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A GIS-BASED SYNTHESIS OF INFORMATION ON SPAWNING DISTRIBUTIONS OF CHINOOK SALMON IN THE CALIFORNIA COAST CHINOOK SALMON ESU

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Abstract

This report presents a database of observations assembled from local expert knowledge on the distribution of chinook salmon in the California Coastal Chinook Salmon Evolutionarily Significant Unit (CCC ESU). Expert knowledge was transcribed into a Geographic Information System (GIS) in a spatial format that was easy to interpret, update, and share. The geospatial database includes 499 habitat observations and 119 observations of barriers to fish passage.

1 Introduction

The California Coastal Chinook Salmon Evolutionarily Significant Unit (CCC ESU) is listed as a threatened species under the Federal Endangered Species Act (ESA). Estimating the quality and extent of available habitat is necessary for developing effective plans to restore these depleted populations; however, spatial data on the spawning distribution of chinook salmon in the CCC ESU are sparse and have not been assembled previously. Indeed, a lack of this type of information contributed to the decision to list the species on the ESA (Myers et al. 1998). In an attempt to fill this gap, we assembled information on the spawning distribution of chinook salmon throughout the CCC ESU, through a series of mapping exercises involving local experts. Our steps for this exercise were to (1) gather and assess available information on chinook distribution in the ESU; (2) synthesize this collected information into a comprehensive spatial data set using a Geographic Information System (GIS); and (3) error-check and resolve conflicting comments.

2 Methods

2.1 Gathering & Assembling Expert Knowledge

Three meetings were held (8 July 2002 [Arcata, CA], 6 August 2002 [Fortuna, CA], and 28 August 2002 [Santa Rosa, CA]) to ensure geographic coverage and to facilitate participation by a broad range of local experts. The meetings were held in a collaborative format to encourage participants to resolve discrepancies before providing opinions. On draft maps at the watershed scale, we asked each expert to note their initials, reference document if applicable, year of observation, and any additional supporting information (e.g., distance from confluence, at road crossing x, etc.) with each observation. Each draft map depicted 1:100k hydrography (USGS 2003) with watershed boundaries[1], roads, and other landscape features to better orient the participant. These procedures were repeated with all available experts until all watersheds in the CCC ESU where field surveying had taken place were included.

We developed coding schemes to categorize observations about chinook distribution according to (1) type (spawning/rearing, rearing/migration, or migration), (2) data quality class (Documented, Professional Observation, Suspected, Disputed, Documented but Upper Spatial Extent Unknown), and (3) time scale (Appendix A). We categorized barrier observations by type and passability (Appendix B).

We digitized the observation data into a GIS using the Dynamic Segmentation

[1] We developed watershed boundaries so that the bounds encompassed the entire drainage area, which was delineated using 1:100K hydrography (USGS 2003) and sixth-level hydrologic unit boundaries (FRAP 1999; NRCS 2002). If these ancillary data were insufficient, DEMs were used to visualize and trace the catchment area.

Model (DSM)[2], which allowed us to store the data as a set of measurements along the stream (ESRI 2002)[3]. Specifically, the DSM allowed for relating linearly referenced data (events, i.e. Chinook presence), stored as a table, onto linear features (routes, i.e. rivers) (Cadkin and Brennan 2002). Additionally, the DSM provided the capability to store overlapping events, which was useful in instances where observations between experts differed. A different color was used for each type of event according to the coding schemes.

To resolve disputes between experts and locate and remedy any mapping errors, we developed a series of 1:24k scale maps for all areas with observations. Each map depicted aggregated observations made by all experts as a base layer with overlays of observations with all possible categories made by an individual expert (Figure 1). We used a hierarchical framework for overlapping or disputed observations where Documented observations took precedence over Professional observations, which took precedence over Suspected. Additional map layers included topographic maps, 1:100k

[2]Dynamic Segmentation refers to a method of referencing data along a linear feature such that measurements along the feature are used for location (ESRI 2001). Events refer to each line or point observation. For line events (Chinook spawning and rearing), two measurements are needed for the start and end points of each line. For point events (barriers), one measurement is needed. Routes are any linear feature upon which events can be located (Cadkin and Brennan 2002). We used a 1:100k routed stream coverage (Christy and Haney 2003; downloadable from http://www.calfish.org/) as the base stream layer upon which we placed georeferenced events. This route system uses a Longitude-Latitude Identifier (LLID)to link each stream to the correct observation. The LLID is the longitude and latitude coordinates at the mouth or confluence of a stream. We used the Digitize Events toolbar (downloadable from http://arcobjectsonline. esri.com/) to digitize each observation. Lastly, we overlayed seamless topographic maps (TOPO 2001) to ensure more accurate digitizing. This system corresponds to similar methodology used in Oregon (Oregon Department of Fish and Wildlife, http://rainbow.dfw.state.or.us/nrimp/24k/docs/workshop.pdf).

