pool habitat. These three tributaries were all in the Southern Subbasin. Ten surveyed tributaries were found to have 30 to 40% of the stream lengths surveyed in pool habitat. The Northern Subbasin had no streams with 30-40% of their survey length in pools. Forty percent or more of stream lengths in pool habitat is considered suitable on the North Coast. Additionally, 9.8% of first and second order surveyed streams and 15.5% of third and forth order surveyed streams in the Mattole Basin are composed of primary pools by survey length. The Southern and Western subbasins had the highest percentage of surveyed stream length in primary pools. Thirty to 55% of survey lengths composed of deep, complex, high quality primary pools is considered desirable. In addition, extensive studies of the Mattole estuary have determined that cooler, deeper pools are lacking (IA Tables, CDFG Appendix F).
- Three of 61 tributaries (and the upper Mattole River) surveyed by CDFG in the Mattole Basin were found to have a mean pool shelter rating exceeding 80. These three tributaries were all in the Southern Subbasin. This indicates that woody debris elements affecting scour are not present throughout the Mattole Basin. Thirty-five surveyed tributaries had shelter rating scores between 30 and 80. The Southern and Western subbasins had the most tributaries with mean pool shelter ratings above 30. Pool shelter ratings of 80 or more are considered suitable, and ratings less than 30 are unsuitable for contributing to shelter that supports salmonids. In addition, extensive studies of the Mattole estuary have determined that complex pools with cover are lacking (CDFG Appendix F).
- Boulders provided the primary form of shelter for salmonids in 40 of the 61 surveyed tributaries (and the upper Mattole River) in the Mattole Basin. The Southern Subbasin was the only subbasin in which boulders did not provide the primary form of shelter in surveyed tributaries; in fact, only two Southern Subbasin tributaries had boulders as the primary form of shelter (CDFG Appendix F).
- Removal of instream large woody debris under direction of CDFG occurred in about 71.5 stream miles in the Mattole Basin during the 1980s. A total of 56,960 cubic feet of wood was removed.

This is equivalent to 445 logs 2 feet x 40 feet. This activity likely had adverse local impacts on salmonid habitat conditions (CDFG Appendix F).

