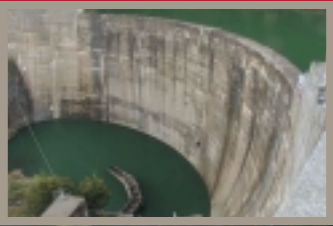
Inventory of Barriers to
FISH PASSAGE
in California's Coastal Watersheds

Conducted and Compiled by
The Coastal Conservancy





The Coastal Conservancy is a state agency that works with the people of California to protect and improve the coast and San Francisco Bay. The Conservancy has helped to open over 80 miles of coast and bay shores to the public and to preserve over 100,000 acres of wetlands, wildlife habitat, and farmland.

The Coastal Conservancy's resource enhancement program provides capital funds and technical assistance for the preservation, enhancement and restoration of wetlands, watersheds, riparian corridors, and other wildlife habitat lands, including, where necessary, acquisition of interests in land, and for technical and scientific services necessary to design and implement such projects.

Proposition 12, the Safe Neighborhood Parks, Clean Water, Clean Air, and Coastal Protection Bond Fund supported this report, through a legislative appropriation sponsored by Senator Byron Sher (D-Palo Alto). This report was made possible by the initiative and effort of the many dedicated individuals working to improve fish passage, all of whom provided invaluable guidance, technical assistance, barrier documentation, and endless optimism for the restoration of California's salmon and steelhead.

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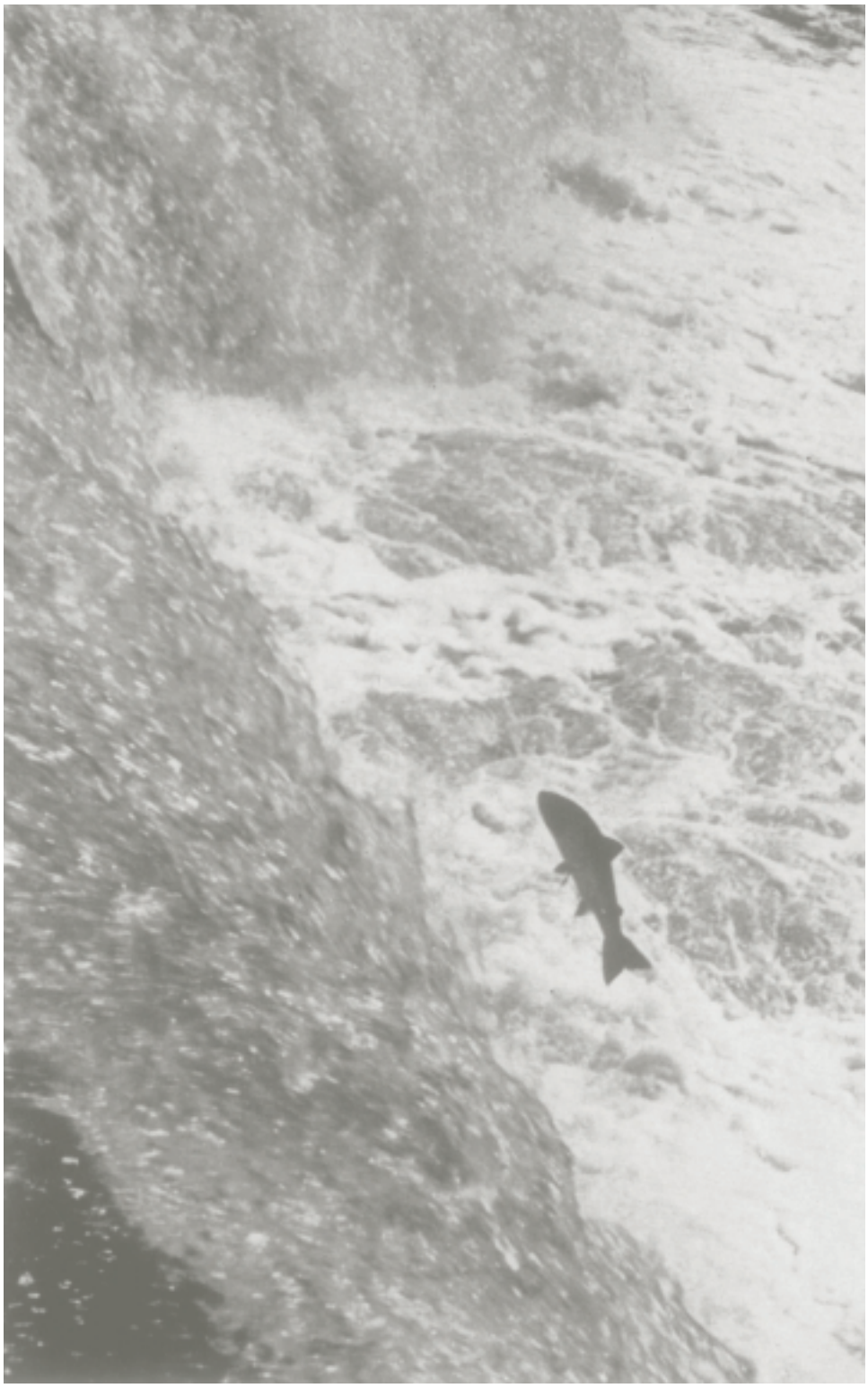

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As I see it, the lesson is clear: if the habitat is available and healthy, the salmon know how to recover. Should we breach one or more dams to save the salmon? That's not a question for a biologist to answer. The citizens of the Pacific Northwest will have to make that difficult choice after weighing the value they place on the salmon against the value they place on the dams. But if we are to recover the salmon, we need healthy rivers. We must give back to the salmon some of their habitat.

We cannot restore the salmon if the obstacles we have put in their path are beyond the capability of their own genetic resources. All the money in the world will not produce sustainable recovery as long as those obstacles remain in place.

— Jim Lichatowich, fishery biologist and author of the book ***Salmon Without Rivers***

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Acknowledgements

Many agencies, companies, and individuals provided invaluable data and technical assistance to the Coastal Conservancy in order to assist with this project, but special thanks are due to the California Department of Fish and Game (DFG), and others, who assisted greatly in this effort. DFG provided office space, equipment, and supplies for the staff assigned to data collection, standardization and presentation. This allowed for an unprecedented level of inter agency cooperation and collaboration, as well as cost savings, thereby ensuring a more thorough effort and facilitating future collaboration on this and other efforts.

DFG also provided the Coastal Conservancy's technical team with field notes and access to information on barriers that had been collected by regional biologists during the past several decades. This information was standardized and entered into the project database. In addition, DFG biologists spent a significant amount of time reviewing, correcting, and adding to PAD data. The many years of dedicated work by DFG's biological and enforcement divisions, and the provision of the data that they have collected, made this report far more comprehensive than it otherwise could have been.

The California Department of Water Resources (DWR) provided a wealth of data, expertise, and experience far beyond the scope of the interagency agreement developed for this project. DWR's State Bulletin 250, a fish passage improvement prescription for the CALFED solution area, helped guide the development of this report. The work of DWR staff in identifying opportunities for the improvement of fish passage within the CALFED boundaries provides a thorough and strategic examination of the potential for passage improvement projects within their project area. Bulletin 250 complements this report, and is an

important resource for partners seeking information with which to prioritize opportunities for fish passage improvement in the CALFED area, principally Central Valley and San Francisco Bay Area streams. DWR staff collected data, helped draft this report, and lent their extensive experience and guidance to the management of this project.

The California Department of Transportation (Caltrans) provided information regarding the many intersections of roads and streams throughout the State, as well as extremely useful background information on Caltrans' own fish passage improvement program.

All of the members of the Fish Passage Forum, an assembly of diverse agencies and interest groups, have assisted the Coastal Conservancy in this undertaking, either through their research, or by way of technical assistance and coordination in statewide fish passage improvement efforts.

Special thanks are due to the staff of the Institute for Fisheries Resources and of the Pacific States Marine Fisheries Commission, who labored under difficult conditions and severe time constraints to prepare this examination of barriers to fish passage in coastal watersheds. Their diligence, technical competence, energy, stamina, and innovation ensured the success of this project.

Finally, this report would have been far less comprehensive without the assistance of everyone who provided passage assessment data. For a complete list of data providers, see Appendix A(4).

Executive Summary

California's salmon, steelhead, and other species are vitally dependent on the ecological integrity of dozens of streams and rivers that flow into the Pacific Ocean along the State's 1,100-mile coastline. These streams provide habitat required by salmonids during the spawning and juvenile phases of their lives. However, the construction of roads, dams, bridges, water diversions, and other structures has fragmented that critical habitat, contributing to the decline of salmon and steelhead resources. Restoring fish populations depends on reopening that habitat through the improvement of fish passage and the modification or removal of barriers. Fish passage improvement depends, in turn, on the correct and rigorous identification of barriers within watersheds.

In order to help restore salmon and steelhead populations, the Conservancy conducted an extensive inventory of fish passage barriers in California's coastal watersheds. This inventory was made possible with an appropriation from the Salmon Habitat Restoration Program sponsored by Senator Byron Sher (D-Palo Alto), and was conducted in a fashion consistent with the Coastal Conservancy's 2003 Strategic Plan.

Some of the barrier data were collected from existing sources, while other barriers were identified in surveys commissioned by the Conservancy. The data were collected and standardized, and are now managed in a peer-reviewed database and GIS that is available for download at www.calfish.org where the barrier data can be displayed together with other fisheries and watershed datasets. This report and accompanying database represent the first comprehensive effort to inventory and assemble barrier information for the entire California coast. The Conservancy believes that this presentation of information will help to deepen our understanding of barriers in a broad-scale

geographic context and promote fish passage improvement projects throughout coastal watersheds.

Results

✣ The Coastal Conservancy has identified a total of 13,016 coastal fish passage assessment sites, a term used for the purposes of this report to define any location researched in the course of conducting this assessment. Of these sites, 3,323 are known to be passage barriers, 636 are known not to be barriers, and 9,057 require further examination or analysis to determine their passage status. *Of all known barriers, 175 are high-priority and 120 are moderate-priority for modification or removal.*

✣ Many data sources or areas remain unexamined, or were not examined as thoroughly as necessary. These include Caltrans records, DFG archives, the State Water Resources Control Board files, and a variety of public and private lands that require field surveys for fish passage assessment purposes.

✣ The ability to gain access to some data sources, such as sites adjacent to private lands but managed by Caltrans, or other structures located on private lands, is limited by the ability of State agency officials to gain access to private lands.

✣ The quality of data in this report is highly variable. Data were obtained from a wide variety of sources, each with its own set of standards and reasons for collecting barrier data. As a result, not all of the fields in the Passage Assessment Database (PAD) could be filled in for every potential barrier. Further assessment or analysis will be needed to refine the data gathered in this reconnaissance-level survey and to assure quality control of data expected to be collected and entered in the future.

✣ Reviewing barrier data in the context of other factors will help prioritize future restoration projects. In this report, potential barriers are displayed alongside ongoing and completed stream habitat restoration projects to demonstrate the importance of analyzing barrier data in context with other fisheries and aquatic data.

✣ Cooperation and coordination within the Fish Passage Forum has prompted an effort now underway to improve existing management and presentation of fisheries data, including barrier data, via the World Wide Web. Upon completion of this inventory, the Conservancy will convey all barrier data to its partners in the Forum, and work together with agencies, local public entities, non-governmental organizations,

and private citizens to improve and promote this new data management system, now known as CalFish.

✣ Analysis of the PAD indicates that some hydrologic units require further inventory to identify potential barrier sites, some require assessment of known passage assessment sites, and some require both. A few appear to require neither, but would benefit from immediate implementation of fish passage improvement projects. Table 2 on page 66 provides a summary by hydrologic unit of inventoried sites, known barriers, density of both by unit area, and other analyses useful for strategically directing future inventory, assessment, and fish passage improvement efforts.

Recommendations

✣ Fund 1) implementation of fish passage improvement projects, and 2) the collection, analysis and management of fish passage barrier data for all watersheds important to the recovery of anadromous fish resources. The second task requires personnel commitments and the conversion of all datasets that are not yet in the PAD to a usable format and a focus on filling in gaps where data are missing in the PAD. Coordination of these efforts between the members of the Fish Passage Forum [see Appendix C(1)] and its partners will achieve cost-savings and scales of economy through inter-agency partnerships and other forms of cooperation. Both State and federal sources should be pursued, including State and federal highway funds, Salmon Recovery Funds, and any other funding sources, including those particularly related to the maintenance or improvement of infrastructure that impedes fish passage.

✣ House fisheries management data, including this barrier data, in the same, easily accessible location to facilitate efforts to analyze watershed conditions more readily and in a broader context than is currently the case.

✣ Equip agency field staff with hand-held computers with GPS capability for the purpose of coordinated data entry into a standardized template. Future efforts to retrieve and analyze available data would be facilitated and enhanced by adopting such a template and means for data entry.

✣ Assess the passage status and severity of identified but unassessed passage assessment sites, such as those identified at Caltrans, the State Water Resources Control Board, the Department of Water Resources Division of Safety of Dams, and located on public and private lands.

- Allocate sufficient staff to landowner outreach efforts to ensure appropriately high response rates for gaining access to private land for fish passage assessment efforts.

- Work with Forum members to craft "safe-harbor" guidelines that would encourage private landowners to participate in fish passage barrier identification and improvement projects.

- Include barrier inventory or assessment components in the design of all future watershed assessment projects, unless it is demonstrated that such inventories or assessments have already been conducted.

- Review barrier data in the context of other factors to help prioritize restoration projects in the future.

- Launch an extensive public outreach campaign designed to educate barrier owners about the opportunities available for assistance with fish passage improvement projects, including funding and technical assistance.

- Promote the Fish Passage Forum as a clearinghouse and venue for the exchange of information and strategic planning for fish passage improvement projects. Doing so will increase efficiency and reduce costs of projects by promoting the directed collection of information and the appropriate prioritization of effort.

- Support the publication of various manuals providing instructions for fish passage improvement and engineering design.

- Ratify the Fish Passage Forum's Memorandum of Understanding [Appendix C(1)(a)], and proceed with the implementation of assignments identified in the Forum's annual work plan [Appendix C(1)(b)].

- Fish passage improvement proponents are urged to review the information in this report and accompanying PAD, particularly Table 2 on page 66 prior to initiating future inventory, assessment, and fish passage improvement efforts. The information distilled in this table will help guide the strategic selection of activities and watersheds requiring attention. For example, some hydrologic units require further inventory to identify potential barrier sites, some require assessment of known passage assessment sites, and some require both. A few appear to require neither, but would benefit from immediate implementation of fish passage improvement projects.

Introduction

This report is a first attempt to inventory and present in a widely accessible format all known barriers to fish passage in California's coastal watersheds as well as opportunities to promote fish passage improvement efforts. The report and accompanying database also synthesize and present some readily accessible data from outside coastal watersheds.

During the 19th and 20th centuries, as roads, bridges, and dams were built on public and private lands along the streams, and as water was diverted by various means, thousands of barriers to fish passage were erected, blocking the passage of anadromous fish, and fragmenting aquatic habitat. Consequently many salmon, steelhead, and cutthroat trout populations have declined drastically, and the sport and commercial fisheries that depended on these populations have either shrank, or vanished.

In recognition of the importance of these fishery resources, and the local economies that depend upon them, the State has taken many steps to reverse the decline.

In 1988 the State Legislature passed The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act (SB-2261), which made it a State policy to significantly increase the natural production of salmon and steelhead. SB-2261 directed the Department of Fish and Game (DFG) to develop a program that would strive to double naturally spawning anadromous fish populations by the year 2000.

DFG has since funded many habitat restoration projects to accomplish the goal outlined in SB-2261. Nevertheless, recovery has proven elusive, and population declines have continued. Increasing numbers of anadromous salmonids have achieved the dubious distinction of being listed on either the State or federal endangered species lists, and many populations have been extirpated.

Because barriers preventing passage to upstream spawning grounds are among the most serious limitations to species recovery, DFG included restoration of lost access to historic habitat among five strategies for California steelhead management. DFG, the Coastal Conservancy, local governments, tribal governments, and a host of other governmental agencies and private, non-profit organizations have worked toward this goal during the last half-century.

In 2001, the California Resources Agency established the eight-point California Coastal Salmon and Watersheds Program, which called for the coordination of State, federal, and local partners working toward the goal of restoring salmon and steelhead populations to naturally sustainable levels. This coordination requirement led to the establishment of the Fish Passage Forum (Forum), a stakeholder group, of which the Coastal Conservancy is a member. A detailed description of this association, its members, and its mission follows in Appendix C(1).

Big River at Montgomery Woods State Park. Historically, coastal streams in California, such as the Big River, hosted abundant runs of anadromous fish, populations now remnant or absent.
(John Mullin photo)

Following the passage of Proposition 12, the Safe Neighborhood Parks, Clean Water, Clean Air, and Coastal Protection Bond, and concurrent with the establishment of the Fish Passage Forum, the State Legislature included in the Fiscal Year '01–'02 budget an allocation of $750,000 to the Coastal Conservancy from the Salmon Restoration Program Component of that bond. The appropriations language advised the Coastal Conservancy to conduct an "inventory of fish passage barriers located on coastal streams that impede access to freshwater spawning habitats for anadromous fish species." The inventory is to be used to identify barriers suitable for decommissioning, demolition, removal, or modification for the purpose of restoring spawning and riparian habitat for anadromous fish, and to enhance aquatic and riparian habitat.

This report identifies 3,323 known and 9,057 potential fish passage barriers in California coastal watersheds. These numbers, though high, most likely represent a fraction of the universe of sites potentially impairing passage for anadromous fish and other aquatic species. For example, few private lands have been assessed for barriers to fish passage.

Introduction

The Coastal Conservancy undertook this project while continuing to assist the ongoing efforts of the Fish Passage Forum to coordinate the work of the governmental and non-profit entities that are working toward the shared goal of facilitating anadromous fish passage. In this report, the Coastal Conservancy presents the results of its effort to implement the legislative mandate to produce an inventory of coastal stream barriers to fish passage.

Field work is the only sure way to identify all barriers to fish passage. These sites on the Sisquoc River (top) and Terwer Creek (bottom) were newly identified in recent surveys.
(Matt Stoecker (top) and Dan Gale (bottom) photos)

In this document, the Coastal Conservancy:

1) Summarizes the findings of the barrier inventory and analyzes the contents of the Passage Assessment Database (PAD), a database created to collect, collate, standardize, and synthesize available data relating to fish passage barriers in coastal watersheds;

2) makes a series of findings and recommendations developed in conjunction with the Fish Passage Forum members and designed to promote greater coordination and cooperation for fish passage improvement projects, and;

3) presents barrier data in an easily accessible electronic format that allows Fish Passage Forum members and others to identify and select for implementation fish passage improvement projects in coastal watersheds.

The project was conducted in four phases. Phase I involved identifying and contacting all individuals and organizations that might have information about fish passage barriers. A summary of the Phase I report is available in Appendix C(3) of this report.

Phase II entailed collecting data from the sources identified in Phase I as well as from newly identified sources in order to identify potential barriers to fish passage in coastal watersheds. This phase is ongoing, and concurrent with Phase III, below.

Phase III consisted of: a) assembling a team of data technicians and Geographic Information System (GIS) experts; b) developing the PAD structure to house available data, including peer review and approval of the structure by the Fish Passage Forum's data subgroup; and, c) outreach to agency officials, non-profits, anglers, and others to collect additional data on barriers to fish passage.

As the data team identified areas where data were lacking, the Coastal Conservancy contracted with biologists and field crews working in selected areas to conduct watershed assessments and inventories. These projects, which included data collection of both habitat and barriers, helped fill in the data gaps on a number of coastal watersheds. Several assessments, including those of Marin County coastal streams, Lower Klamath River tributaries, and the Sisquoc River are complete.

In Phase III, the Coastal Conservancy's team of data technicians and GIS experts standardized the data and entered it into the database. In order to improve the data in the PAD, the data team also visited with a variety of data sources including regional DFG biologists and other State and federal officials. The biologists checked passage assessment sites that were already in the database and provided up-to-date information about those sites as well as adding new sites that were not yet in the database.

The PAD data are now available for initial presentation and analysis in GIS layers and periodic updates are available for download at www.calfish.org where the barrier data can be displayed together with other fisheries and watershed datasets. The data team also helped craft this report and its findings. A compact disk containing all of the assembled data is available upon request. For copies, please contact Michael Bowen at mbowen@scc.ca.gov.

Phase IV, the project development phase, is ongoing, and the Conservancy is working with many local partners on fish passage improvement projects. This report will be widely distributed electronically and in hard copy to sister agencies and Coastal Conservancy partners in order to facilitate the development of more fish passage improvement projects. Chapter Three of this report explains the project development process, and how this inventory can assist with project development and implementation.

The hope is that this coast-wide report on barriers to fish passage will provide the Coastal Conservancy's many partners with a starting point from which they may undertake the difficult task of designing fish passage improvement projects. This important work will restore access to anadromous fish habitat in many coastal watersheds and, it is hoped, lead to the restoration of California's wild salmon and steelhead populations.

Background

What Is A Barrier?

Developing a working definition of a barrier has been a challenging task. Natural impediments to anadromy can range from steep slopes, waterfalls, and chutes to log and debris jams. Human-made, or "anthropogenic," features vary in size, shape, and type, as well as relative severity in their impediment to the free migration of anadromous salmonids. From the sandbar or tide gate, lowermost in the watershed and closest to the ocean, to the waterfall or dam at the uppermost extent of anadromy, all impediments are either natural or anthropogenic limits to the range of salmon and steelhead. Therefore, for the purposes of this report, a barrier is defined as any in-stream condition, feature, or structure that permanently or under certain conditions temporarily impedes the free passage of anadromous fish.