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hydrography, and the barrier data set. Each expert was asked to review all maps for which they contributed information. To ensure the correct classification and spatial extent of each observation, we asked each expert to verify each delineation and provide any comments or needed corrections.

3 Structure and Summary of the Chinook Distribution Database

The databases (downloadable from http://santacruz.nmfs.noaa.gov/publications/ software/673) contain 499 events depicting chinook spawning and rearing, and 119 events depicting barriers to fish passage (Figure 2). Chinook spawning and rearing was reported in 2135 stream kilometers in the CCC ESU with 53% as Documented, 4% as Professional Observation, and 43% as Suspected (Table 1). (As noted above, the databases contains observations that overlap in space and in time, but these tabular results present aggregated data that contain spatially and temporally unique events.) In addition to these tabular summaries, the observations can be displayed on watershed level maps by class and time (Figure 3).

Observations were concentrated in the northern portion of the ESU, while relatively few observations occurred south of the Eel River basin (Figure 2). The entire Eel River basin accounted for 62% of the total stream kilometers present in the database. While this patterns appears to reflect the actual distribution of chinook, there may also be some geographic bias in sampling because fewer surveys were conducted farther south where chinook are though to be much less abundant.

The distribution of barriers to chinook passage were more concentrated in inland portions of larger watersheds. Small, coastal watersheds had few barrier observations; however, the Little River, one of the smallest watersheds in the ESU, contained 10 of the total 119 observations (8%). Watersheds with > 10 barrier observations included the Mad (11), South Fork Eel (13), Russian (15), and Upper Eel (21). Sixty-two percent of the observed barriers were natural barriers. Eighty-five percent of all observations were either impassable or only passable under some flows. The distribution of these observations likely reflects the same geographic bias noted above.

3.1 Caveats

Some caution should be applied in interpreting these results. First, there are degrees of subjectivity for some of the observations, which we indicated by data quality classes. Second, measurements of each delineation or observation were not precise as the data set was delineated and digitized manually on maps, and therefore there may be small errors in actual locations and the summarized tabular data. Additionally, as noted in the preceding section, there appears to be a geographic sampling bias, and therefore we do not intend to conclude that fish are not distributed in these less or unsampled areas. Nonetheless, these data provide the best current estimate of the spatial extents and locations of chinook distribution in the ESU, and can be updated as further information becomes available.

3.2 Potential Applications

These data may be useful for helping develop effective recovery plans in several ways. We can use these data to guide field surveys in those suspected areas, and in so doing generate more accurate presence/absence data for the ESU. These data might also be used to determine population structure within the ESU. Also, these results can be used as a validation data set for models that predict fish distribution (e.g. habitat suitability models). For example, we have modeled the intrinsic potential for fish habitat based on the underlying geomorphology and hydrology (stream gradient, valley constraint, and discharge) (Burnett et al., 2003; Agrawal et al., In review). The chinook spatial data that were generated through the mapping exercises can be used to compare and quantify modeled results.

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6 Tables

Table 1: Total stream kilometers per aggregated observation category for basins where chinook observations were identified

Basin	Documented	Professional Obs.	Suspected	Total
Bear R	0.00	0.00	45.65	45.65
Elk R - CA	31.20	0.00	7.70	38.90
Freshwater Cr	19.03	1.09	22.98	43.10
Garcia R	0.00	0.00	29.40	29.40
Jacoby Cr	0.00	0.00	2.94	2.94
Little River - N	24.18	0.40	6.26	30.84
Lower Eel R	36.80	2.31	67.90	107.02
Mad R	99.86	2.60	19.00	121.45
Maple Cr	8.80	0.00	7.20	16.00
Mattole R	67.90	0.00	70.43	138.33
Middle Fork Eel R	184.36	8.12	64.26	256.74
North Fork Eel R	36.30	3.30	40.71	80.31
Noyo R	0.00	0.00	1.00	1.00
Redwood Cr	44.08	4.00	63.25	111.33
Russian R	10.78	43.63	147.93	202.34
Salmon Cr - N	0.00	0.00	10.20	10.20
South Fork Eel R	268.97	7.93	125.50	402.39
Ten Mile R	0.00	7.08	0.00	7.08
Upper Eel R	243.76	0.00	117.28	361.04
Van Duzen R	65.91	0.00	63.40	129.31
Total	1141.92	80.45	912.99	2135.36