- Available data for two metrics indicate that sediment is impairing the cold water fisheries of a number of tributaries in the Mattole Basin. Reported values for pool filling (V*) calculated by the MSG during 2000 in Bridge Creek was 0.04. The values in seven other creeks, Mill, Conklin, Squaw, Westlund, Middle, and Honeydew Creeks, and the mainstem Mattole River, ranged from 0.22 to 0.27. Except for Bridge Creek, all are slightly higher than a target value for V* of 0.21 recommended in the Mattole River TMDL, Technical Support Document (Regional Water Board, 2002). Pebble counts (D50s) during 2001 collected by the Regional Water Board varied from 65 mm to 14mm, indicating low to high rates of sediment transport and deposition, respectively. The latter values indicate natural and/or land use activities may be introducing fine to medium sized sediment particles into local streams. A numeric target is not proposed for D50 in the Mattole River TMDL: Technical Support Document. Collectively (except for Bridge Creek), values for V* and D50 were borderline suitable to unsuitable for salmonids.
- During all analyzed sample years in the entire Mattole Basin, maximum weekly average temperatures (MWATs) were somewhat suitable to unsuitable on 106 out of 133 occasions at 77 sampling stations. Fully suitable MWATs for salmonids are from 50 °F to 60 °F. The Southern Subbasin was almost equally split, with 13 of 14 occasions at nine thermograph stations reporting suitable MWATs. All other Mattole subbasins had a majority of records with MWATs somewhat suitable to unsuitable for salmonids. Maximum temperatures for salmonid suitability were generally more favorable for salmonid survival with 68% of the records at 71 thermograph stations reporting temperatures under 75°F, the maximum temperature above which may be lethal to salmonids. At a total of 32 stations in the Estuary Subbasin and Mattole mainstem, had 36 suitable to 28 unsuitable maximum temperature records. The Northern Subbasin, with 11 of 15 unsuitable records, had the highest ratio of unsuitable to suitable temperatures. The Eastern Subbasin for 23 thermograph records at ten stations had 14 suitable to nine unsuitable maximum temperatures over 75°F. The Southern Subbasin, for 36 records at nine thermograph stations, had no unsuitable maximum temperatures, while the Western Subbasin had 30 suitable to eight unsuitable records.
- Twenty-six of 61 tributaries (and the Upper Mattole River) surveyed by CDFG in the Mattole Basin exceeded the recommended shade canopy density levels of 80% for North Coast streams. Only one tributary in the Northern Subbasin exceeded 80% canopy density. Additionally, 50 surveyed tributaries exceeded 50% shade canopy density levels. All surveyed tributaries in the Southern Subbasin and 16 out of 18 surveyed tributaries in both the Eastern and Western subbasins exceeded 50% canopy density levels. Shade canopy density below 50% is considered unsuitable (CDFG Appendix F).
- Twenty-three of 61 tributaries (and the upper Mattole River) surveyed by CDFG in the Mattole Basin were found to provide spawning reaches with favorable cobble embeddedness values in at least half of the stream reach lengths surveyed. Surveyed tributaries across all of the Mattole subbasins had poor cobble embeddedness values (CDFG Appendix F).
- Two tributaries out of 13, Honeydew Creek and Bridge Creek, had residual pool filling, known as V*, at levels below 0.30, a level considered low, and thus suitable salmonid habitat for this metric. The other 11 streams experienced low to moderate rates of pool filling. Only Honeydew Creek out of 14 sites had pebble counts, or D50s, ≥ 69 mm, a value considered well suited to most salmonid spawning gravel measured on an entire riffle (NCRWQCB Appendix E).
- CDFG has conducted an analysis of macroinvertebrate data collected by BLM and PALCO since 1994 on 17 tributary streams and two sites on the mainstem Mattole River. The results showed stream conditions ranged from fair to excellent. Baker Creek in the Southern Subbasin had good to excellent conditions (CDFG Appendix F).
- Out of 49 stream reaches examined for the presence of sensitive amphibian species, torrent salamanders found in eleven reaches and tailed frogs were found in 15 reaches. Neither torrent salamanders nor tailed frogs were detected in the Eastern Subbasin (Welsh et al. 2002).
- Artificial fish passage barriers block 10.2-11.2% of the estimated historic coho salmon habitat in the Mattole Basin. The greatest percentage of estimated historic coho habitat blocked in the Mattole

Basin is in the Southern Subbasin. Additionally, 0.9% of surveyed stream channel in the Mattole Basin was dry. The percentage of dry channel in surveyed tributaries was similar across all Mattole subbasins (IA Tables, CDFG Appendix F).

- The NCWAP analysis of tributary recommendations given in the Mattole Basin showed that the most important recommendation category was Instream Habitat, followed by Erosion/Sediment, Riparian/Water Temperature, Gravel/Substrate, and Other (Tributary Recommendation Analysis, pg.152).

What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?

<u>Conclusions:</u>

- Geologic units within the basin can be grouped into one of three bedrock terrains (hard, moderate, and soft) and one for Quaternary alluvial units. Larger landslides are more prevalent in soft terrain and are typically earthflows, while smaller slides, typically debris slides, are more prevalent in hard and moderate terrains;
- Weak geologic materials, steep slopes, high rainfall, and strong earthquakes common to the basin result in high rates of natural landsliding and surface erosion, particularly in soft terrain. These natural processes can be exacerbated by human land use within the basin. About one half of the basin is considered to have a high to very high landslide potential;
- In general, the subbasins can be ranked in terms of relative impacts with geologically unstable areas linked to adverse stream effects. The Northern Subbasin has the largest proportion of geologically unstable (soft) terrain, which is linked to the highest amount of historically active landslides, gullies, and stream features indicative of excess sediment production, transport, and storage. The Southern Subbasin has the lowest proportion of geologically unstable terrain, historically active landslides, gullies, and stream features indicative of excess sediment production and transport. The Eastern and Western Subbasins are intermediate between these two extremes due to the variability in the proportion of soft terrain and steep slopes;
- Source and transport reaches of the blue line streams as depicted on NCWAP stream network maps, were identified primarily in bedrock terrains, while response (depositional) reaches were identified in the Quaternary (alluvial) unit reaches. Features indicative of excess sediment production, transport, and storage have decreased throughout most of the basin in the period between 1984 and 2000. The reduction in these features was greatest in the hard terrain. The distribution of these features in bedrock terrains suggests that portions of the areas interpreted as having a high to very high landslide potential are also the sources of sediment that has been delivered to streams;
- Human activities such as timberland conversion to grasslands and brush, grazing, timber harvest, and road construction and use, have interacted with natural geologic instability to increase sediment production above naturally high background levels. Historic timber harvesting and streamside road construction reduced riparian canopy and increased direct sediment inputs and water temperature. Overall, the current landscape is comprised of smaller diameter forest stands than in pre-European times. Decades of fire suppression have created dense forest stands and brush-lands leading to the designation of Mattole Basin population centers as high wildfire threat areas.