Appendix A(1) contains definitions of all barrier types included in the PAD. This list was peer-reviewed by the Data Subgroup of the Fish Passage Forum prior to use in this report. In cases where datasets included barriers of a type not included in this list, the type was listed as "Other" and the specific type was described in the comments field for those barrier records.

How Do Barriers Affect Coastal Watersheds?

Barriers to fish passage can have profoundly deleterious effects on coastal watersheds and the species that live there. Permanent barriers to fish movement result in habitat fragmentation and a vast reduction of available habitat for spawning and rearing. Other effects may include increased levels of sedimentation, turbidity, and predation, in addition to alteration of stream flows, degradation of stream channels, depletion of riparian areas, modification of water temperature regimes, and loss of habitat diversity and complexity. Barriers can also impair sediment

transport, diminishing the replenishment of sediments and sands to California's beaches.

The effects associated with the physical construction, maintenance, and even removal of barriers, and the cumulative effects of large numbers of structures within a watershed, pose significant risk to the recovery and long-term viability of listed salmon and steelhead populations within the State of California. Barriers have contributed to the decline of anadromous fish populations statewide. Appendix B(2) contains a table with an update of California and Federal Endangered Species Act status for California anadromous salmonids as of August 6, 2004.

Some barriers are clearly bad, while others are beneficial. Dams, such as Twitchell Dam on the Cuyama River (above), cut off important habitat and restrict flows below the dam. In contrast, sandbars at the mouths of estuaries (below) are beneficial in their contribution to conditions vital to the successful growth of juvenile salmonids, and other life forms dependent upon healthy coastal estuaries. The Gualala River estuary and sandbar is shown.

There is no direct correlation between the size of a barrier and its effect. The severity of a barrier depends on many factors including flow, channel configuration, and slope. Similarly, severity and permanence affect anadromous fish and other aquatic organisms in many ways and to varying degrees. The smallest series of culverts on an important spawning and rearing stream may cumulatively impair fish passage as severely as the largest dam. Both can represent permanent, impassable obstructions to the upstream and downstream movement of salmonids, and both hinder the recovery of California's salmon and steelhead populations.

Seemingly unrelated factors can profoundly affect the severity and permanence of a barrier. For example, free passage of anadromous salmonids through culverts requires specific water depths, but upstream diversions may be permitted without consideration to their effect on water depth, and hence fish passage, in culverts below the point of diversion. And although some sites identified in this report, particularly points of water diversion, present no direct physical limitation to the movement of aquatic organisms, their effects, such as reductions in stream flow or contributions to sub-optimal temperature conditions, may cause temporal barriers to fish passage. These barriers can cumulatively have severe impacts on aquatic resources and overall habitat quality. Since water diversions are often unpermitted and unrecorded, their cumulative effects on the recovery of salmon and steelhead are immensely difficult to quantify and characterize.

Barriers are best assessed in the context of overall watershed health, but it is also important to consider the habitat requirements of different salmonids and life stages; these requirements are summarized in Appendix B(1).

Results

Purpose and Goals

In recognition of the importance of California's once-abundant salmon and steelhead populations, the Coastal Conservancy, with funds specifically appropriated for the purpose, conducted an inventory of existing barriers to fish passage throughout the State. The inventory is to be used to identify barriers suitable for decommissioning, demolition, removal, or modification to restore spawning and riparian habitat for salmon and steelhead and to enhance aquatic and riparian habitat.

The authors of the report with valuable input from the members of the Fish Passage Forum, made every effort to ensure consistency with both the authorization of funds for this project and the Coastal Conservancy's 2003 Strategic Plan, which seeks to improve water quality, habitat and other coastal resources within coastal watersheds and the ocean. The Strategic Plan calls for the development of approximately 70 plans and projects that preserve and restore coastal watersheds and create river parkways.

Consistent with Goal 6, Objective A of the Conservancy's Strategic Plan, the study will allow the Conservancy and its partners to identify and implement projects that will increase available habitat for aquatic species, notably salmon and steelhead, by removing barriers to their free migration. By so doing, the Conservancy will ensure measurable increases in available habitat and, presumably, in anadromous fish populations within and above project areas. In order to ensure the success of this strategy, Conservancy staff will, in conjunction with future grantees, monitor the efficacy of the fish passage improvement projects recommended consistent with this report, and chronicle the degree of success at each site.

Project Overview

This project was divided into four phases. The Coastal Conservancy sought to:

1) Provide the first overview of the activities of individuals and local, State, and federal agencies concerned with the barriers on coastal streams;

2) collect, collate, standardize and synthesize all available data relating to barriers to fish passage in coastal watersheds;

3) present barrier data in an easily accessible and comprehensible way; and,

4) use the data to design, permit, and implement projects to improve fish passage throughout coastal watersheds. The goal of this undertaking is to expedite projects leading directly to the protection and restoration of the State's wild anadromous fishery resources.

Phase I of the project involved identifying and interviewing those individuals or agencies that have information about coastal barriers or are actually engaged in projects to restore fish passage and habitat in coastal streams. Phase I was an exploratory effort designed to expedite Phase II, a longer-term data collection project to identify sites potentially obstructing the passage of anadromous salmonids through coastal watersheds.

Phase II of the project involved further outreach to all of the data sources identified in the Phase I report. This outreach to the fisheries community and to agency officials was intended to collect available data on barriers to fish passage. Towards this end, the Conservancy assembled a team of data technicians and GIS experts to conduct outreach, assist in the collection and collation of data, and to enter the data into a database that has been peer reviewed and approved by the members of the Fish Passage Forum's Data Subgroup.

In Phase III of the project the Conservancy's team of data technicians and GIS experts standardized the data to present it in GIS layers easily accessible to any member of the public via the World Wide Web. The team also assisted with developing a hard copy of the report and a compact disk of the data, which are available upon request.

In selected areas where data were lacking, the Conservancy contracted with local biologists and field crews to conduct watershed inventories

The inventory of passage assessment sites may be as simple a process as the location of an instream structure, without any further analysis to determine whether or not that structure blocks fish passage. Assessment of a site is more detailed work that requires survey work and hydraulic assessment of a particular location and structure, usually to determine the severity of the barrier.

and assessments, thereby filling gaps in our understanding of the condition of coastal watersheds. In these instances barrier data were augmented by the collection of habitat data, thereby increasing the cost effectiveness of the exploratory efforts.

Despite the Conservancy's outreach efforts, however, a universe of untapped data in regional files, including information about barriers on many coastal streams, remains unexamined. For this reason, the data team has also been meeting with regional DFG biologists so that they can review and edit the data in the PAD. The biologists are providing up-to-date information about those sites as well as adding new sites not yet in the database. The Conservancy will commission additional surveys as needed in order to enhance the existing PAD data.

Upon completion of this report, and as the fourth phase of this undertaking, the Conservancy will continue to seek Board authorization of fish passage improvement projects, including barrier inventories and assessments, project selection, and targeted funding for planning, design, implementation, and monitoring of fish passage improvement projects. This document, in combination with the Conservancy's 2003 Strategic Plan, and in consultation with the members of the Fish Passage Forum and sister agency personnel, will help guide Conservancy staff and their partners in requests for the disbursement of funds for fish passage improvement projects throughout California's coastal watersheds.

Method

The Passage Assessment Database (PAD) was developed to provide a common framework for the collection, management, and analysis of potential barriers to fish passage in California streams. It is intended to capture basic information about each potential barrier to help identify and assess fish passage assessment sites on a statewide scale. The set of data fields included in the PAD was chosen to meet the needs of the Coastal Conservancy's barrier assessment program, and was reviewed and approved by the member agencies of the Fish Passage Forum. The PAD was designed to be flexible so that as the database grows, other modules may be added to increase data detail and complexity.

There are two main components of the PAD, the Passage table and the Datasets table. The Passage table contains or links to all of the core information about individual fish passage sites (potential barriers). For a complete list of passage information collected in the PAD, refer to Appendix A(2). The Datasets table contains one record for each source of data that is included in the PAD. There are thus many records in the Passage table corresponding to a single record in the Datasets table. The Datasets table contains information about the entire dataset, including the person and agency responsible. Also included in the Datasets table is a list of any other passage information that was provided in the original dataset but is not entered into the PAD because it is currently outside of the scope of this database. As a result, it will be possible to locate further information about records in the PAD if greater detail is desired. A background compact disk, complete with data sources, is available upon request.

The PAD incorporates the barrier ranking criteria recommended in Section IX of the California Salmonid Stream Habitat Restoration Manual published by the Department of Fish and Game. Terminology used for barrier status is also consistent with Section IX. Section IX is attached as Appendix C(2).

The PAD is intended to be compatible with a variety of other data sources related to anadromous fish issues. All potential barriers are identified with geographic location information. With few exceptions [see Data Quality and Limitations discussion in Appendix A(2)], all locations are stored in a shapefile. This file can be used to represent the potential barriers on maps or to provide latitude/longitude coordinates. Digitizing the potential barriers along the streams in which they are located creates the shapefile. Because each potential barrier is referenced to standardized maps of the boundaries of water bodies (hydrography), it is very easy to combine the PAD data with other fisheries data tied to the same hydrography.

The base for digitizing most structures and sites in the PAD is 1:100,000 (1:100K) hydrography. Each stream in the hydrography is routed and identified with a unique identification number. Structure/site locations are stored as "addresses" along the hydrography, referenced with the stream's unique ID and their distance from its mouth. This process helps standardize the many different data formats that are brought together in the PAD.

Collected data characterizing the location of passage assessment sites often requires adjustment to accurately depict the site location on a map. For example data for dams may depict the site hundreds of feet

from the stream channel. In other cases, tributaries are too small to be represented in 100K-scale hydrography. In the interest of standardizing data, data relating to the potential barriers are stored simply as shapefiles with no reference to the hydrography. This means that all digitized structures/sites can be included on maps and in analyses, but that 310 non-digitized sites do not appear on the maps included in this report.

Locations are digitized in 100K streams using a pair of customized ArcView extensions. One extension allows single points to be entered one by one using hard-copy maps or text descriptions of the site as reference. The other extension automatically relocates the sites to the nearest water body, or "snaps" entire datasets of points to the 100K hydrography from existing shapefiles. Points are snapped to the nearest stream within a set distance.

Datasets with location information in latitude/longitude coordinates collected using Global Positioning Systems (GPS) were processed by converting the GPS coordinates to decimal degrees and then snapping these points to the 100K hydrography.

All geographic data that are received for use in the PAD are saved in their original format as well as in their final standardized format. If there are any problems with the PAD data, it will always be possible to return to the original dataset for a solution.

Complete database documentation and a discussion of data quality and limitations are included in Appendix A(2).

Results

✣ This report has identified 13,016 anadromous fish passage assessment sites in California's coastal watersheds. Undoubtedly many more potential barriers exist that have not yet been surveyed or added to the PAD. Similarly, some identified barriers may no longer exist. The following results are based on the current holdings of the PAD, which is continuously being updated.

✣ In addition to the 13,016 passage assessment sites in the database, 7,284 interior stream sites have been included in the PAD. In the interest of disseminating as much information as possible, these data have been included for reference purposes. The non-coastal data are mostly from the Sacramento River system and the National Inventory of Dams dataset. These Central Valley data arrived in easily converted formats, and were sometimes included with other data sets. Therefore,

it was sometimes easier to include these data than to exclude them. The inclusion of this data should not imply that the Conservancy has conducted a thorough examination of barrier data sources outside of coastal watersheds. However, the data points demonstrate the extent to which historic anadromous fish habitat has been blocked by the construction of large-scale dams. Central Valley streams are more thoroughly examined in the joint DFG-DWR Bulletin 250, a useful tool for identifying fish passage improvement possibilities in the Central Valley and CALFED region.

✣ Of the 13,016 passage assessment sites in the database, 3,323 are known to be total or partial barriers to anadromous fish passage, and an additional 636 sites are known not to be barriers. The other 9,057 sites are of unknown passage status. More data analysis, field-testing, and verification are necessary to assess the status of these sites and to determine if they are impairing passage of anadromous salmonids. Field testing consistent with Section IX of the California Salmonid Stream Habitat Restoration Manual and the NOAA Fisheries Passage Protocol, both of which are included in Appendix C(2) of this report, is recommended.

✣ In addition to the 13,016 coastal passage assessment sites in the PAD there are at least an additional 9,912 potential stream crossings (and therefore potential barriers to fish passage) at sites owned or managed by Caltrans. The estimated number of Caltrans road/stream crossings on coastal watersheds is 3,684. Due to data quality concerns, the data received from Caltrans require substantial analysis prior to addition to the database, and most of the sites require assessment to determine whether or not they constitute barriers to fish passage.

✣ There are a number of limitations to the data currently in the PAD. These include records that may be duplicate records for which there is currently no location information, and records with incomplete information regarding barrier status. For a complete discussion of data quality and limitations, see Appendix A(2).

✣ Analysis of the PAD indicates that some hydrologic units require further inventory to identify potential barrier sites, some require assessment of known passage assessment sites, and some require both. A few appear to require neither, but would benefit from immediate implementation of fish passage improvement projects. Table 2 on page 66 provides a summary by hydrologic unit of inventoried sites, known barriers, density of both by unit area, and other analyses useful for strategically directing future inventory, assessment, and fish passage improvement efforts.

Results

✣ Among the passage assessment sites inventoried and assessed a minimum of 175 high-priority total barriers to fish passage and 120 high-priority partial/temporal barriers to fish passage warrant immediate attention. These barriers require modification or removal for the purpose of improving fish passage and thereby helping to restore California's wild anadromous fisheries. The regional breakdown of these sites is identified in Table 1 below.

	NORTH COAST	BAY AREA	CENTRAL COAST	SOUTH COAST	STATEWIDE COASTAL
TOTAL BARRIER ARTIFICIAL	**487**	**74**	**273**	**164**	**998**
Dam	60	37	118	133	
Stream crossing	400	33	94	27	
Diversion	1		2		
Logjam	20	1	27		
Others	6	3	32	4	
TOTAL BARRIER NATURAL	**477**	**3**	**268**	**21**	**769**
HIGH-PRIORITY ARTIFICIAL TOTAL BARRIERS	**65**	**8**	**91**	**11**	**175**
PARTIAL/TEMPORAL BARRIER ARTIFICIAL	**588**	**86**	**583**	**74**	**1331**
Dam	62	40	130	9	
Stream crossing	474	36	233	60	
Diversion	1		2		
Logjam	22	7	64		
Others	29	3	154	5	
HIGH-PRIORITY PARTIAL/TEMPORAL BARRIERS ARTIFICIAL	**16**	**8**	**76**	**20**	**120**

Table 1. High-priority PAD Records as Specified by Data Sources

Maps

The PAD was used to create a series of maps that illustrate the data in the database at several different geographic scales. These maps, beginning on page 19, depict the large number of potential barriers, as well as showing gaps in the data and areas where much more barrier survey work must be done. However, before future assessments are commissioned, data from each watershed should be examined, both qualitatively and quantitatively. It does not follow that a large number of data

sources indicates a wealth of data, nor does a small number of data sources indicate a paucity of data.

Not all potential barriers in the PAD are represented on the maps. This is due to a lack of usable location information in the some of the original datasets. Of the 20,300 total statewide passage assessment sites in the database, 19,990 could be digitized and used in the maps. Correcting this deficiency will be a top priority for the authors of this report.

Statewide

Two maps were prepared to provide a statewide perspective on the barrier data collected in the PAD. The first map (Figure 1) represents the relative numbers of digitized inventoried sites in each watershed in California. The second (Figure 2) shows the relative numbers of known barriers in each watershed. Also included on each map is a chart showing the total number of each type of potential barrier site in the entire database. The list of passage site types is condensed from the list of types in the PAD in order to increase map readability. The passage site type categories displayed in the maps are as follows:

- Dam — earthen, rock, concrete dams, and tidegates

- Stream Crossing — includes road and utility crossings

- Water Diversion — includes screened and unscreened diversions

- Non-Structural Sites — includes log jams, waterfalls, natural grade changes, temperatures, insufficient or subterranean flows, landslides, velocity barriers.

- Fish Passage Facility — fishways, fish ladders

- Other Sites — includes flood control channels, grade control channels, flow measurement weirs, bedrock chutes, and gravel/borrow pits

- Unknown Sites — includes sites whose types were not identified in the original datasets

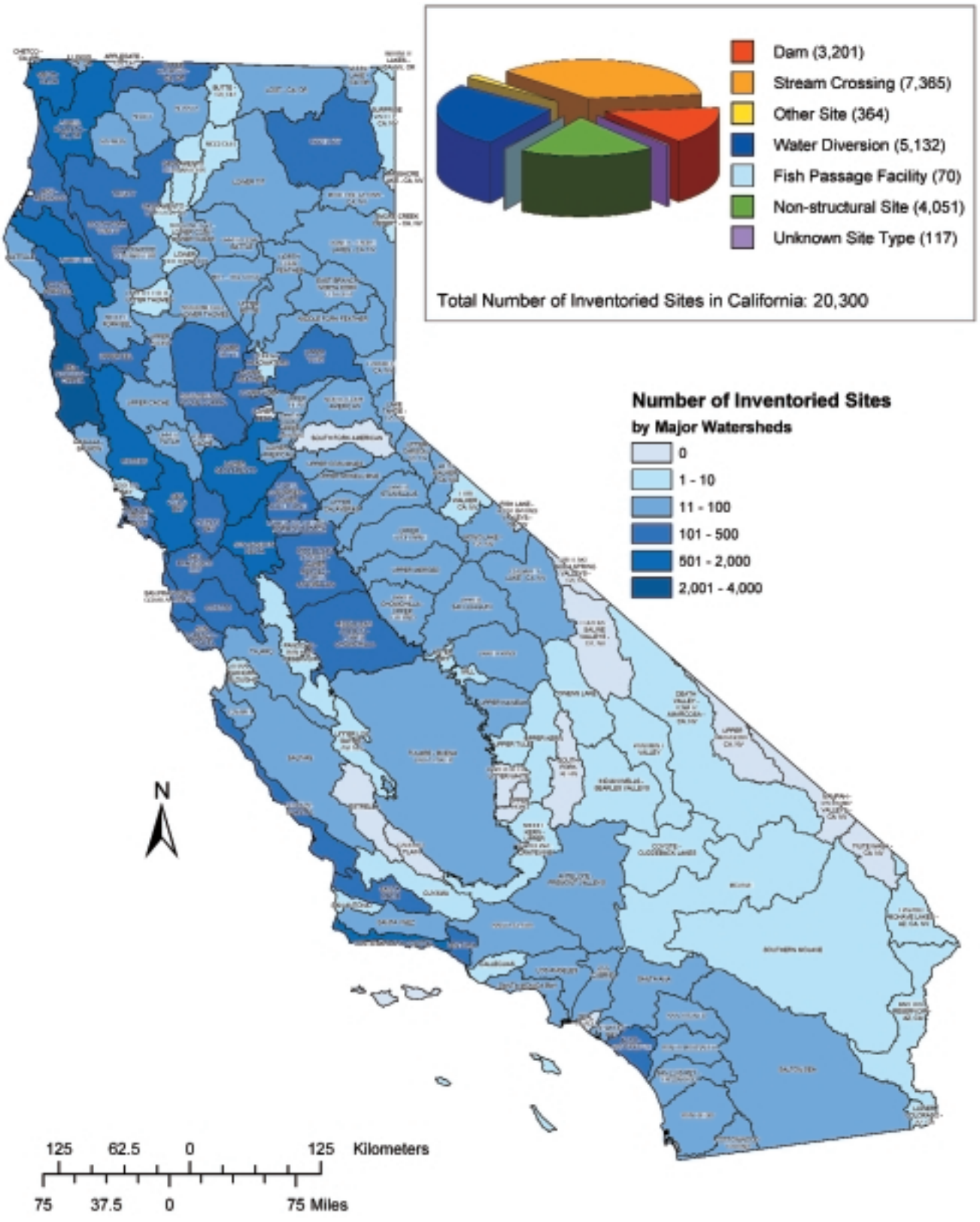


Figure 1. Fish Passage Barrier Assessment: Inventoried Sites in California Watersheds