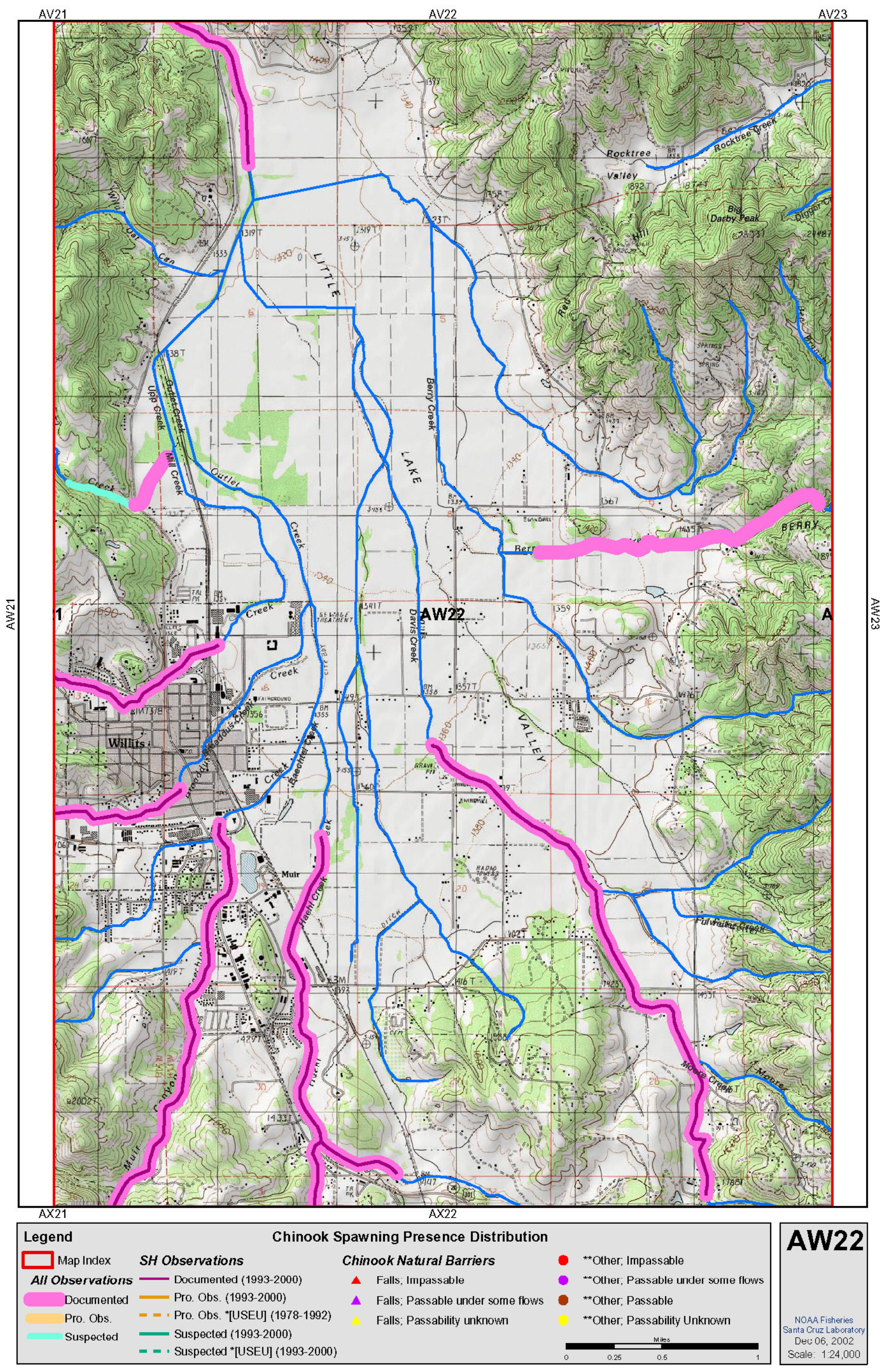

Figure 1: Example map prepared from the initial digitizing of observations. Individuals' observations were overlaid on aggregated observations (documented, professional observation, and suspected) provided by all experts so the individual could reference other comments about a particular reach.