<u>Supporting Evidence:</u>

- The hard, moderate, soft and Quaternary unit terrains each comprises 40%, 28%, 25% and 7% respectively, of the watershed.
- Fifty five percent (by area) of the historically-active landslides, 46% of the dormant landslides, and 81% of the gullies mapped in the watershed occur in the soft terrain.
- Seventy-six percent of the small landslides, mostly debris slides, occur in the steep slopes of the hard and moderate terrains.
- Approximately 50% of the watershed has been interpreted as having a high to very high landslide potential.
- Over 90% of the source and transport reaches were identified along streams crossing bedrock.

- About 85% of the streams in the Quaternary units were mapped as response reaches.
- Thirty six percent (1984) and 21% (2000) of the total stream length were affected by features indicative of excess sediment production, transport, and storage.
- A 40% reduction in the total length of features indicative of excess sediment production, transport, and storage, as well as a 14% reduction in the proportion of streams affected by these features was observed between 1984 and 2000. This reduction in stream features was observed to have occurred primarily in the bedrock stream reaches.
- About 99% of features indicative of excess sediment production, transport, and storage in bedrock terrains were identified within areas interpreted as having a high to very high landslide potential (areas within LPM Category 4 and 5).

How has land use affected these natural processes?

Conclusions:

- 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. Excess sediment remains in the Mattole mainstem despite decades of low timber harvesting activity;
- Currently, roads are a major land use contributor of sediment (CDF, 2002). Large storms or other catastrophic events combined with poor road location and construction practices have the potential to deliver large and adverse amounts of sediment into stream systems;
- Water extraction for agriculture, road maintenance, and residential use has the direct effect of reducing the amount of available habitat for fish;
- Large woody debris recruitment potential is limited by the low percentage of near-stream forest stands containing trees in large diameter classes;
- Grazing is widespread on privately owned grasslands and has shifted to cattle since the enactment of predation protection measures. Stock impacts to streams are not widespread, but watercourse exclusionary fencing is limited.

Supporting Evidence:

- Many of these effects are spatially and temporally removed from their upland sources. Excess sediment remains in the mainstem of the Mattole despite decades of low timber harvesting activity. Grazing is widespread on privately owned grasslands and has shifted to cattle since the enactment of predation protection measures. Exclusionary fencing is limited. Currently, roads are a major land use contributor of sediment. Large storms or other catastrophic events combined with poor road location and construction practices have the potential to deliver large and adverse amounts of sediment into the stream systems.
- Water extraction for agriculture, road maintenance, and residential use has the direct effect of reducing the amount of available habitat for fish.

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

Conclusions:

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

- Impacted estuarine conditions;
- General basin-wide lack of habitat complexity;
- High instream sediment levels;
- High summer water temperatures;
- Reduced basin-wide coho and Chinook meta-populations.

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

Recommendations:

Flow and Water Quality Improvement Activities:

- Discourage unnecessary and wasteful use of water during summer low flow periods to improve stream surface flows and fish habitat, especially in the Southern Subbasin;
- Increase the use of water storage and catchments systems that collect rainwater in the winter for use in the drier summer season;
- Support local efforts to educate landowners about water storage and catchments systems, and find ways to support and subsidize development of these systems;
- Support and expand ongoing local 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;
- Support efforts to determine the role of sediment in the mainstem Mattole River in elevated estuarine water temperatures.