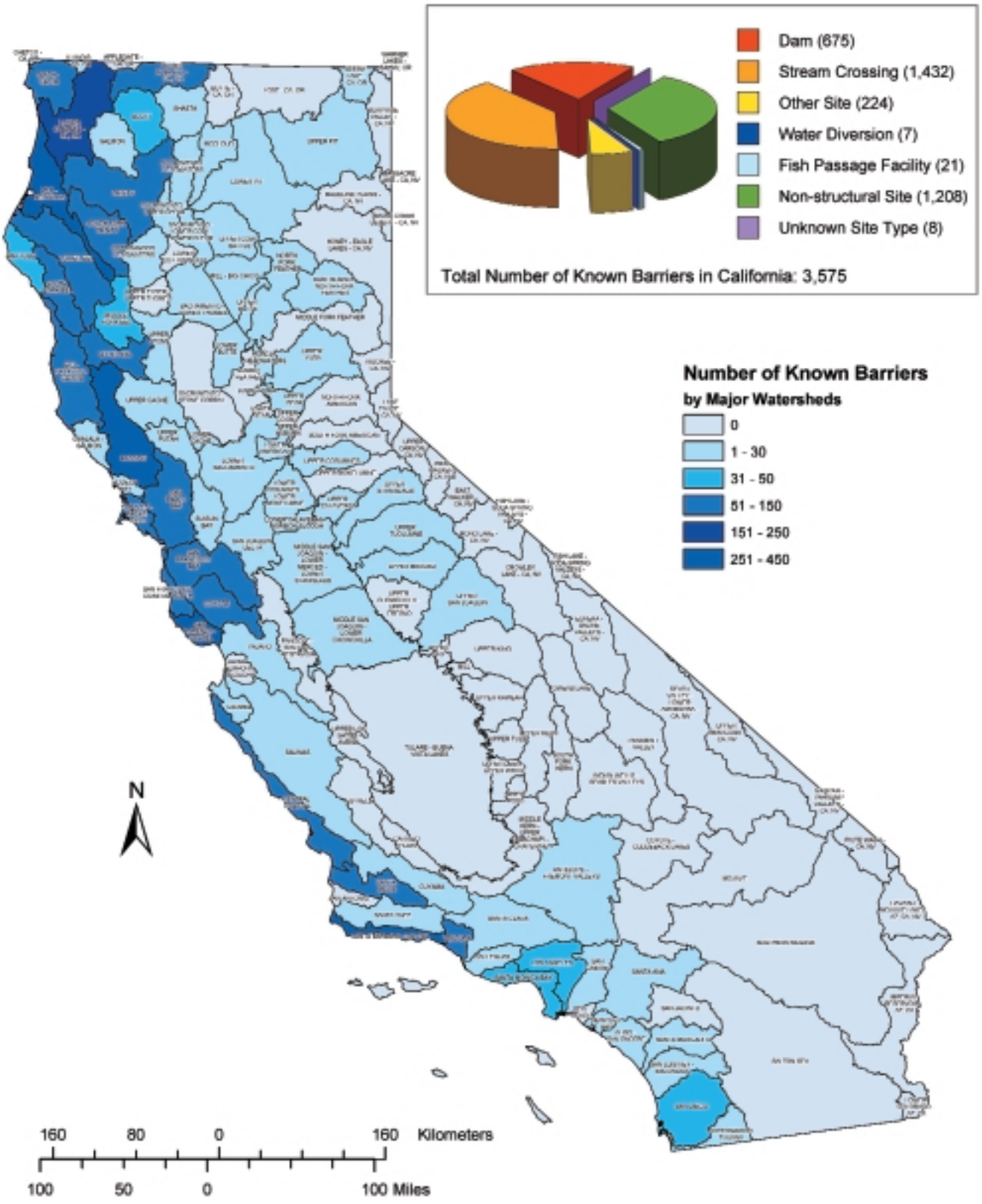


Figure 2. Fish Passage Barrier Assessment: Known Barriers in California Watersheds

Results

Regional

The next series of maps presents a regional perspective on fish passage barriers identified in the PAD. For each of four coastal regions — the North Coast, Bay Area, Central Coast and South Coast — two maps were created. The first set of maps shows all inventoried passage sites in

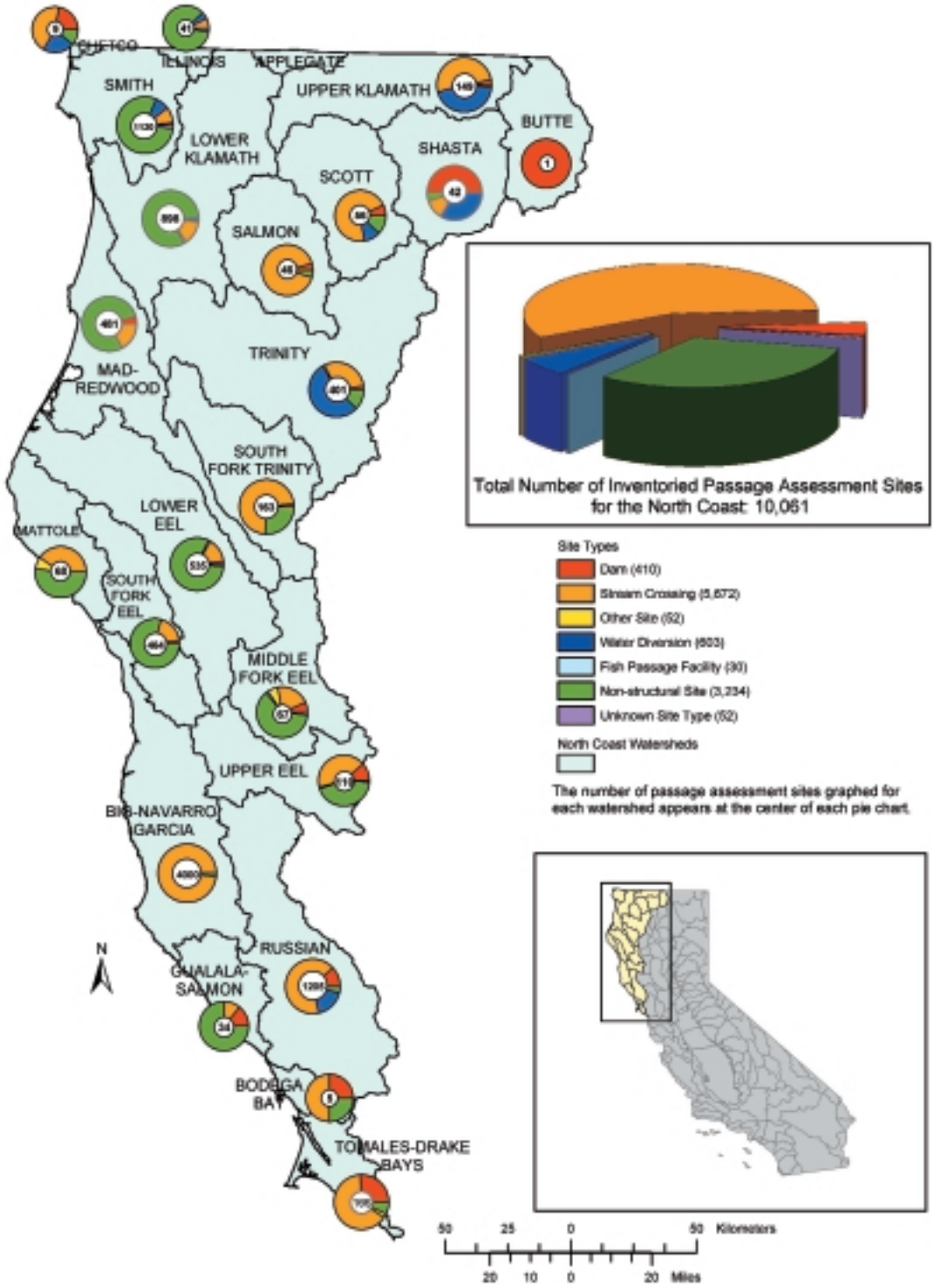


Figure 3. Fish Passage Barrier Assessment: Inventoried Sites in North Coastal Watersheds

the database, summarized by type in each watershed (Figures 3, 5, 7, 9). The second set of maps shows only barriers that are known to totally or partially prevent fish passage (Figures 4, 6, 8, 10). Passage site type categories are as described above for the statewide maps.

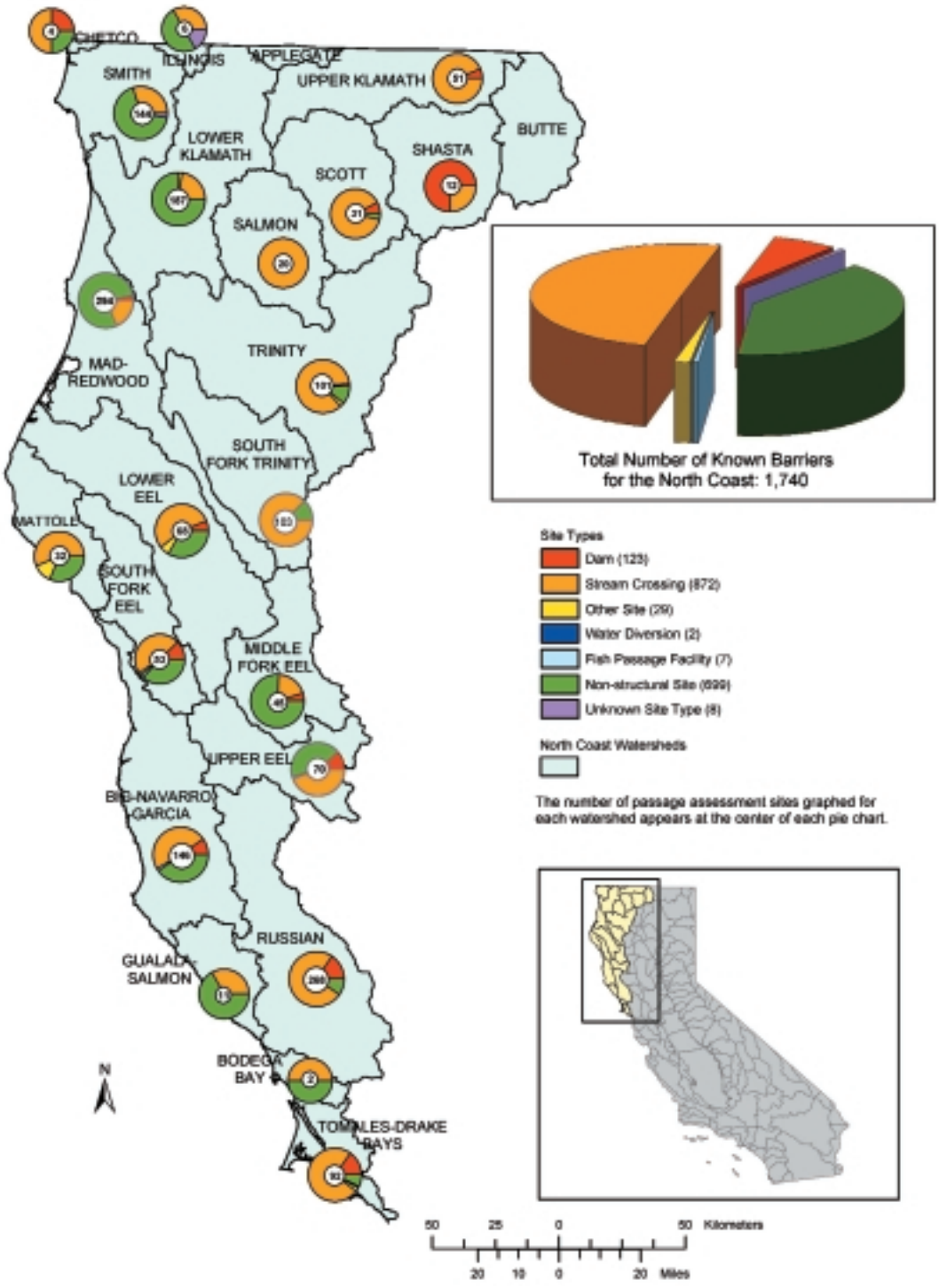


Figure 4.
Fish Passage Barrier Assessment: Known Barriers in North Coastal Watersheds

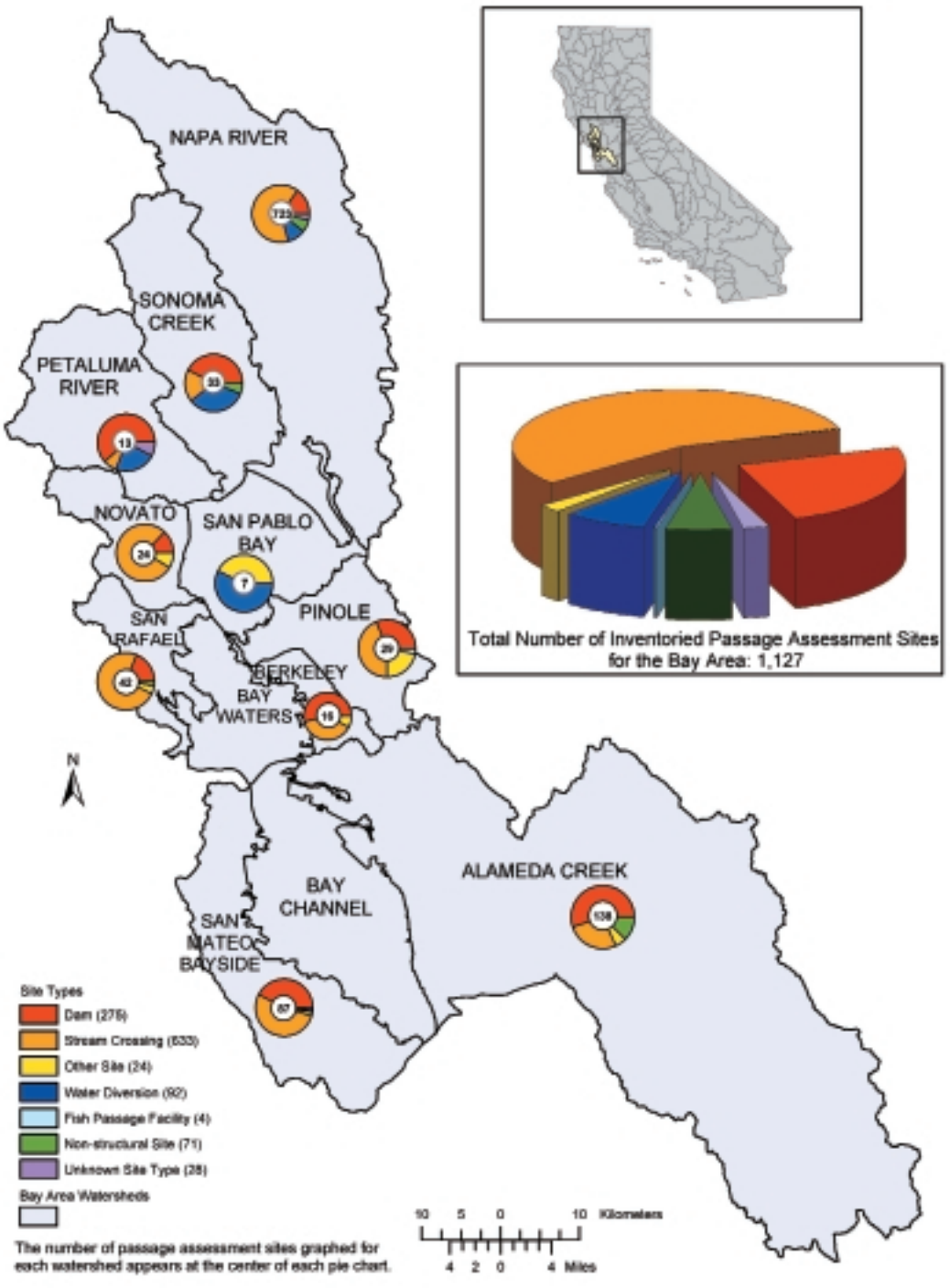


Figure 5. Fish Passage Barrier Assessment: Inventoried Sites in Bay Area Watersheds

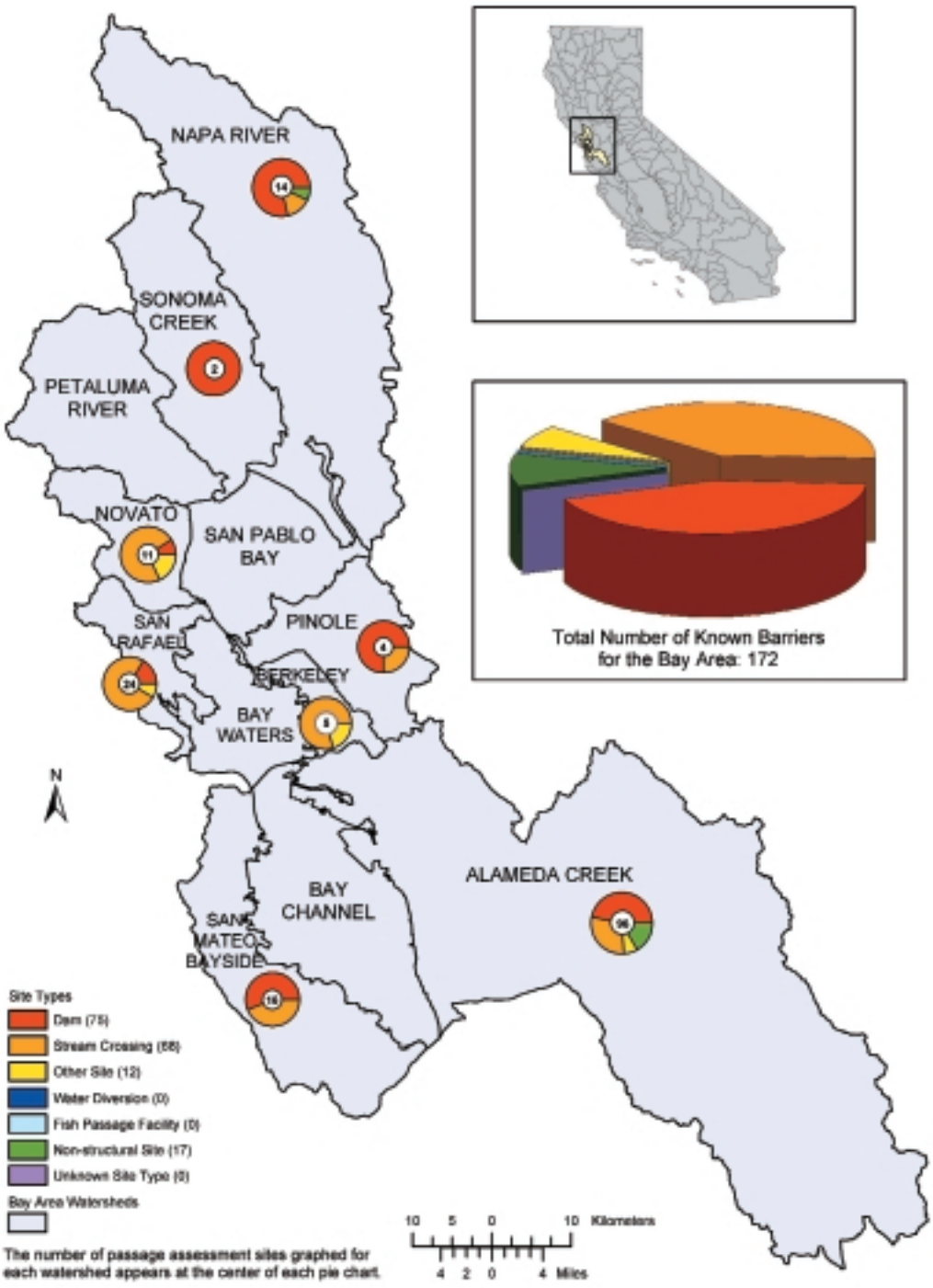


Figure 6.
Fish Passage Barrier Assessment: Known Barriers in Bay Area Watersheds

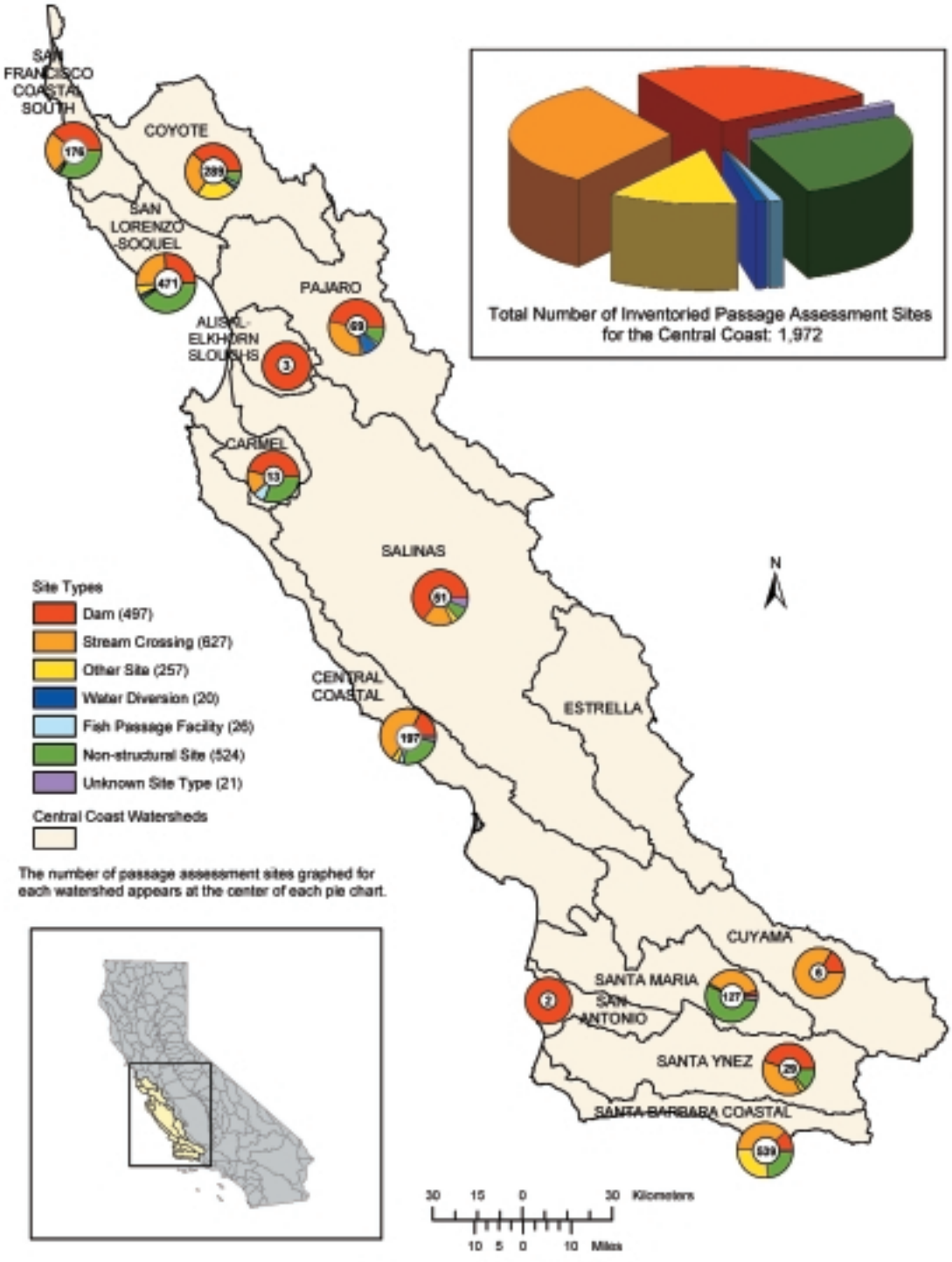


Figure 7. Fish Passage Barrier Assessment: Inventoried Sites in Central Coastal Watersheds