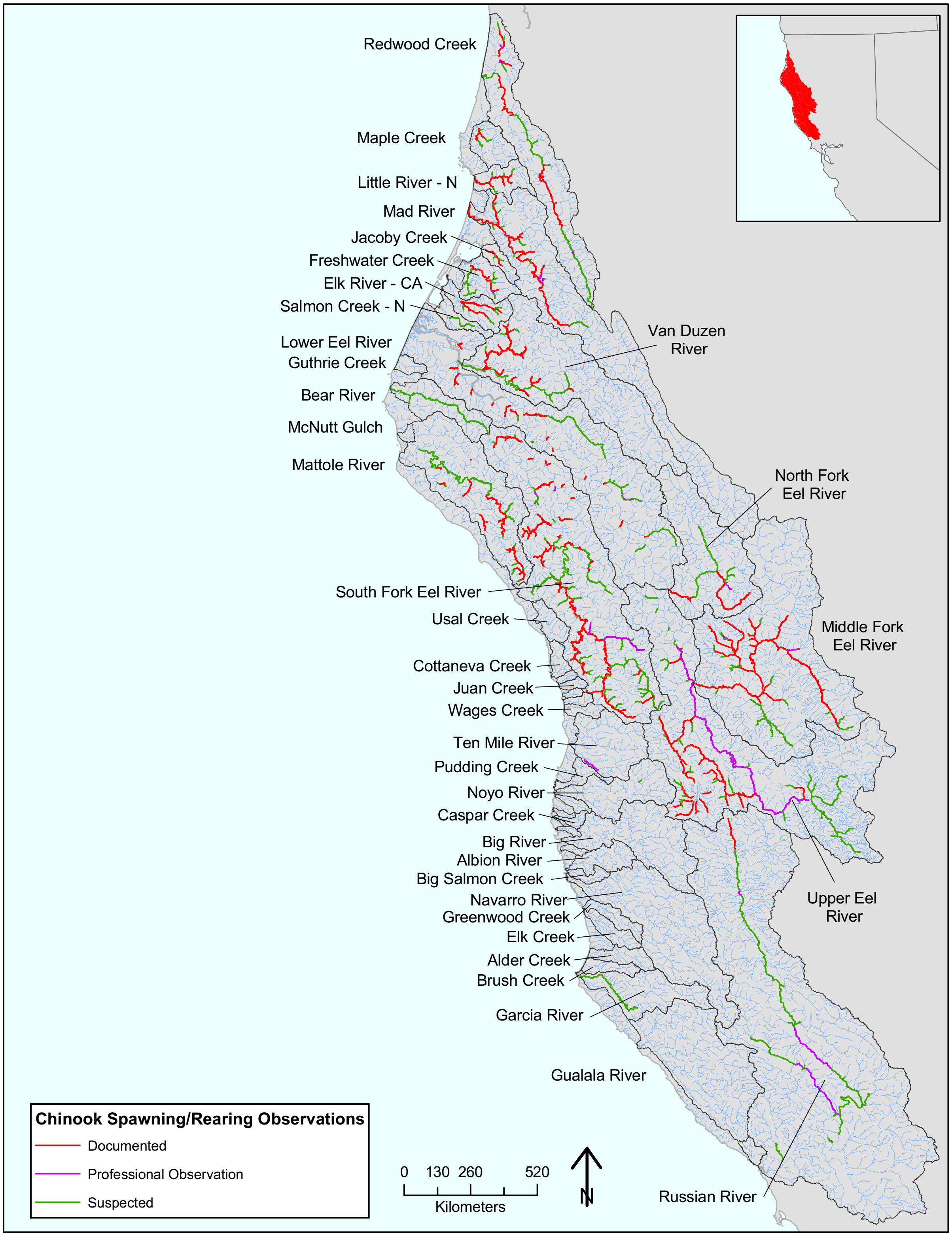

Figure 2: Map showing all gathered observations.