Erosion and Sediment Delivery Reduction Activities:

- Reduce sediment deposition to the estuary by supporting a basin-wide road and erosion assessment/control program such as the Mattole Restoration Council's *Good Roads, Clear Creeks* effort. Continue to conduct and implement road and erosion assessments such as the ongoing efforts in the Dry and Westlund planning watersheds in the Eastern Subbasin. Expand road assessment efforts because of the potential for further sediment delivery from active and abandoned roads, many of which are in close proximity to stream channels, especially in the Bridge and Thompson planning watersheds in the Southern Subbasin;
- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the basin and especially in the North Fork Mattole and the Upper North Fork Mattole rivers, Mattole Canyon, Blue Slide, Squaw, Honeydew, and Bear creeks;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- At stream bank erosion sites, encourage cooperative efforts to reduce sediment yield to streams. CGS mapping indicates eroding banks are not a significant basin wide issue, but may be of localized importance. They occur in isolated, relatively short reaches distributed throughout the Mattole Basin;
- Based on the high incidence of unstable slopes in the Northern Subbasin, any future sub-division development proposals should be based on an existing county-imposed forty acre minimum parcel sub-division ordinances;
- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams. For example, low impact yarding systems should be used in timber harvest operations on steep and unstable slopes to reduce soil compaction, surface disturbance, and resultant sediment yield.

Riparian and Habitat Improvement Activities:

- Where current canopy is inadequate and site conditions, including geology, are appropriate, initiate tree planting and other vegetation management to hasten the development of denser and more extensive riparian canopy, especially in the Northern Subbasin;
- Landowners and managers in the Northern and Western subbasins should work to add more large organic debris and shelter structures to streams in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids;
- Ensure that stream reaches with high quality habitat in the Mattole Basin are protected from degradation. This is especially important in the Southern Subbasin. The best stream conditions as

evaluated by the stream reach EMDS were found in the South Fork of Vanauken Creek, Mill Creek - at Mattole river-mile 56.2 (RM 56.2), Stanley Creek, Thompson Creek, Yew Creek, and Lost Man Creek Tributary in the Southern Subbasin, and in Harrow Creek in the Eastern Subbasin. Refugia investigation criteria, which include biological parameters, indicated Bear Creek was the best stream evaluated in the Mattole Basin.

Supplemental Fish Rescue and Rearing Activities:

- Since 1982 a successful cooperative salmonid rearing facility in the Mattole Basin headwaters has been operated by the Mattole Salmon Group (MSG) and CDFG. They also operate a Chinook juvenile out-migrant rescue rearing program near the estuary, which released 2,400 coded-wire-tagged Chinook sub-yearlings in October 2002. These programs should be continued as needed to supplement wild populations while the improvements from long-term watershed and stream restoration efforts develop;
- Initiate a systematic program to monitor the effectiveness of fish rescue and rearing activities, and determine the need for the continuance of cooperative, supplemental fish rearing efforts;
- Update as scheduled the MSG/CDFG five-year plan that provides guidance to the cooperative rearing and rescue projects. Base the periodic plan updates on the findings of the effectiveness monitoring program and best available science.

Education, Research, and Monitoring Activities:

- Utilize Humboldt State University studies conducted in the early 1990s as baseline information to periodically monitor trends in estuarine conditions and fish production;
- Encourage ongoing stream inventories and fishery surveys of tributaries throughout the Mattole Basin, especially in the Northern Subbasin;
- In order to protect privacy while developing data, the possibility of training local landowners to survey their own streams and to conduct salmonid population status surveys throughout the basin would be advisable;
- Further study to investigate the affects to water quality from timberland herbicide use is recommended;
- Follow the procedures and guidelines outlined by NCRWQCB to protect water quality from ground applications of pesticides;
- Encourage appropriate chemical transportation and storage practices as well as early spill reporting and clean-up procedures;
- Conduct training as needed and desired to assist landowners, managers, consultants, and other interested parties in the construction and appropriate application of landslide occurrence and potential maps from GIS analysis