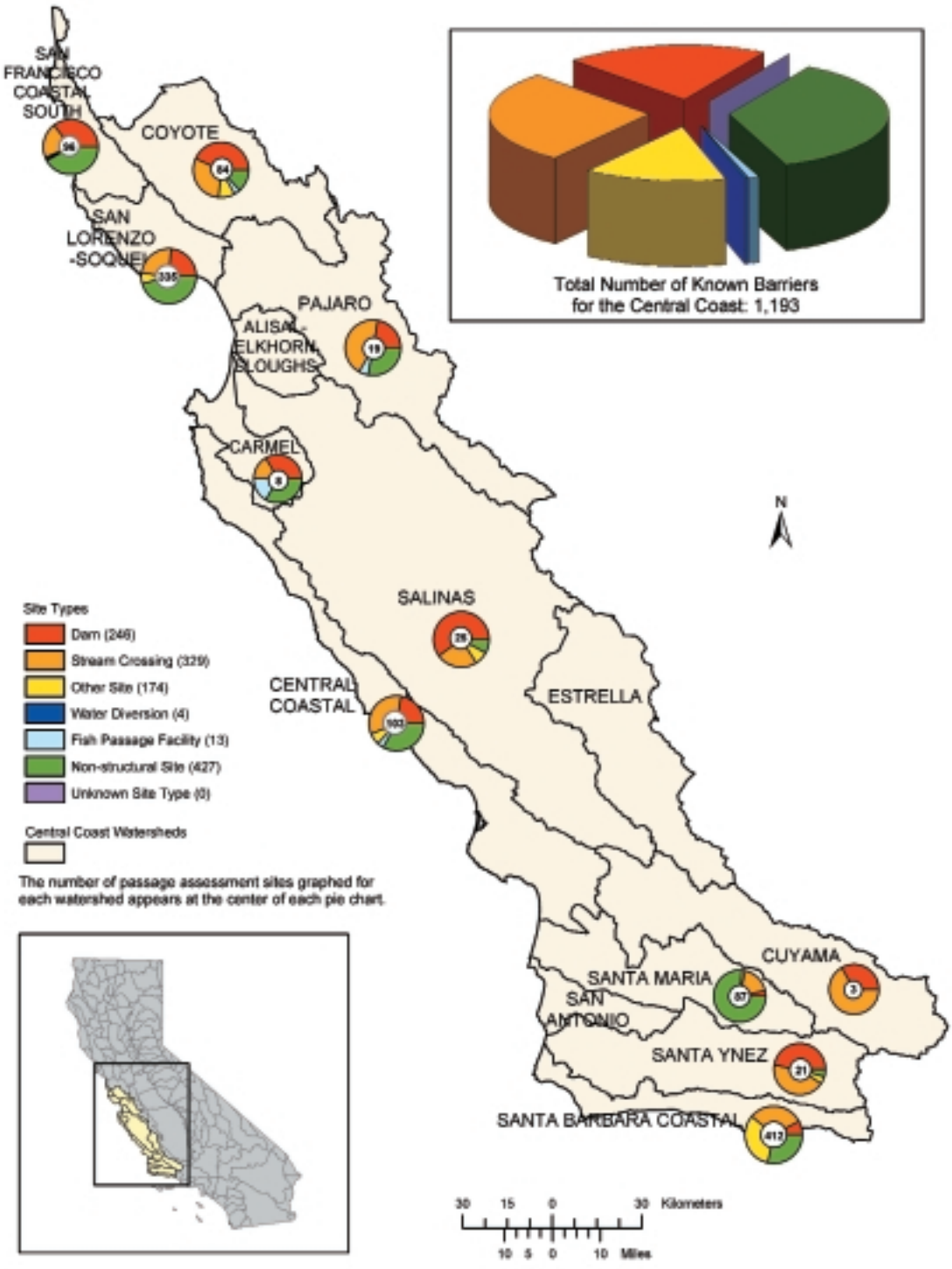


Figure 8.
Fish Passage Barrier Assessment: Known Barrier in Central Coastal Watersheds

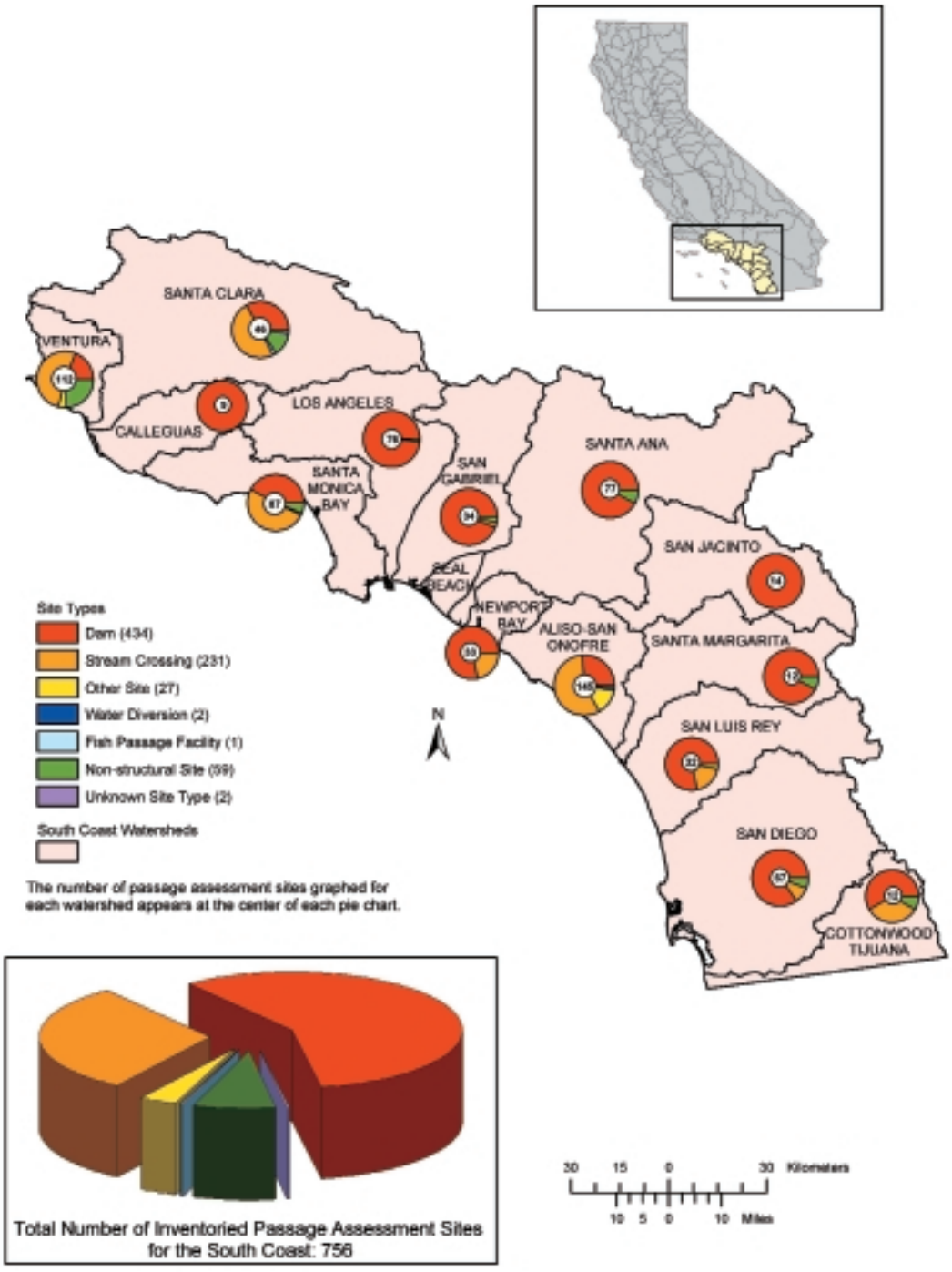


Figure 9. Fish Passage Barrier Assessment: Inventoried Sites in South Coastal Watersheds

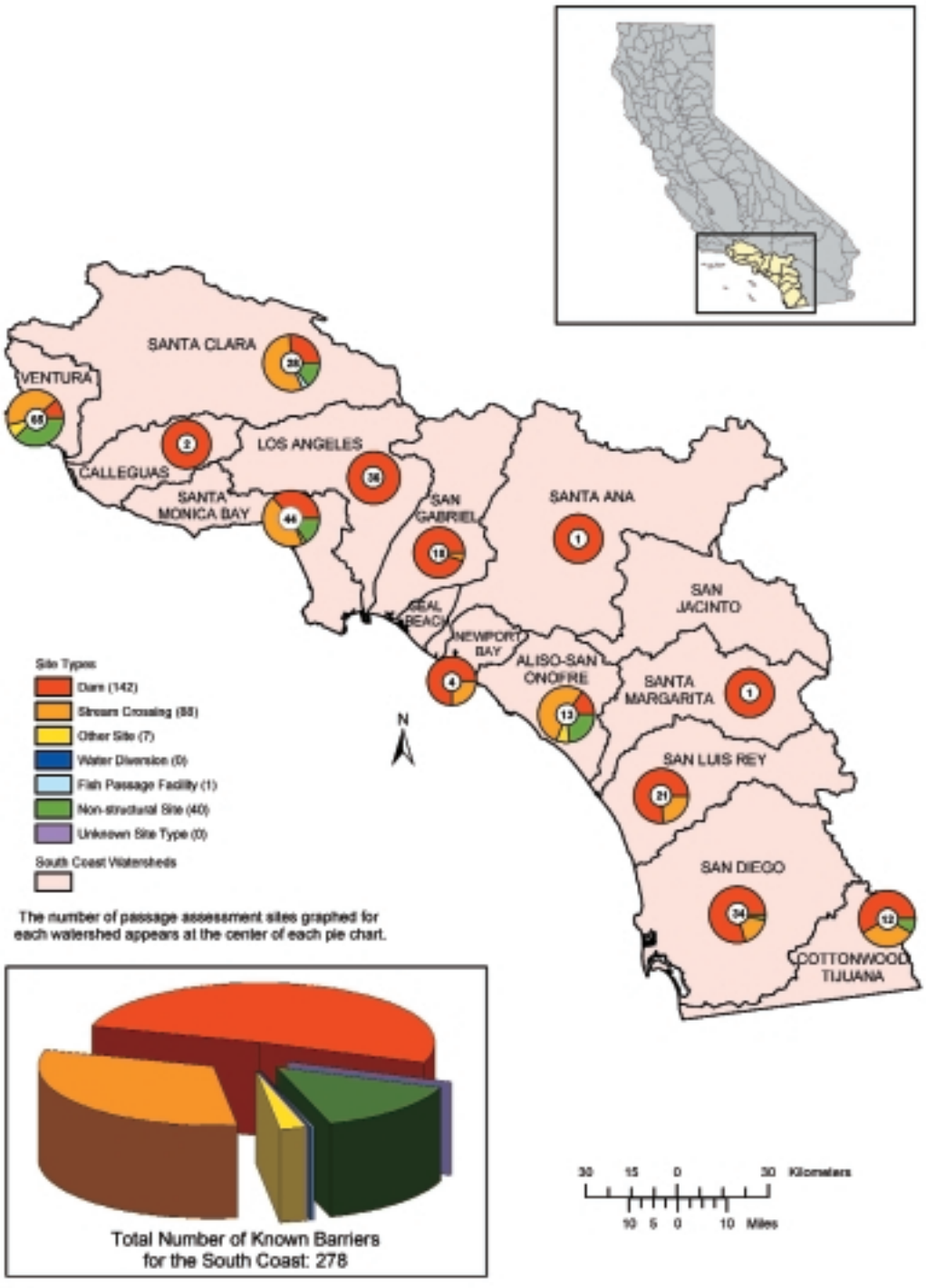


Figure 10.
Fish Passage Barrier Assessment: Known Barriers in South Coastal Watersheds

Results

Watershed

Fish passage data are available for review at any level of detail in the accompanying database. Further detail from data received for this effort will also be made available to interested parties. The following maps illustrate the data on an individual watershed basis. One hydrologic unit from each region has been selected as a sample to illustrate

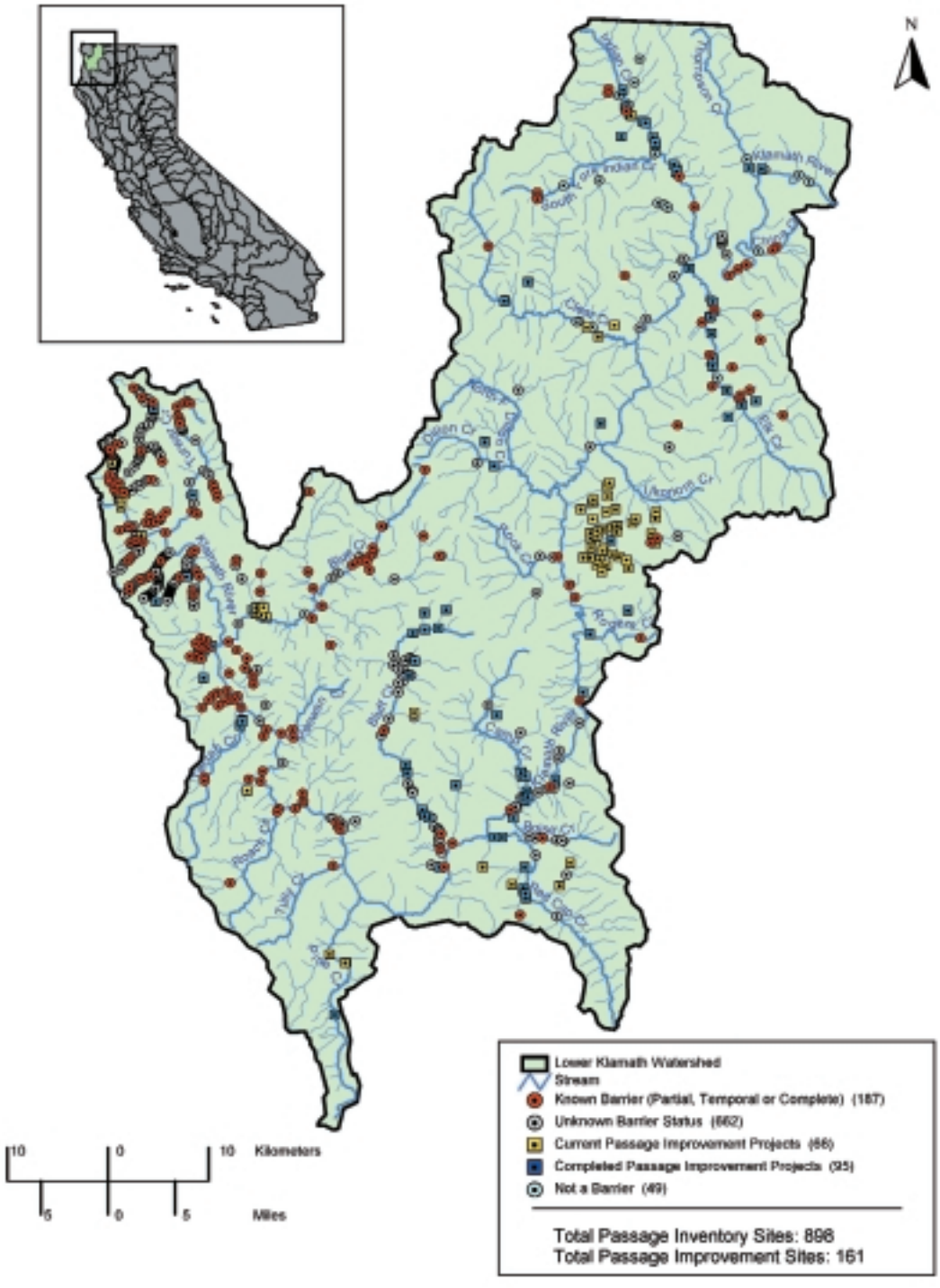


Figure 11. Fish Passage Barrier Assessment: Inventoried Sites in the Lower Klamath Watershed

the scope and nature of barriers to fish passage in specific coastal watersheds. Included on these maps are points representing fish passage improvement projects from the California Habitat Restoration Project Database (see Appendix A(3) for database description). These maps demonstrate the value of analyzing barrier data in conjunction with related fish and aquatic habitat datasets.

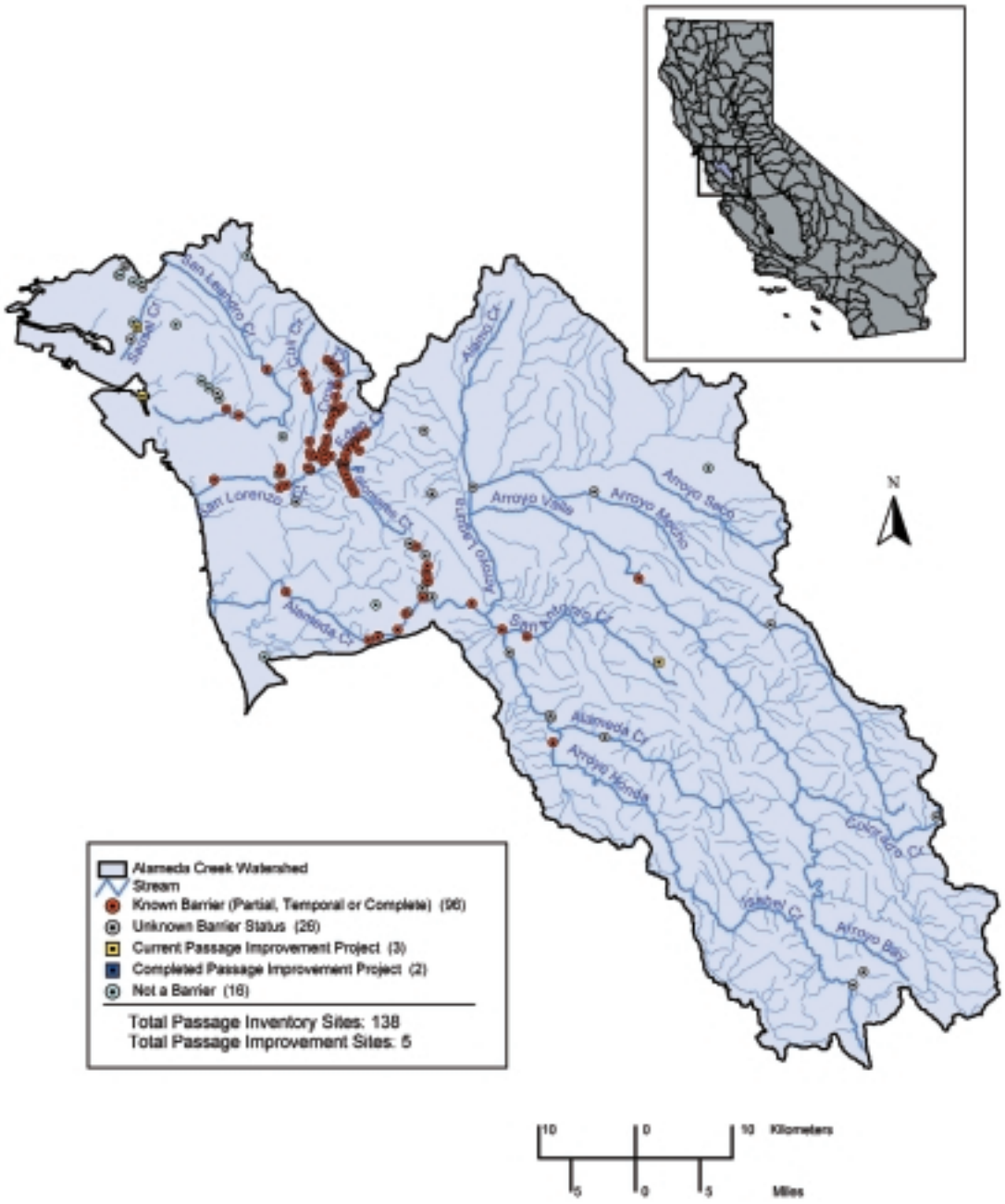


Figure 12.
Fish Passage Barrier Assessment: Inventoried Sites in the Alameda Watershed