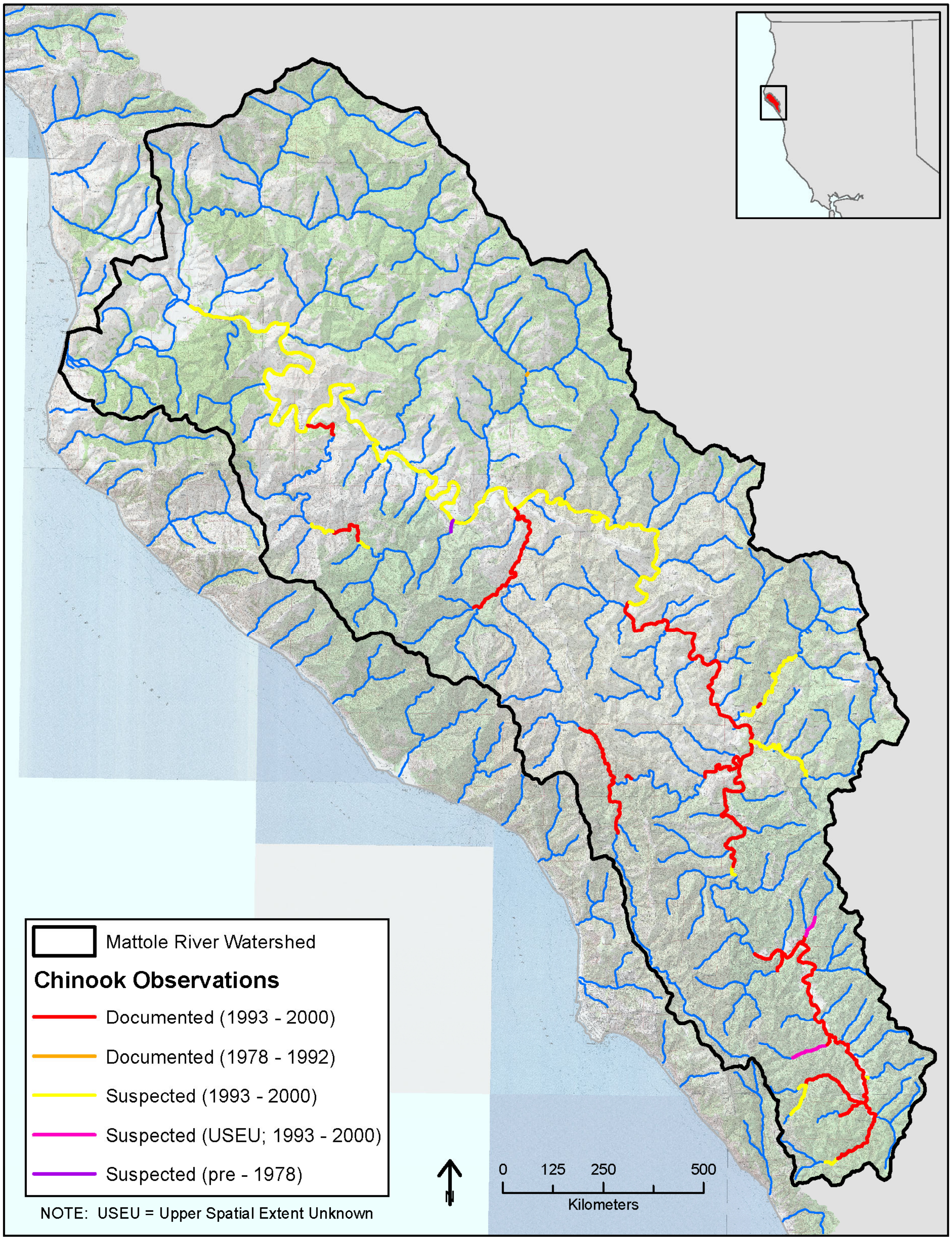

Figure 3: Detailed view of Chinook observations within the Mattole River watershed.

Appendix A: Fish Distribution Codes

Use Type Codes:

1. Spawning/Rearing (spawning areas where some period of juvenile residence is presumed)

2. Rearing/Migration (areas where summer surveys have detected presence of non-migratory fish, but from which they eventually migrate)

3. Migration (areas where fish were collected by upstream or downstream traps OR areas between known spawning or rearing areas that must be traversed to reach ocean)

4. Absent (above longstanding natural barrier or not detected in repeated surveys)

Data Quality Codes:

1. Documented (records in hand; note that it applies to observations of both presence and absence)

2. Professional observation (undocumented; applies to both presence and absence)

3. Suspected based on habitat conditions, accessibility (applies to both presence and absence)

4. Disputed (biologists disagree about potential use)

5. Documented with spatial upper extent unknown

6. Professional observation with spatial upper extent unknown

7. Suspected with spatial upper extent unknown

Temporal Codes:

1. Within the last two generations (1993-2000)

2. Within the last three to five generations (1978-1992)

3. Historical ($>$ 5 generations ago; pre-1978)

Appendix B: Barrier Codes

Type:

1. Natural falls
2. Cascades, chutes and other natural barriers (except falls and bars)
3. Dam with no passage structure
4. Dam with passage structure
5. Diversion/irrigation/dewatered
6. Culvert
7. Bars (i.e. at mouth of rivers)
8. Other man-made: e.g. mill ponds, tidal gates, agricultural dikes

   * log and debris jams are not included in any code

Chinook Passability:

1. Impassable
2. Passable under some flows
3. Passable
4. Unknown

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