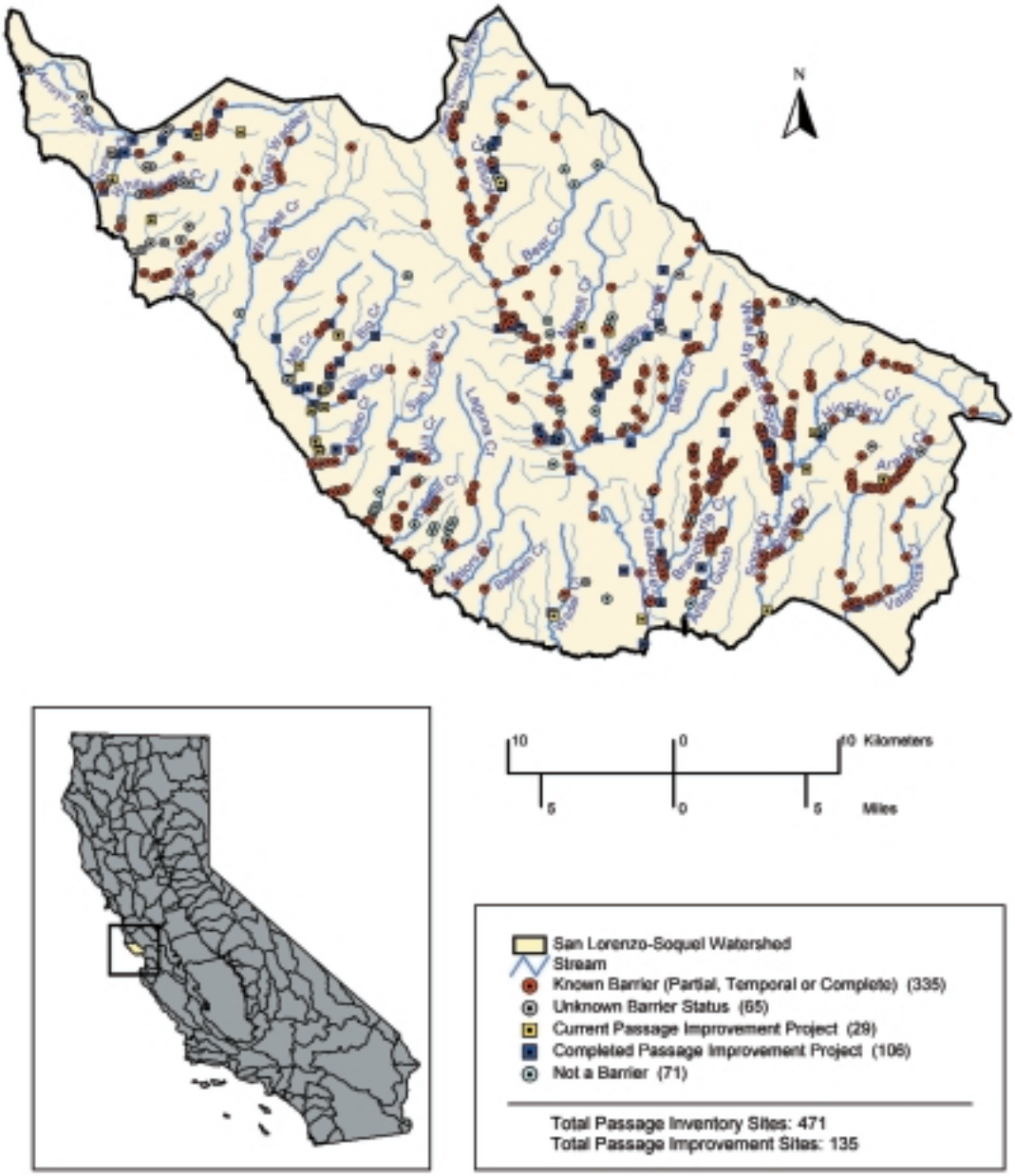


Figure 13. Fish Passage Barrier Assessment: Inventoried Sites in the San Lorenzo-Soquel Watershed

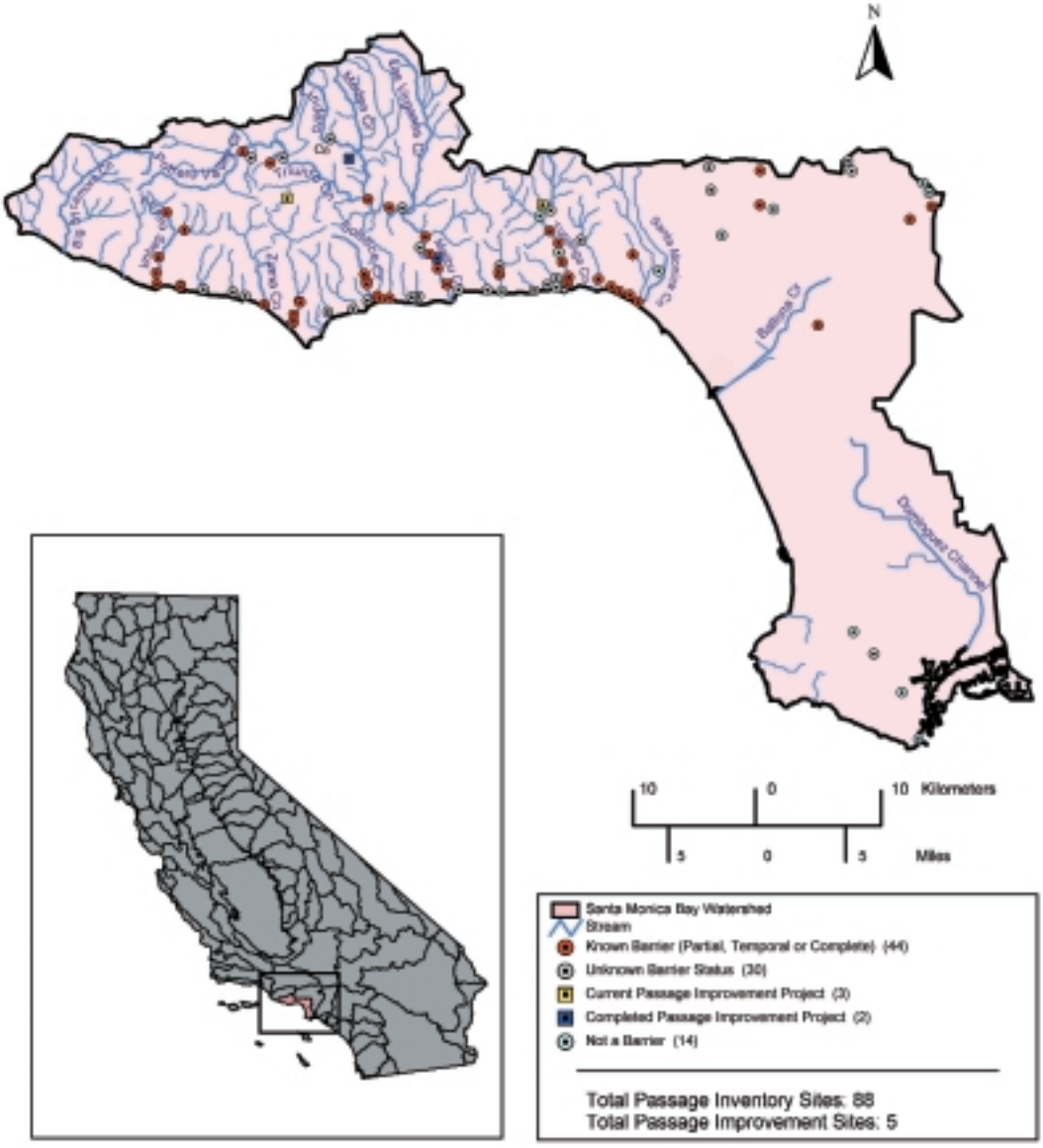


Figure 14.
Fish Passage Barrier Assessment: Inventoried Sites in the Santa Monica Bay Watershed

Sample Barrier Data and Regional Highlights

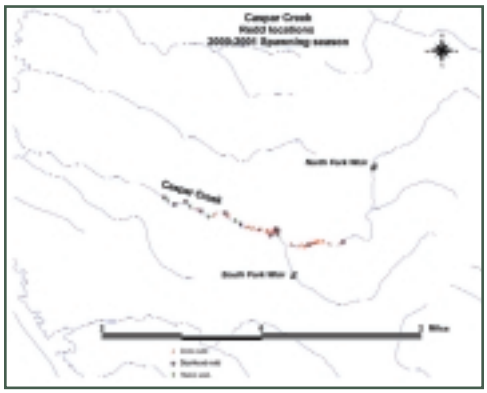
As described above, barriers to fish passage come in many shapes and sizes. The following images and data from the Fish Passage Assessment Database illustrate sample barriers for each California region.

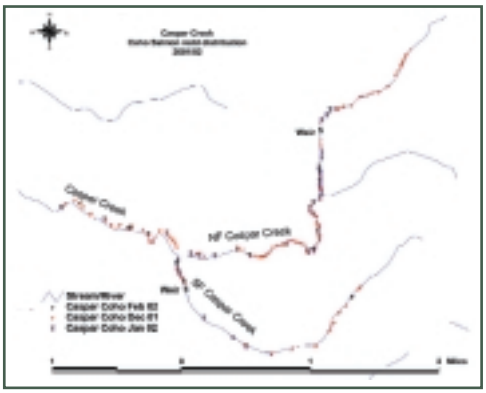
PAD ID 7578 **STREAM** Terwer Creek (Klamath River)
SITE NAME Terwer Creek Log Jam
BARRIER TYPE log jam **LLID** 1240010415197 **BEG FT** 56226
LAT 41.62111 **LONG** -123.98833
PASSAGE STATUS not a barrier
TREATMENT NEEDED no **TREATMENT STATUS** completed
COUNTY Humboldt **OWNER** Simpson Timber Company
DATA SOURCE Yurok Tribal Fisheries Program
SOURCE REFERENCE Inventory and Assessment of Anadromous Fish Passage Barriers in the Lower Klamath River Sub-Basin, California, D. B. Gale
SOURCE COMMENTS Additional information available.
SITE COMMENTS Large woody debris jam posed a complete barrier to upstream passage. Modified by Yurok Tribal Fisheries Program in fall 2002 to re-establish passage. Now being monitored for project success.

PAD ID 7288, 7289 **STREAM** Quinby Creek (Trinity River)
SITE NAME Denny Road
BARRIER TYPE road crossing (culvert) **LLID** 1233849409519 **BEG FT** 794
LAT 40.95306 **LONG** -123.38733
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** none
COUNTY Trinity **OWNER** Trinity County
DATA SOURCE Ross Taylor and Associates
SOURCE REFERENCE Final Report: Trinity County Culvert Inventory and Fish Passage Evaluation, R. N. Taylor, M. Love, T. D. Grey, A. L. Knoche
SOURCE COMMENTS Additional information available.
SITE COMMENTS Good fish habitat, hardwood with few conifers in canopy. Cobbles to med/large boulders in stream bed. Large deep pool at outlet. Approximately 6.4 kilometers (4 miles 19,200 ft) of habitat above crossing. Modifying the existing culverts to improve passage should be considered due to the high cost of implementing a full replacement because the stream crossing contains nearly 6,000 cubic yards of fill material. Greater than 10% channel slope below culvert. The upstream is fairly steep and very little information exists regarding habitat quality or fish distribution. Quinby Creek may be utilized by summer-run steelhead. FishXing result: RED.

PAD ID 7307, 7308, 7309 **STREAM** Little Browns Creek (Trinity River)
SITE NAME Roundy Road
BARRIER TYPE road crossing (culvert) **LLID** 1229287406953 **BEG FT** 3716
LAT 40.77797 **LONG** -122.89277
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Trinity **OWNER** Trinity County
DATA SOURCE Ross Taylor and Associates
SOURCE REFERENCE Final Report: Trinity County Culvert Inventory and Fish Passage Evaluation, R. N. Taylor, M. Love, T. D. Grey, A. L. Knoche
SOURCE COMMENTS Additional information available.
SITE COMMENTS High-priority due to severity of barrier. "RED" for all species and life stages, condition and sizing of current culvert, and quantity and quality of upstream habitat. Both coho salmon and steelhead are known to currently utilize Little Browns Creek for spawning and rearing. Adult fish have been observed up to this crossing, but none above it. A full replacement is recommended because the current crossing (comprised of three culverts) is undersized. The replacement project must address the potential for head-cutting of the upstream channel. Grade control weirs are recommended to minimize head-cutting, however, some upstream channel scour may be beneficial due to its aggraded condition. Upstream mixed grasses and bushes with some conifers. Downstream, hardwoods with some conifers. Good habitat downstream, with fish, large jump into culverts. Historically culverts get washed out.

PAD ID 8347 **STREAM** Caspar Creek (Pacific Ocean)
SITE NAME Pool and Weir with Fish Ladder in Disrepair
BARRIER TYPE fish passage facility **LLID** 1238158393618 **BEG FT** 31727
LAT 39.361183 **LONG** -123.73145
PASSAGE STATUS partial and temporal barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Mendocino **OWNER** Department of Forestry and Fire Protection
DATA SOURCE Department of Fish and Game
SOURCE REFERENCE Electronic Data File, A. Grass, D. Highland, Scott Harris
SOURCE COMMENTS
SITE COMMENTS This photo of the North Fork Caspar Creek fish ladder does not show the degraded condition of the facility. Leakage in the structure results in insufficient flow and impaired passability within the ladder during low flow periods — spring outmigration, summer emigration. This condition, which often precludes spawning in the upper reaches of the creek, is exactly mirrored on South Fork Caspar Creek. Additional location information: T17N, R17W, S16, USGS Mathison Peak.





PAD ID 8545, 8546 **STREAM** Ryan Creek (Eel River)
SITE NAME Highway 101 Culvert
BARRIER TYPE road crossing (culvert) **LLID** 1233768394765 **BEG FT** 619
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** none
COUNTY Mendocino **OWNER** California Department of Transportation
DATA SOURCE Department of Fish and Game
SOURCE REFERENCE Electronic Data File, A. Grass, D. Highland, 2002
SOURCE COMMENTS
SITE COMMENTS Caltrans culverts blocking North and South Forks Ryan Creek, tributary to mainstem Eel River. Planned removal of county road culvert immediately downstream of Caltrans culverts in summer 2003 will provide anadromous fish passage to 8545 and 8546, thereby increasing opportunities for providing fish passage throughout this tributary.

PAD ID 7207 **STREAM** Digger Creek (Pacific Ocean)
SITE NAME Ocean Drive
BARRIER TYPE Road crossing (culvert) **LLID** 1238152394089 **BEG FT** 2018
LAT 39.4067 **LONG** -123.8089
PASSAGE STATUS full
TREATMENT NEEDED no **TREATMENT STATUS** completed
COUNTY Mendocino **OWNER** Mendocino County Department of Transportation
DATA SOURCE Ross Taylor and Associates
SOURCE REFERENCE Final Report: Coastal Mendocino County Culvert Inventory and Fish Passage Evaluation, R. N. Taylor
SOURCE COMMENTS Additional information available.
SITE COMMENTS Replaced in 2003 with an open-bottom, pre-manufactured arch structure that allows anadromous fish passage. Additional road crossings: Downstream (950' and 2,000'): two culverts within the Mendocino Coast Botanical Gardens replaced with small bridges in 2001 and 2002. Upstream (600'): Highway 1; concrete box culvert with perched outlet (about 3'); probable 100% barrier. USGS map indicates crossings exist on private roads, 600' and 2,300' upstream of Highway 1.


before, upstream


before, downstream


after, downstream


after, upstream

PAD ID 25512 **STREAM** Bridge Creek (Navarro River)
SITE NAME Masonite Road Crossing
BARRIER TYPE road crossing (culvert) **LLID** **BEG FT**
LAT 39.15963 **LONG** -123.42509
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Mendocino **OWNER** Mendocino Redwood Company
DATA SOURCE Mendocino Redwood Company, Trout Unlimited
SOURCE REFERENCE Email Communications, S. Downie, Ch. Surfleet
SOURCE COMMENTS
SITE COMMENTS Culvert will be replaced with bridge. Bridge Creek is tributary to South Branch North Fork Navarro River. Barrier affects 2.4 kilometers (1.5 miles) of stream habitat in good condition above barrier that would be good steelhead spawning and juvenile rearing habitat. Coho salmon have been observed in the South Branch North Fork Navarro in select years; coho are present in North Fork Navarro. Imminent failure of barrier will deposit large amounts of sediment downstream and into the Navarro River. Site visited by DFG personnel.

PAD ID 6998 **STREAM** Schooner Gulch (Pacific Ocean)
SITE NAME North Fork Schooner Gulch Crossing
BARRIER TYPE road crossing (culvert) **LLID** **BEG FT**
LAT 38.92040 **LONG** -123.69488
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** none
COUNTY Mendocino **OWNER** private subdivision
DATA SOURCE Trout Unlimited
SOURCE REFERENCE Email Communications, D. Katz
SOURCE COMMENTS
SITE COMMENTS The crossing is located less than a mile upstream from the confluence with the mainstem Schooner Gulch. Upstream of the site is approximately 2.4 kilometers (1.5 miles) of potential steelhead and coho salmon, spawning and rearing habitat. In addition to the benefits of fish passage to historic spawning grounds, the removal of the unstable and eroding crossing fill will reduce downstream sediment impacts all the way to the nearby Pacific Ocean. The completion of this project will compliment the previous work in Schooner Gulch that implemented erosion control measures in 2/3 of the Schooner Gulch watershed. Additional road work is needed to reduce near-crossing sediment inputs.

PAD ID 199892 **STREAM** Willow Creek (Russian River)
SITE NAME Willow Creek Road
BARRIER TYPE road crossing (culvert) **LLID** 1230960384392 **BEG FT** 4800
LAT 38.00726 **LONG** -123.01425
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned. Tentative plans are to remove a portion of the road across the flood plain and replace it with a span bridge that will allow fish and sediment to pass. Estimated cost to replace road and culvert with a bridge is $1–2 million. No funding is currently available.
COUNTY Sonoma **OWNER** Sonoma County (Department of Transportation and Public Works; county road through State park — Sonoma Coast State Beach)
DATA SOURCE Prunuske Chatham, Inc. (Ecological Restoration)
SOURCE REFERENCE Willow Creek Fish Barrier, E. Austensen, 2003
SOURCE COMMENTS
SITE COMMENTS County road fill across flood plain. Barrier affects ± 4.8 kilometers (3 miles) of fish habitat along Willow Creek by blocking passage during outward migration of coho and steelhead. Currently, the road is a barrier to both fish passage and sediment transport. Barrier date: installed about 1970.

PAD ID 76 **STREAM** Alameda Creek (San Francisco Bay)
SITE NAME Bay Area Rapid Transit Weir
BARRIER TYPE grade control structure **LLID** 1221458375945 **BEG FT** 59234
LAT 37.56855 **LONG** -121.98778
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Alameda **OWNER** Alameda County
DATA SOURCE Department of Fish and Game, Department of Water Resources, Coastal Conservancy
SOURCE REFERENCE Steelhead Migration Barrier Survey of San Francisco Bay Area Creeks, E. Cleugh, C. McKnight; California Rivers Assessment Interactive Web Database
SOURCE COMMENTS Project planning details available from Coastal Conservancy.
SITE COMMENTS The concrete apron of the BART Weir is an impassable fish barrier due to its steep slope and the high sheeting velocities that occur over its surface. A proposed fishway would lift fish from the drop structure area to the pool upstream of the Middle Inflatable Dam regardless of whether the dam is inflated or not. The proposed design eliminates the need for two separate ladders and the possibility of fish falling back over the BART Weir's sloping apron. The lower portion of the fishway is designed as a vertical slot fishway for fish passage when the Middle Inflatable Dam is deflated. The proposed design affords the least channel constriction at the top of the drop structure of options considered. It also can be constructed without compromising the structural integrity of the adjacent retaining walls and bridge footings.

PAD ID 15 **STREAM** Alameda Creek San Francisco Bay)
SITE NAME Lower Inflatable Dam
BARRIER TYPE dam **LLID** 1221458375945 **BEG FT** 56558
LAT 37.56580 **LONG** -121.99580
PASSAGE STATUS partial barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Alameda **OWNER** Alameda County Water District
DATA SOURCE Department of Fish and Game, Department of Water Resources, Coastal Conservancy
SOURCE REFERENCE Steelhead Migration Barrier Survey of San Francisco Bay Area Creeks, E. Cleugh, C. McKnight; California Rivers Assessment Interactive Web Database; Stonybrook Creek Fish Passage Assessment, M. Love
SOURCE COMMENTS Project planning details available from Coastal Conservancy.
SITE COMMENTS When the Lower Inflatable Dam is raised, the 7 to 9-foot high dam (the dam inflates up to six feet over the sill) is beyond the leaping ability of the steelhead. When the dam is lowered, fish can migrate past the 2 to 3-foot high dam sill without going through a fishway, but passage can be greatly improved during low flow conditions by concentrating flow to one side of the channel and roughening the concrete apron. A small curb (six inches high) should be constructed to concentrate flows to the right bank for dam down and low flow conditions. Concentrating flow to the right bank may also help form a channel to guide fish to the proposed fishway or roughened sill area. Instream flows below this dam can vary from several thousand cfs to near zero. Since instream flow requirements have yet to be established, the proposed fishway needs to operate over this wide range of flows. Two fishways (ladders) housed in one structure are proposed: 1) a false weir Alaska Steeppass ladder would operate when flows past the lower dam are about 5 to 25 cfs, 2) a vertical slot fishway would to operate when channel flows past the dam are above 25 cfs. During low flow conditions, the upper pool fishways may not have sufficient flow to operate effectively, and therefore the steeppass fishway could be operated as a fish trap for trap and haul operations if necessary. Trapped fish could be transported and released into streams in the upper watershed.

PAD ID 7084 **STREAM** Bear Gulch (San Francisquito Creek/San Francisco Bay)
SITE NAME Bear Gulch Diversion Dam #15
BARRIER TYPE dam **LLID** **BEG FT**
LAT 37.43300 **LONG** -122.23000
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** none
COUNTY San Mateo **OWNER** California Water Service
DATA SOURCE San Francisquito Watershed Council, U.S. Army Corps of Engineers
SOURCE REFERENCE Adult Steelhead Passage in the Bear Creek Watershed, J. J. Smith, D. R. Harden
SOURCE COMMENTS Additional information available.
SITE COMMENTS Pre-1914 (1860's) dam used as a diversion location for large domestic water supply. Pool at the base of the ten-foot high dam is roughly one-foot deep. Water is diverted to Bear Gulch Reservoir east of Woodside. The dam blocks access to 0.96 kilometers (0.6 miles) of habitat with relatively good pools, good substrate conditions, and high summer streamflow. Discussions should be undertaken with California Water Service about potential modification of the structure (including lowering) that would improve fish passage and maintain or improve water diversion operations.

PAD ID 5865 **STREAM** Stevens Creek (San Francisco Bay)
SITE NAME HWY 101 Crossing at Vernon Avenue
BARRIER TYPE road crossing (culvert) **LLID** 1220673374299 **BEG FT** 7863
LAT **LONG**
PASSAGE STATUS partial barrier
TREATMENT NEEDED yes **TREATMENT STATUS** none
COUNTY Santa Clara **OWNER** California Department of Transportation
DATA SOURCE Department of Fish and Game
SOURCE REFERENCE Steelhead Migration Barrier Survey of San Francisco Bay Area Creeks, E. Cleugh, C. McKnight
SOURCE COMMENTS
SITE COMMENTS Grade control structure. The drop structure has 3–4 rock pools below. Four grouted rock structures below concrete box culvert (approx. 600 feet long). Approximate two-foot jump onto concrete slab downstream of crossing and approximate one-foot jump onto concrete slab upstream of crossing. Stevens Creek is 34.2 kilometers (21.4 miles) long to Stevens Creek Reservoir. The watershed area comprises 18,700 acres. Data originated from Santa Clara Valley Water District's Barrier Survey.

PAD ID 5501 **STREAM** Whitehouse Creek (Pacific Ocean)
SITE NAME Highway 1 Concrete Culvert
BARRIER TYPE road crossing (culvert) **LLID** 1223458371457 **BEG FT** 1191
LAT **LONG**
PASSAGE STATUS temporal/total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** none
COUNTY San Mateo **OWNER**
DATA SOURCE Department of Fish and Game
SOURCE REFERENCE History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay, R. G. Titus, D.C. Erman, W.M. Snider
SOURCE COMMENTS
SITE COMMENTS Concrete culvert, 300 feet in length, curved with the upstream half one foot higher than the downstream half. Significant almost-barrier near the ocean, adversely affects fish production in a largely-protected watershed. Coho are not known from this watershed, but it is in the middle of their southern range and they might come back if passage is provided. A local stakeholder group is interested.

PAD ID 8072 **STREAM** West Branch Soquel Creek (Pacific Ocean)
SITE NAME Concrete Ford with Culvert
BARRIER TYPE road crossing (culvert) **LLID** 1219390370444 **BEG FT** 9756
LAT **LONG**
PASSAGE STATUS temporal barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Santa Cruz **OWNER** Santa Cruz County
DATA SOURCE Department of Fish and Game
SOURCE REFERENCE Electronic Data File, J. Nelson; Soquel Creek Watershed Assessment and Enhancement Plan, Santa Cruz County Resource Conservation District
SOURCE COMMENTS See 1996 DFG habitat typing survey.
SITE COMMENTS Five-foot diameter culvert (defunct) through concrete ford crossing channel. Remediation: remove and replace with bridge or notch center with grate on top. Total length of anadromy 11.4 kilometers (7.1 miles). Significant impediments that adversely affect fish production in a watershed that seems to be a refuge in the Soquel system, and were identified as such by a stakeholder-led comprehensive watershed assessment. It's coho habitat.

PAD ID 188 **STREAM** Santa Rosa Creek (Pacific Ocean)
SITE NAME Ferrasci Road Culverts and Denil Ladders
BARRIER TYPE road crossing (culvert) **LLID** 1211105355685 **BEG FT** 17431
LAT 35.5687 **LONG** -120.06445
PASSAGE STATUS temporal
TREATMENT NEEDED yes **TREATMENT STATUS** unknown
COUNTY San Luis Obispo **OWNER** San Luis Obispo County
DATA SOURCE CDFG, Land Conservancy of SLO Co., California Conservation Corps
SOURCE REFERENCE Electronic Data File, B. Stark, Electronic Data File, A. Grass, D. Highland
SOURCE COMMENTS
SITE COMMENTS Barrier at high flows, frequently plugs with debris, highest priority, hydraulic assessment completed, regional priority. The crossing was installed by the county in 1965 and the ladder was inserted at a later date after the crossing had caused down cutting. The culverts are 4 ft. dia. and the ladder is slightly wider. It is a denil type with metal baffles. This creek moves a lot of bedload up to boulder size, woody and vegetative debris and agricultural debris (fence wire, plastic, old machine parts, pipe, etc.) and plugs or is obstructed after virtually every significant storm.

PAD ID 300103 **STREAM** Cuyama River (Santa Maria River)
SITE NAME Twitchell Dam
BARRIER TYPE dam (earth & rock fill) **LLID** **BEG FT**
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** none
COUNTY San Luis Obispo **OWNER** U.S. Bureau of Reclamation, Santa Maria Valley Water Conservation District
DATA SOURCE Stoecker Ecological Consulting
SOURCE REFERENCE Electronic Data File, M.W. Stoecker
SOURCE COMMENTS
SITE COMMENTS The Santa Maria River is formed by the confluence of the Cuyama and Sisquoc Rivers. The project provides recharge to the groundwater basin underlying the Santa Maria Valley and also provides flood protection. There is a loss of capacity due to sedimentation. Augmenting capacity may provide a means to increase storage for downstream flows suitable for fish passage. The manipulated water releases associated with project operations constitute the most limiting migration barrier to the now endangered steelhead of the Santa Maria River watershed. The dam physically blocks steelhead from accessing more than half of the watershed. The manipulated downstream water releases have exacerbated the discontinuity of surface flows and in turn limited steelhead migration along the Santa Maria River between the Pacific Ocean and the Sisquoc River. A Bureau representative recently stated that the downstream water releases are managed so that surface flows do not reach the Pacific Ocean and as much of the stream flow as possible is percolated into the underground aquifer.

PAD ID 7768 **STREAM** Gaviota Creek (Pacific Ocean)
SITE NAME Hwy 101 Crossing — Box Culvert
BARRIER TYPE road crossing **LLID** 1202260344703 **BEG FT** 22939
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** none
COUNTY Santa Barbara **OWNER** California Department of Transportation
DATA SOURCE Matt W. Stoecker and Conception Coast Project, California Department of Transportation
SOURCE REFERENCE Steelhead Assessment and Recovery Opportunities in Southern Santa Barbara, M.W. Stoecker and Conception Coast Project
SOURCE COMMENTS Additional information available.
SITE COMMENTS The excessive length, smooth bottom, and steep slope of this culvert produce shallow flow conditions and/or excessive water velocities that prevent all upstream migration of salmonids during all flow conditions. This culvert was observed to be directly blocking upstream access to an adult steelhead. This structure received the highest immediate priority ranking in the entire study area using the Immediate Keystone Barrier Priority Ranking method.

PAD ID 8959 **STREAM** Arroyo Hondo (Pacific Ocean)
SITE NAME Highway 101 Culvert
BARRIER TYPE road crossing **LLID** 1201405344734 **BEG FT** 162
LAT **LONG**
PASSAGE STATUS partial barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Santa Barbara **OWNER** California Department of Transportation
DATA SOURCE Matt W. Stoecker and Conception Coast Project, California Department of Fish and Game, California Department of Transportation, Division of Environmental Analysis, National Marine Fisheries Service
SOURCE REFERENCE Steelhead Assessment and Recovery Opportunities in Southern Santa Barbara, M.W. Stoecker and Conception Coast Project
SOURCE COMMENTS Additional information available.
SITE COMMENTS Fishway planned. Submitted plans for improvement. Total length of structure: 0.09 miles. It appears upstream steelhead passage is possible during moderate to high flow conditions when there is adequate water depth inside the mild sloping culvert and moderate water velocities are encountered. However, the window of opportunity for steelhead to pass upstream is very short and may not occur often, or at all, during a migration season with low stream flows. Excellent salmonid habitat conditions exist in Arroyo Hondo Creek upstream of the highway. This is the only anthropogenic barrier on the creek and improving access at this culvert ensures access to all accessible habitat in the watershed. Photo right: www.westcoastroads.com.

PAD ID 8938 **STREAM** Maria Ygnacio Creek (Atascadero Creek)
SITE NAME Channelization under Union Pacific Railroad and Hwy 101 Bridges
BARRIER TYPE flood control channel **LLID** 1198094344251 **BEG FT** 6402
LAT **LONG**
PASSAGE STATUS partial barrier
TREATMENT NEEDED yes **TREATMENT STATUS** unknown
COUNTY Santa Barbara **OWNER** Union Pacific Railroad, California Department of Transportation
DATA SOURCE Matt W. Stoecker and Conception Coast Project, California Department of Transportation Division of Environmental Analysis, Southern California Steelhead Coalition
SOURCE REFERENCE Steelhead Assessment and Recovery Opportunities in Southern Santa Barbara, M.W. Stoecker and Conception Coast Project
SOURCE COMMENTS
SITE COMMENTS Total length of structure: 0.06 miles. Photo left: David Pritchett. Photo right: Jonathon Mann, NOAA Fisheries.

PAD ID 8926 **STREAM** Mission Creek (Pacific Ocean)
SITE NAME Concrete Channel
BARRIER TYPE flood control channel **LLID** 1196866344124 **BEG FT** 5865
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Santa Barbara **OWNER** California Department of Transportation
DATA SOURCE Matt W. Stoecker and Conception Coast Project, California Department of Transportation Division of Environmental Analysis, Southern California Steelhead Coalition
SOURCE REFERENCE Steelhead Assessment and Recovery Opportunities in Southern Santa Barbara, M.W. Stoecker and Conception Coast Project; Personal Communication, D. Pritchett
SOURCE COMMENTS Additional information available.
SITE COMMENTS Total length of structure: 0.74 miles. From Castillo Bridge to upstream of Arrellaga Bridge. During low flows, upstream steelhead migration is not possible due to the unconfined, shallow water depth throughout the channel. When adequate water depth occurs in the channel, accelerated stream velocities are sustained throughout the long channel with no velocity breaks. Upstream steelhead passage is prevented due to exhaustion attempting to migrate the long channel. Location identified by the Environmental Defense Center. Due to the structural and political complexity of providing flood control and landowner safety, stream restoration and steelhead passage in lower Mission Creek needs to be addressed in a much larger planning process that seems to be moving forward in Santa Barbara. In order to make the most informed decision about the future of lower Mission Creek, a watershed-focused stakeholder planning process should be initiated that assesses long-term fish passage alternatives from the ocean to at least the Santa Barbara Natural History Museum. Photo: David Pritchett.

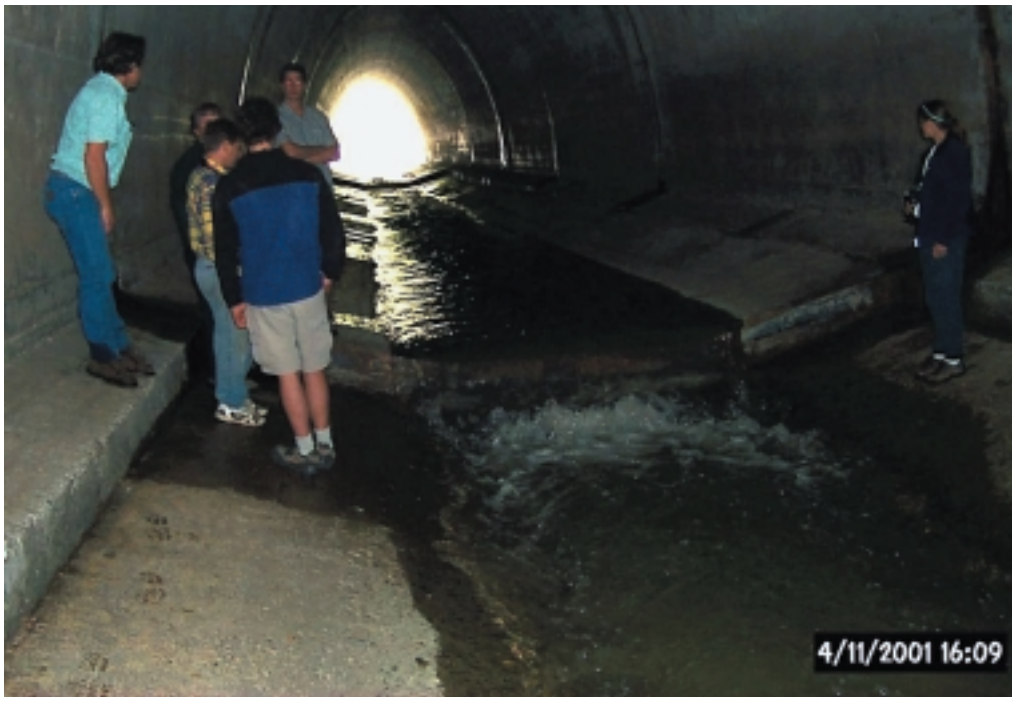
PAD ID 7890 **STREAM** San Ysidro Creek (Pacific Ocean)
SITE NAME Debris Basin Dam
BARRIER TYPE dam **LLID** 11196244344191 **BEG FT** 12049
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** unknown
COUNTY Santa Barbara **OWNER** Santa Barbara County Flood Control District
DATA SOURCE Matt W. Stoecker and Conception Coast Project
SOURCE REFERENCE Steelhead Assessment and Recovery Opportunities in Southern Santa Barbara
SOURCE COMMENTS Additional information available.
SITE COMMENTS During migration flows, the jump onto the apron and passage among the large embedded boulders would be easy for adult and juvenile salmonids. The 5-foot jump into the culvert presents an extremely high degree of difficulty due to the absence of any jump depth and pool formation during low and moderate flows. The long, smooth culvert running through the debris dam is impassable to upstream migrating steelhead due to the shallow water depth during low flows and the excessive water velocities produced by the 4.8% slope.

PAD ID 7870 **STREAM** Carpinteria Creek (Pacific Ocean)
SITE NAME Private Bridge and Channelization
BARRIER TYPE road crossing **LLID** 1195195343904 **BEG FT** 15470
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** unknown
COUNTY Santa Barbara **OWNER** private landowner(s) (non-corporate)
DATA SOURCE Matt W. Stoecker and Conception Coast Project
SOURCE REFERENCE Steelhead Assessment and Recovery Opportunities in Southern Santa Barbara
SOURCE COMMENTS
SITE COMMENTS Due to the combined difficulty of migrating across this complex structure, upstream steelhead migration is likely completely blocked.

PAD ID 7879 **STREAM** Gobernador Creek (Carpinteria Creek)
SITE NAME Culvert Stream Crossing
BARRIER TYPE road crossing **LLID** 1194851344012 **BEG FT** 7812
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** unknown
COUNTY Santa Barbara **OWNER**
DATA SOURCE Matt W. Stoecker and Conception Coast Project
SOURCE REFERENCE Steelhead Assessment and Recovery Opportunities in Southern Santa Barbara
SOURCE COMMENTS Additional information available.
SITE COMMENTS The downstream pool has sufficient depth for a steelhead to execute a vertical jump of at least six feet and likely more during high flows as the pool becomes deeper. During migration flows, the 10-foot vertical jump and 15-foot horizontal jump to the crossing make this structure impassable to upstream migrating steelhead. The small, smooth metal culverts provide no opportunity for fish passage.

PAD ID 7880 **STREAM** Gobernador Creek (Carpinteria Creek)
SITE NAME Debris Basin Dam
BARRIER TYPE dam **LLID** 1194851344012 **BEG FT** 8850
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Santa Barbara **OWNER** Santa Barbara County Flood Control District
DATA SOURCE Matt W. Stoecker and Conception Coast Project
SOURCE REFERENCE Steelhead Assessment and Recovery Opportunities in Southern Santa Barbara
SOURCE COMMENTS Additional information available.
SITE COMMENTS During migration flows, the jump onto the apron and passage among the large embedded boulders would be moderately difficult for adult steelhead. The long, smooth culvert through the debris dam is impassable to upstream migrating steelhead due to the shallow water depth during low flows and the excessive water velocities during moderate and high flows. Photo left: Santa Barbara County Flood Control and Water Conservation District.

PAD ID 8920 **STREAM** Rincon Creek (Pacific Ocean)
SITE NAME Highway 101 Culvert
BARRIER TYPE road crossing (culvert) **LLID** 1194759343733 **BEG FT** 885
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Ventura **OWNER** California Department of Transportation
DATA SOURCE Department of Water Resources, National Marine Fisheries Service, California Department of Transportation
SOURCE REFERENCE Fish passage impediments in the southern California ESU for steelhead, K. Johnson; History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay, R. G. Titus, D.C. Erman, W.M. Snider; Steelhead Assessment and Recovery Opportunities in Southern Santa Barbara, M.W. Stoecker and Conception Coast Project
SOURCE COMMENTS
SITE COMMENTS 750-foot culvert with a steep concrete inlet apron. Santa Barbara County (border with Ventura County), Santa Ynez Mountains. Downstream end of culvert is 0.16 kilometers (0.1 miles) from ocean at upper edge of the lagoon. Built: 1940's under freeway and railroad corridor. Proposed CalTrans Project to construct fish ladder. The alternative to replace the culvert with a bridge would provide the most effective upstream migration for steelhead as well as meet the 100-year flood conveyance capacity. Feasibility study now underway by Corps of Engineers with County of Santa Barbara as co-sponsor. Upstream erosion still a watershed problem to address for Casitas Creek, tributary to Rincon Creek. Rincon Creek is good trout habitat. Photo: Jonathon Mann, NOAA Fisheries.



PAD ID 100361 **STREAM** Matilija Creek (Ventura River)
SITE NAME Matilija Dam
BARRIER TYPE dam (arch) **LLID** 1192992344852 **BEG FT** 3357
LAT 34.48500 **LONG** -119.30700
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Ventura **OWNER** Ventura County
DATA SOURCE Southern California Steelhead Coalition, Department of Fish and Game, Army Corps of Engineers
SOURCE REFERENCE History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay, R. G. Titus, D.C. Erman, W.M. Snider
SOURCE COMMENTS
SITE COMMENTS Middle Fork of Matilija Creek. Decrepit fish ladder boxes below, reservoir above. Dam removal feasibility study now underway. Photo: David Pritchett.

PAD ID 7094 **STREAM** Arroyo Sequit (Pacific Ocean)
SITE NAME Lower Arizona Crossing at Leo Carrillo State Park Campground
BARRIER TYPE road crossing (low-flow) **LLID** 1189329340445 **BEG FT** 546
LAT **LONG**
PASSAGE STATUS partial barrier
TREATMENT NEEDED yes **TREATMENT STATUS** none
COUNTY Los Angeles **OWNER** Department of Parks and Recreation
DATA SOURCE Greystone Environmental Consultants
SOURCE REFERENCE Biological Assessment for the Southern California Steelhead Coalition
SOURCE COMMENTS
SITE COMMENTS Barrier during high flow periods. Arizona crossing is constructed by pouring a concrete apron across a portion of the streambed to allow for a low water crossing for vehicles. A hefty road crossing connecting campground to beach. Vertical drop about 1.3 meters at time of picture, autumn 2002. Site to be analyzed fully in Coastal Conservancy-funded assessment of Santa Monica Mountains streams, led by CalTrout. Steelhead occasionally sited in upper Arroyo Sequit, but passage improvement needed. Photo: David Pritchett.

PAD ID 7098 **STREAM** Solstice Creek (Pacific Ocean)
SITE NAME Pacific Coast Highway Culvert
BARRIER TYPE road crossing (culvert) **LLID** 1187414340325 **BEG FT** 220
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** ongoing
COUNTY Los Angeles **OWNER** California Department of Transportation (structure), State Parks (property), City of Malibu (road)
DATA SOURCE Greystone Environmental Consultants, California Department of Transportation
SOURCE REFERENCE Biological Assessment for the Southern California Steelhead Coalition
SOURCE COMMENTS
SITE COMMENTS Two highway culverts. Caltrans is in the process of removing the road culvert. Four Arizona crossings and several other man-made structures are upstream.

PAD ID 7375 **STREAM** Malibu Creek (Pacific Ocean)
SITE NAME Rindge Dam
BARRIER TYPE dam (arch) **LLID** 1186792340318 **BEG FT** 15146
LAT **LONG**
PASSAGE STATUS total barrier
TREATMENT NEEDED yes **TREATMENT STATUS** planned
COUNTY Los Angeles **OWNER** Department of Parks and Recreation
DATA SOURCE Southern California Steelhead Coalition, Greystone Environmental Consultants, Entrix Incorporated, Department of Fish and Game
SOURCE REFERENCE History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay, R. G. Titus, D.C. Erman, W.M. Snider
SOURCE COMMENTS
SITE COMMENTS 3.8 kilometers (2.4 miles) upstream from ocean. Feasibility study now underway following models developed for Matilija Dam study. Funds provided by Coastal Conservancy and Santa Monica Bay Project. Photo: David Pritchett (view from Piuma Road, across canyon from Malibu Canyon Road).

Results

Dataset Sources

Figures 15a and 15b illustrate the numbers of datasets in the PAD for each watershed in California. These maps shows which watersheds have likely had more extensive barrier assessment work done, although the map is also a reflection of where data were more easily obtained. The distribution of dataset sources can be useful for determining where more survey work needs to be done to identify and assess existing barriers to fish passage.

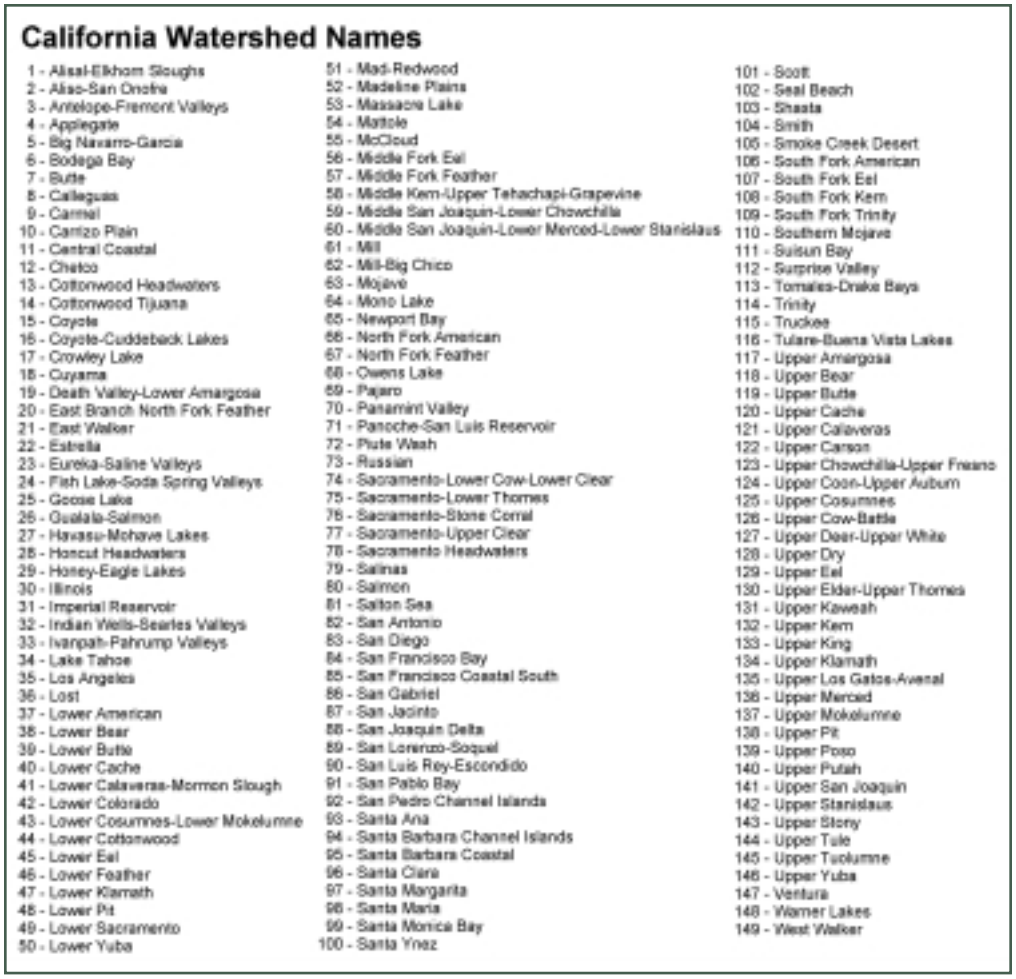


Figure 15a.
Passage Assessment Database:
Watershed Names

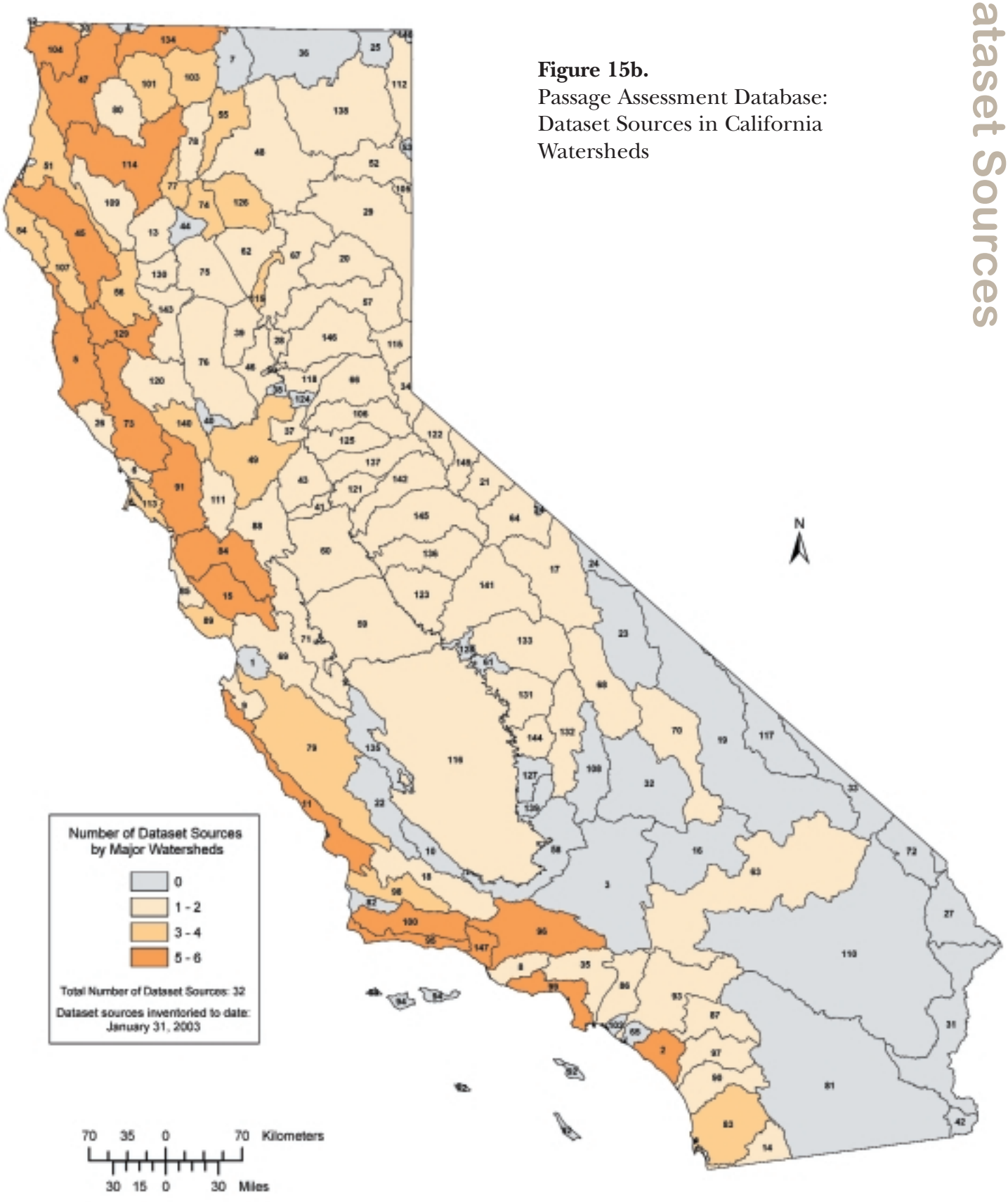


Figure 15b.
Passage Assessment Database: Dataset Sources in California Watersheds

Results

Table 2 provides a breakdown by hydrologic unit of data sources, computation of density of barriers, and other analyses intended to help demonstrate availability of data for particular watersheds, to help prioritize future watershed assessment efforts, and to develop working hypotheses to guide future fish passage improvement efforts. For example, one might infer from the high number of inventoried sites and known barriers in the Santa Barbara Coastal, Smith, and Big-Navarro-Garcia hydrologic units that little further assessment is needed in those watersheds, and that future effort might be better directed towards specific fish passage improvement projects. Conversely, very little is known about the status of fish passage within the very large Salinas watershed, and future inventory and assessments there and elsewhere would better guide fish passage improvement efforts. Similarly, one might infer from the Cuyama (one site, one barrier) that further assessments in the upper watershed are warranted, and that in the Santa Ana hydrologic unit (80 sites, no known barriers) that sites are identified, but unassessed for severity of barrier status, and that refined assessment is warranted there. The following list of definitions explains each column:

Inv. Sites = total number of inventoried sites/structures
Known Barriers = total number of known barriers (partial, temporal or total barrier)
Data Sources = total number of regional or local sources that provided the data (statewide data sources excluded)
Area (sq.mi) = total area of watershed in square miles
Site/Area = inventoried sites per unit area
Order Site/Area = watersheds ordered based on number of inventoried sites per unit area (from lowest to highest)
Bar/Area = known barriers per unit area
Order Bar/Area = watersheds ordered based on number of known barriers per unit area (from lowest to highest)
Length of Streams (mi) = total length of all digitized streams in each watershed, in miles (based on 1:100k hydrography)
Site/Mile = inventoried sites per one mile of digitized stream
Order Site/Mile = watersheds ordered based on number of inventories sites per one mile of digitized stream
Bar/Mile = known barriers per one mile of digitized stream
Order Bar/Mile = watersheds ordered based on number of known barriers per one mile of digitized stream

WATERSHED	Inv. Site	Known Bar	Data Source	Area (sq.mi)	Site/Area	Order Site/Area	Bar/Area	Order Bar/Area	Stream (mi)	Site/Mile	Order Site/Mile	Bar/Mile	Order Bar/Mile
ALAMEDA CREEK	138	96	5	678	0.1571	34	0.109	46	1176	0.1174	34	0.0816	44
ALISAL-ELKHN SLGHS	3	0	0	244	0.0164	9	0	1	347	0.0115	8	0	1
ALISO-SAN ONOFRE	145	13	6	504	0.2878	41	0.026	26	744	0.1950	39	0.0175	28
APPLEGATE	0	0	0	78	0	1	0	1	0	0	1	0	1
BERKELEY	16	5	2	35	0.3678	47	0.057	37	8	1.6733	61	0.2574	58
BIG-NAVARRO-GARCIA	4006	149	6	1272	3.1436	62	0.115	45	1950	2.0513	62	0.0749	42
BODEGA BAY	5	2	3	152	0.0329	15	0.013	16	158	0.0316	16	0.0126	18
BUTTE	1	0	0	610	0.0016	4	0	1	0	0	1	0	1
CALLEGUAS	9	2	0	381	0.0236	11	0.005	13	473	0.0190	13	0.0042	13
CARMEL	13	8	2	319	0.0407	16	0.025	22	427	0.0304	15	0.0187	21
CENTRAL COASTAL	197	103	10	1102	0.1823	37	0.094	42	1383	0.1453	37	0.0752	43
CHETCO	9	4	2	25	0.3549	46	0.158	53	34	0.2644	44	0.1175	50
COTTONWD TIJUANA	12	12	2	469	0.0256	12	0.026	25	473	0.0254	14	0.0254	29
COYOTE	269	84	3	638	0.3423	44	0.100	45	990	0.2990	45	0.0849	46
CUYAMA	6	3	4	1144	0.0052	6	0.003	12	1997	0.0031	6	0.0015	12
ESTRELLA	0	0	0	948	0.0000	1	0	1	1221	0	1	0	1
GUALALA-SALMON	34	11	3	358	0.0951	29	0.031	29	470	0.0724	26	0.0234	28
ILLINOIS	41	6	1	51	0.8084	55	0.118	49	117	0.3504	49	0.0513	39
LOS ANGELES	78	35	3	835	0.0910	28	0.042	34	700	0.0975	31	0.0449	37
LOWER EEL	535	68	5	1534	0.3487	45	0.044	35	2295	0.2331	42	0.0296	31
LOWER KLAMATH	898	187	6	1536	0.5866	52	0.134	51	2088	0.4330	50	0.0910	48
MAD-REDWOOD	481	294	6	1163	0.4137	49	0.253	57	1617	0.3384	47	0.2674	56
MATTOLE	68	32	4	520	0.1308	31	0.062	39	651	0.1045	32	0.0492	38
MIDDLE FORK EEL	67	45	3	753	0.0898	27	0.060	36	1066	0.0629	24	0.0423	36
NAPA RIVER	723	14	2	417	1.7348	61	0.034	30	678	1.0659	59	0.0206	23
NEWPORT BAY	33	4	0	159	0.2015	40	0.025	23	148	0.2157	41	0.0270	30
NOVATO	24	11	2	72	0.3209	43	0.153	52	54	0.4264	49	0.2040	55
PAJARO	69	19	3	1312	0.0526	21	0.014	17	1848	0.0373	20	0.0103	16
PETALUMA RIVER	13	0	2	148	0.0886	26	0	1	163	0.0796	28	0	1
PINOLE	29	4	1	101	0.3158	42	0.039	33	96	0.3269	46	0.0439	34
RUSSIAN	1206	268	9	1485	0.8107	56	0.180	55	1906	0.6350	54	0.1414	52
SALINAS	51	25	3	3280	0.0158	7	0.008	14	4496	0.0116	6	0.0060	15
SALMON	46	20	3	751	0.0612	24	0.027	27	897	0.0531	23	0.0231	27
SAN ANTONIO	2	0	0	222	0.0045	5	0	1	246	0.0041	7	0	1
SAN DIEGO	57	34	4	1408	0.0462	19	0.024	21	1746	0.0372	19	0.0195	22
SAN FRAN. CSTL SO	178	96	5	269	0.6568	53	0.354	59	342	0.5171	53	0.2775	59
SAN GABRIEL	34	18	1	713	0.0477	20	0.025	24	784	0.0434	21	0.0230	26
SAN JACINTO	14	0	0	765	0.0183	10	0	1	0	0	1	0	1
SAN LORENZO-SOL	471	335	4	377	1.2504	58	0.887	61	516	0.9148	58	0.6493	61
SAN LUIS REY-ESC	32	21	3	777	0.0412	17	0.027	28	958	0.0334	17	0.0219	24
SAN MATEO BAYSIDE	87	19	2	169	0.5166	51	0.095	43	106	0.8282	55	0.1525	53
SAN PABLO BAY	7	0	1	115	0.0610	23	0	1	144	0.0486	22	0	1
SAN RAFAEL	57	24	3	62	0.9028	57	0.387	60	65	0.8582	56	0.3652	60
SANTA ANA	77	1	1	1682	0.0458	18	0.001	10	2075	0.0371	18	0.0005	10
SANTA BARBARA CSTL	538	412	4	400	1.3458	59	1.029	62	625	0.8620	57	0.6589	62
SANTA CLARA	46	28	6	1613	0.0291	13	0.017	19	2462	0.0189	12	0.0113	17
SANTA MARGARITA	12	1	1	741	0.0162	8	0.001	11	1026	0.0117	10	0.0010	11
SANTA MARIA	127	87	3	711	0.1771	36	0.122	50	1056	0.1194	35	0.0824	45
SANTA MONICA BAY	67	44	6	597	0.1441	32	0.074	40	434	0.1584	40	0.1015	49
SANTA YNEZ	29	21	5	699	0.0323	14	0.023	20	1542	0.0188	11	0.0136	19
SCOTT	56	31	4	814	0.0998	25	0.038	32	857	0.0653	25	0.0362	32
SEAL BEACH	0	0	0	92	0.0000	1	0	1	24	0	1	0	1
SHASTA	42	12	3	795	0.0528	22	0.015	18	534	0.0787	27	0.0225	25
SMITH	1120	144	5	804	1.3928	60	0.179	54	891	1.2566	60	0.1616	54
SONOMA CREEK	33	2	2	167	0.1981	39	0.012	15	408	0.0809	30	0.0049	14
SOUTH FORK EEL	464	53	7	689	0.6762	54	0.077	41	939	0.4962	52	0.0564	41
SOUTH FORK TRINITY	163	163	3	931	0.1751	35	0.111	47	1158	0.1407	36	0.0889	47
TOMALES-DRK BAYS	166	92	6	359	0.4902	50	0.256	58	402	0.4353	51	0.2291	57
TRINITY	401	161	5	2038	0.1968	38	0.079	38	2396	0.1674	38	0.0672	35
UPPER EEL	116	70	6	708	0.1528	33	0.099	44	1344	0.0804	29	0.0521	40
UPPER KLAMATH	149	51	4	1420	0.1014	30	0.034	31	1291	0.1115	33	0.0372	33
VENTURA	112	65	6	275	0.4073	48	0.236	56	460	0.2434	43	0.1413	51

North Coast Region
Bay Area Region
Central Coast Region
South Coast Region

Table 2. Passage Assessment Database: Dataset Sources in California Watersheds by Hydrologic Unit

Data Sources Requiring Further Examination

Despite the vast number of sites catalogued in this inventory, many more remain unexamined. The universe of data includes a great variety of sources, many of which are treated in this report. However, substantial additional effort is required to collect, collate, and analyze existing information from a variety of sources that currently have data in formats that are not immediately accessible for inclusion in the PAD, not to mention the need to conduct future on-the-ground assessments in coastal watersheds. Some such data sources are described below.

Department of Fish and Game

A variety of data located in regional field offices of the DFG deserves attention and investigation to broaden the State's knowledge of existing barriers to fish passage. The Conservancy and the DFG are working together to examine historical files on barriers and convey that information to the PAD. The DFG's Streambed Alteration Permit (1601 and 1603 permit) records are of particular interest, but are especially numerous and difficult to analyze for possible inclusion in the PAD. Of thousands of permits in each region, hundreds relate directly to fish passage, but these require substantial review to determine passage status.

California Department of Transportation

In light of Caltrans' management of a great many road-stream crossing sites throughout the State, possibly the most important source of data requiring investigation is that of potential barrier sites owned or managed by Caltrans.

Caltrans is conducting a statewide fish passage assessment in order to determine the scope and magnitude of culvert rehabilitation and replacement projects needed to restore passage for fish. The statewide assessment was initiated along North Coast highways and has expanded to include surveying streams along the Central Coast of California. Data from these examinations were included in the PAD, and provided a vital contribution to this inventory. It is unknown when this effort will be completed.

To help with the initial identification of road and stream crossings that need to be surveyed, Caltrans used GIS analysis to intersect their road and stream geographic layers. The resulting point layer represents potential crossings that need to be surveyed to determine whether there are really road and stream crossings in those locations, and if so, the fish passage status of each one. The following three maps (Figures 16, 17, 18) show the potential Caltrans road and stream crossings.

These maps make clear how much more work must be done to gain a comprehensive understanding of fish passage barriers in California. It should be noted that some of the potential crossings in the Caltrans data are already included in the PAD dataset, having been inventoried by one of the many agencies and organizations that contributed data to this effort. Also, as indicated above, Caltrans contributed datasets of surveyed fish passage assessment sites that were included in the PAD and the maps in Figures 1 through 14. As with many of the inventoried sites identified in this report, further assessment of most Caltrans structures is necessary to determine the extent to which these facilities impede fish passage.

A significant economy of scale for inventorying and assessing potential barriers to fish passage can be achieved through cooperation with outside entities experienced in this field. For example, inter agency agreements with the DFG, or the Department of Water Resources would probably achieve substantial time and cost savings in the collection of this information.

A similar model worked well in Oregon, where, in an effort to rapidly assess the severity of barriers to fish passage in coastal watersheds, the Oregon Department of Fish and Wildlife (ODFW) and the Oregon Department of Transportation (ODOT) employed a simple inter agency agreement to accomplish the task. This agreement led to a study and ensuing report entitled Assessment of Road Culverts for Fish Passage Problems on State and County Owned Roads, September, 1999.

Although the "first pass," or cursory survey approach taken, in combination with the absence of right of way issues, resulted in a relatively low project cost, the project utilized highly efficient survey techniques that may warrant investigation for possible adaptation to California's situation. Unfortunately, at least two factors limit the application of this model in California.

First, and unlike their counterparts in California, Oregon wildlife officials have vested right-of-entry for purposes of identifying and assessing barriers to fish passage. In California, Caltrans maintains this right for purposes of facility maintenance, but not for environmental assessment purposes. Therefore, it is Caltrans policy to seek permission through administrative channels for entry to Caltrans sites for purposes of environmental assessment purposes, such as fish passage assessment. This approach substantially increases the cost and time and time required to conduct fish passage assessments. For example, a recent effort to assess barriers to fish passage at Caltrans sites in District 1 (North Coast

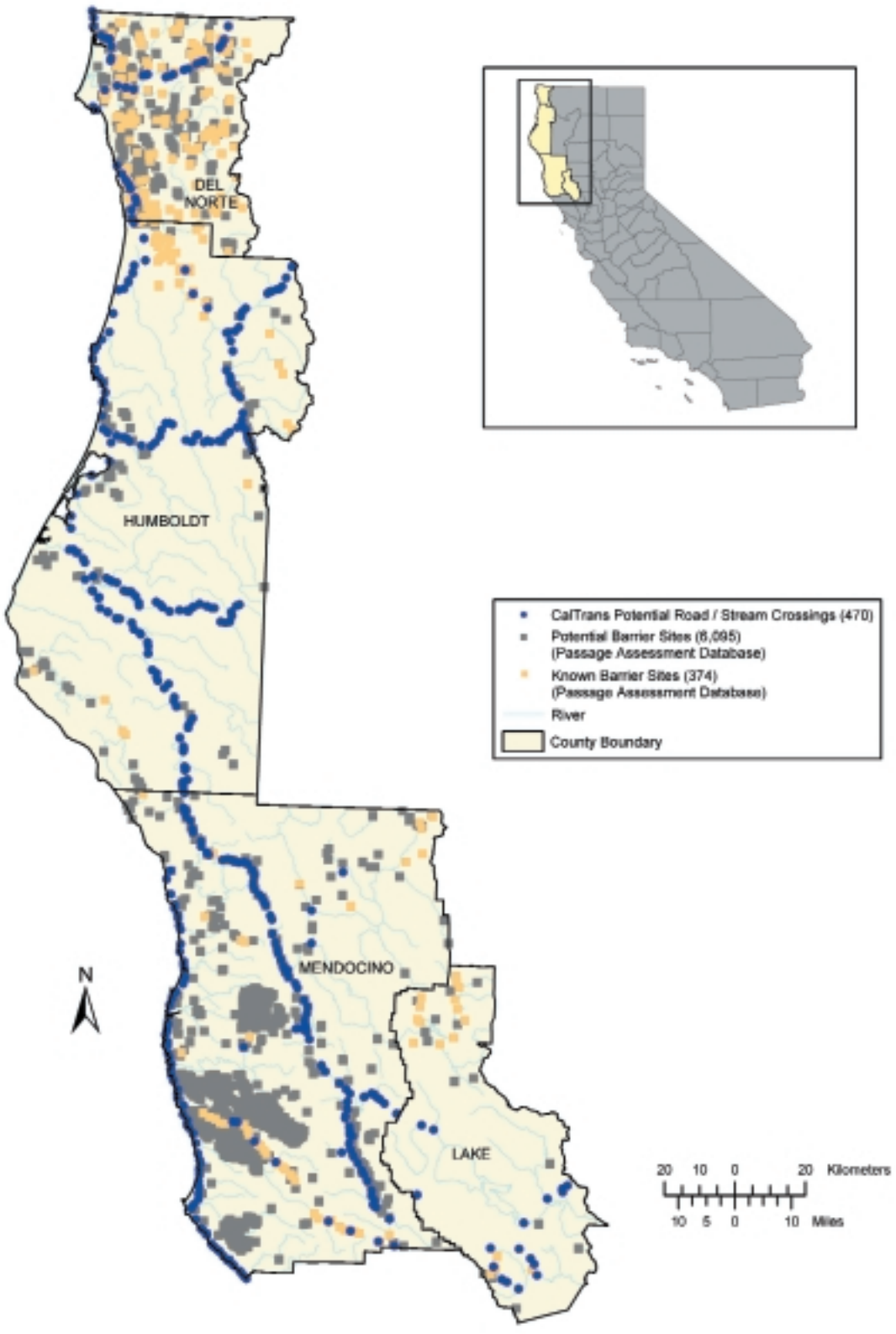


Figure 16. California Department of Transportation Potential Road/Stream Crossings: District 1

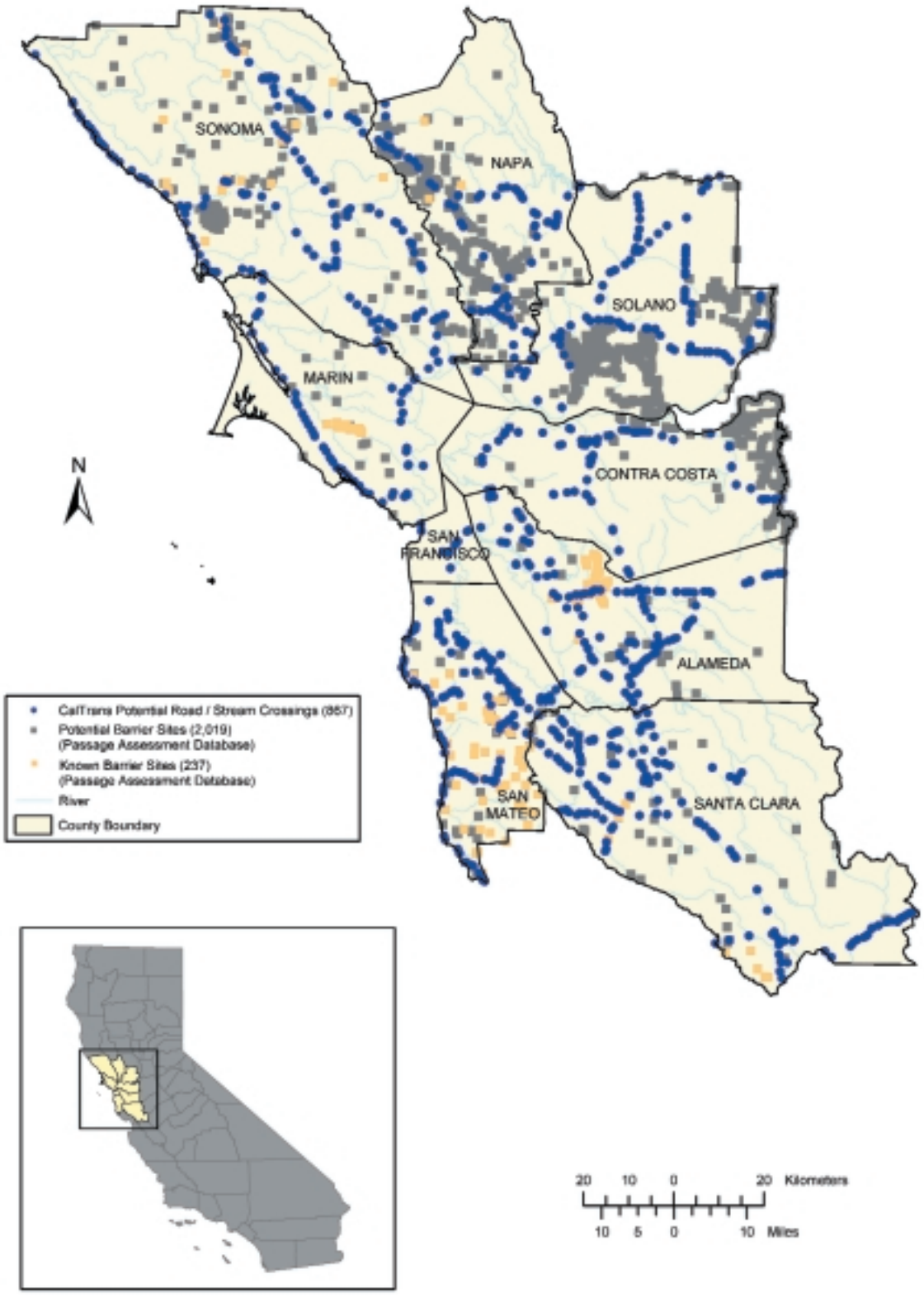


Figure 17. California Department of Transportation Potential Road/Stream Crossings: District 4

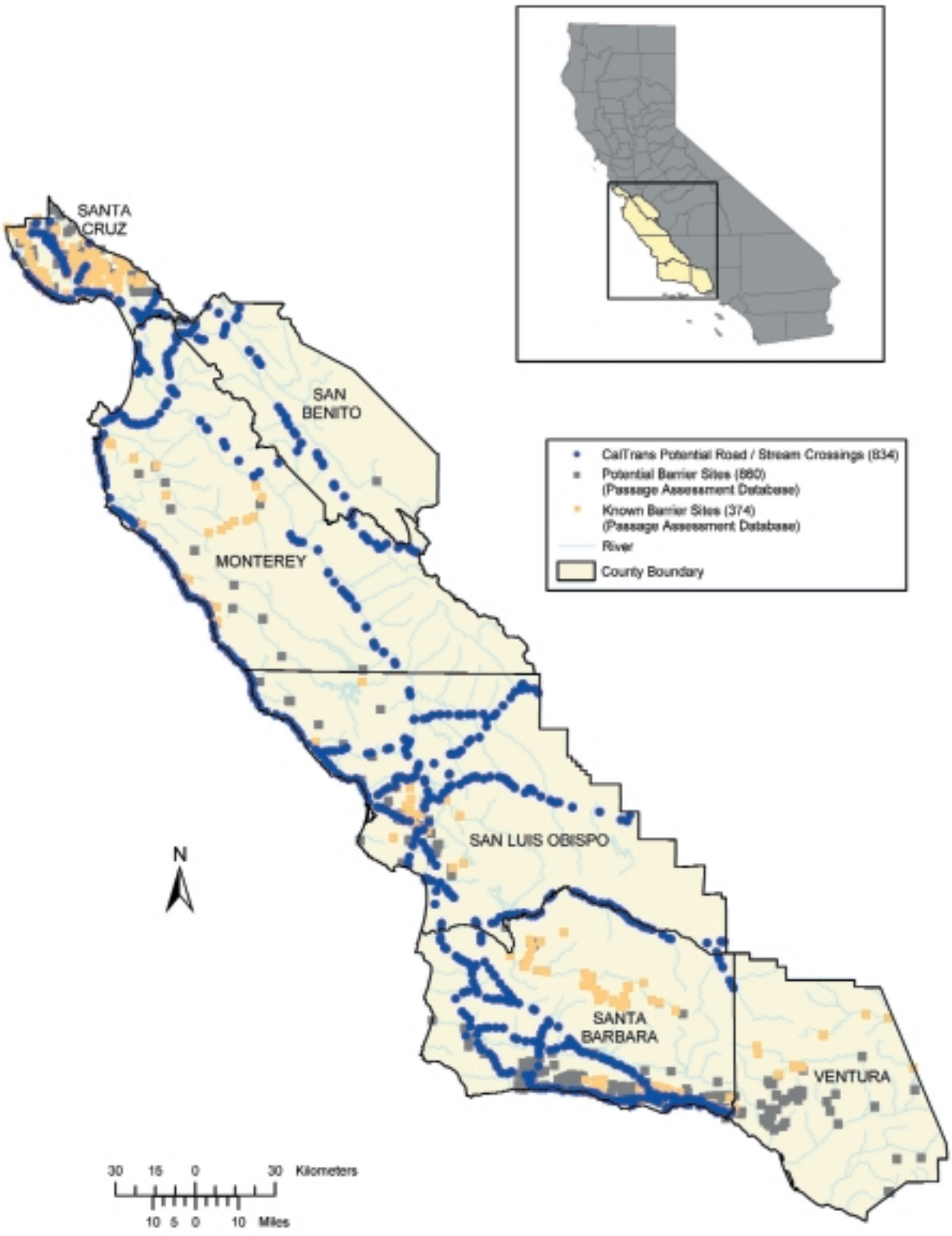


Figure 18. California Department of Transportation Potential Road/Stream Crossings: District 5

District) was launched with a solicitation letter for entry to 505 landowners. After at least two mailings and many phone explanations of the project, 66% of landowners provided entry, 12% declined entry, and 32% did not respond at any time. It was the experience of staff assigned to this project that when landowners were contacted in person, and were provided a complete explanation of the project, access was provided unconditionally. Therefore, successful assessment of Caltrans barriers may simply depend on staff resources available to conduct outreach. Such resources, in combination with the sort of "safe-harbor agreement" mentioned above, would undoubtedly improve our ability to assess barriers to fish passage on private lands.

Second, due to budget constraints, seasonal aide positions in California have been slashed, thereby impeding the State's ability to conduct this work at a lower cost than might otherwise be possible. Therefore, during these times of financial crisis, pooling agency resources for fish passage improvement and other purposes is more necessary than ever. The use of inter agency agreements for fish passage investigation would greatly assist all parties seeking the removal of barriers to fish passage.

Department of Water Resources

The Division of Safety of Dams (DSOD), a division of the Department of Water Resources (DWR), has jurisdiction over a number of known or suspected fish passage barriers in California. DWR, through an inter-agency agreement with the Conservancy, examined historical records at DSOD to determine a) passage status at jurisdictional dams, and, b) number of facilities once considered jurisdictional which, through modification, no longer are jurisdictional, but may continue to pose impediments to fish passage. Dams under jurisdiction are artificial barriers, together with appurtenant works, which are 25 feet or more in height or have an impounding capacity of 50 acre-feet or more. Any artificial barrier not in excess of six feet in height, regardless of storage capacity, or that has a storage capacity not in excess of 15 acre-feet, regardless of height, is not considered jurisdictional.

State Water Resources Control Board

The nature of in-stream structures and the well-documented effects of in-stream diversions upon fishery resources indicate the importance of extending this investigation to the archives of the State Water Resources Control Board (SWRCB). Comprehensive information regarding approximately 32,000 permitted or licensed water rights, including a great many dams and diversions, including notations on the presence of in-stream and off-site storage facilities, and including comment letters regarding fish passage from the DFG, are on file at the SWRCB archives. Unfortunately, this information is especially difficult to access for analysis.

The database currently in use at the SWRCB does not track presence of fishways at the diversion site, indication of whether storage is in-stream or off-site, history of protest of permit applications by DFG or others relating to fish passage, or anything else useful for the examination of diversions for the purpose of determining their effect on fish passage. Within the SWRCB database, there are approximately 32,000 records of water rights applications. However, a water rights application can have multiple records in the data base, one record for each owner and each water source. Currently, the SWRCB database has 14,398 applications for water appropriations. Of those, 8,978 are active water rights (7,134 licenses and 1,844 permits) and 758 are pending, meaning that no permit has yet been issued. 4,662 applications have been cancelled or revoked. Any remaining data possibly represents multiple listings for the same water rights application or other information not directly relating to fish passage.

It is quite likely that the results of an investigation of these records will yield troubling results. In modern times, water rights permits have been conditioned to provide for fish passage only where DFG has expressed concern in the form of a protest to a pending application or a complaint on an existing facility, and certainly not in every instance where a protest or complaint is filed. Therefore, many of these records may inform the data team of new barriers to fish passage that went unrecorded previously.

The Conservancy has invited SWRCB staff to join the Fish Passage Forum, explore potential areas of cooperation and common interest, and help identify measures leading to the more efficient management of such important data. It should also be noted that although the SWRCB officially notices the DSOD of jurisdictional dams permitted by the SWRCB, no such mention is made of non-jurisdictional dams. Therefore, a potentially significant number of small dams that are not in DSOD records may be present in SWRCB records, so examination of these records should be a top priority for future barrier inventory efforts. Moreover, since the SWRCB now encourages the development of off-site storage facilities to minimize effects of diversion to aquatic resources, more effective data management should be implemented in order to track the construction and maintenance of in-stream and off-site reservoirs and water storage and diversion facilities.

National Inventory of Dams

Although the Conservancy's inventory of barriers to fish passage included the National Inventory of Dams (NID) California dataset 1,478, the NID dataset includes no information about passage status at the facilities included in the dataset. The Conservancy is making every

effort to determine fish passage status at these sites, but improvement of the NID dataset is necessary from an aquatic ecology and resource management perspective. The Aspen Institute, in their 2002 report entitled "Dam Removal - A New Option For A New Century," made a series of recommendations along these lines, and those recommendations are available for review at http://www.aspeninstitute.org/index.asp.

Private Lands

One of the most significant areas requiring further examination is private land. Many road and stream crossings exist on private lands, but few of these sites have been examined. Proponents of fish passage improvement projects are encouraged to work with local entities such as resource conservation districts in order to identify opportunities for public-private partnerships in the area of fish passage inventory and assessment.

The allowance of a safe-harbor provision for cooperative landowners, an agreement that respects private property concerns and prevents punitive enforcement actions resulting from restoration-oriented access, would greatly assist this limitation. Currently, the United States Fish and Wildlife Service (USFWS) does provide such protections, but the National Oceanic and Atmospheric Administration Fisheries Branch (NOAA Fisheries), whose mandate includes the federal protection of fish species of commercial interest, including salmon and steelhead, do not.

Fixing Passage Problems

This report is intended to encourage and facilitate fish passage improvement projects in coastal streams, thereby helping to achieve the State's goal of increasing naturally producing anadromous salmonid populations. By collating and disseminating all available data relating to in-stream structures in a coherent and standardized format, the Conservancy and its partners have provided a means by which interested parties may review barriers not merely as individual units, but as a series of features that fragment available habitat within a given watershed.

These data are provided at a broad, reconnaissance level in order to assist watershed-based analysis in the context of as many factors as possible. However, more detailed background data were often received for this project and are available from the Coastal Conservancy upon request. A summary of the data received and included is attached as Appendix A(4). Prior to implementing fish passage improvement projects, project proponents will need to collect more detailed, project-specific information, including biological background material, engineering specifications, and the social, economic, and legal settings of the barriers themselves.

Maintenance and management of this database in conjunction with other data sources is also instrumental to the long-term viability of this project. The Coastal Conservancy is exploring opportunities to continue data collection and management in conjunction with the other members of the Fish Passage Forum. DFG has expressed interest in housing and maintaining this database as part of its ongoing information management program.

NOAA Fisheries Passage Guidelines for anadromous salmonids, as well as DFG-approved protocols for assessing severity and preparing for the modification/removal of barriers to fish passage, are included in Appendix C(2) of this report. Project proponents are encouraged to review this section to develop a thorough understanding of the complexities involved in fish passage improvement projects. Some entities, such as FishNet4C, host seminars on fish passage improvement to provide project proponents with an overview of project development.

Removing barriers can be done, at relatively low cost, with high benefits both in terms of recovery of species, and maintenance of infrastructure. Here at McGarvey Creek, tributary to the Klamath River, a 100-foot culvert posing a complete barrier to fish migration was removed, as well as the soil on top of it, the channel was restored to its original configuration, and steelhead may now access habitat upstream of the restoration site. Moreover, the costly maintenance of this site is no longer a concern to the landowner, Simpson Resource Management, Inc.

Identifying willing partners, landowners, and facility managers is the most crucial requirement for the success of fish passage improvement efforts. An increasing number of successful fish passage improvement efforts are demonstrating the effectiveness of treating barriers, and are in turn diminishing the fear associated with modifying in-stream structures. Counties throughout the Pacific Northwest and California have learned that, despite the high, up-front capital cost associated with culvert modifications, substantial savings accrue over the long term due to lower maintenance costs.

This trend could be enhanced and amplified by the development of a recommendation now under consideration by the Coho Recovery Team, a group of agency officials, private landowners, and others attempting to develop a coordinated recovery plan for coho salmon, which are now proposed for listing under the California Endangered Species Act. The proposed language, due for recommendation to the California Fish and Game Commission in August 2003, would provide for a "safe-harbor" to landowners participating in fish recovery activities. Under this proposal, agency officials could more readily gain access to private lands for recovery actions, but would hold landowners harmless for existing violations of code that prove deleterious to anadromous fish.

The State of California might also learn from recent fish passage improvement efforts in the Commonwealth of Pennsylvania, which recently conducted a highly successful anadromous fish passage improvement program that could help fish passage improvement proponents in California and elsewhere. In an effort to improve fish passage, as well as reduce drowning at Pennsylvania's many dams, the Pennsylvania Fish and Boat Commission launched a campaign to notify dam owners of their fish passage and public safety responsibilities,

apprise them of available funds and technical assistance for meeting existing requirements, and coordinate efforts with willing landowners to rapidly and efficiently develop functional fish passage facilities and safety notices at Pennsylvania's dam sites. Since 1995 Pennsylvania has improved fish passage at a great many sites, removed 60 obsolete dams, and developed a list of 50 more fish passage improvement project sites at which the owners seek permission and funding for modification or removal of the facility. Through collaborative effort and a strong public education campaign, as well as an outreach program to facility owners and operators, the Fish Passage Forum could develop a similar salmon recovery project. Fish and Game Codes 5930–5948 address State law regarding fish passage at dams, requiring the DFG to "from time to time, examine all dams in all rivers and streams in this State naturally frequented by fish" and to "order in writing the owner of the dam to provide the dam, within a specified time, with a durable and efficient fishway, of such form and capacity and in such a location as shall be determined by the department." The Fish Passage Forum provides a convenient venue whereby member organizations may collaborate in developing public education programs to encourage barrier owners and operators to work with the Forum members on fish passage improvement.

In a similar vein, the Aspen Institute, a prominent think-tank, recently assembled a broad array of interest groups to explore the concept of dam removal. The inclusion of dam owners as well as conservation groups ensured a remarkably candid discussion about resource management potentials. The findings of that group were released in a 2002 report entitled "Dam Removal — A New Option For A New Century." The report contains data collection and analysis recommendations that are highly consistent with the findings of this report. The report can be found at www.aspeninstitute.org/AspenInstitute/files/CCLIBRARY FILES/FILENAME/0000000074/damremovaloption.pdf and its findings are summarized in Appendix D(3) of this report.

The purpose of this report is to prompt agencies and individuals to examine barriers to fish passage in the context of the watersheds where barriers exist, and to provide sufficient information with which those entities can begin the difficult task of developing fish passage improvement projects. The Coastal Conservancy will circulate this report and collaborate with its partners in the Fish Passage Forum to encourage the submittal of fish passage improvement project proposals directed to the Conservancy and others. This report, the Conservancy's 2003 Strategic Plan, and the input from sister agencies and other partners will help guide the Conservancy's selection of projects for design and implementation.

Project Selection

Funding requests for fish passage improvement projects submitted to the Coastal Conservancy will be reviewed on a first-come, first-served basis for consistency with the Coastal Conservancy's standard project selection guidelines and the 2003 Strategic Plan, and with special consideration given for project rationale developed in conjunction with this report and its accompanying GIS platform, both of which will assist potential grantees to explain the watershed-level prioritization for their projects. Applicants are also strongly encouraged to solicit the input and advice of federal and State biologists from their region. The following ranking mechanisms will assist project proponents to select projects in a logical fashion and to substantiate their requests for planning and implementation funds.

Severity Ranking

Techniques ranging from anecdotal evidence to professional judgment to specific software programs assist project planners with the task of assessing the severity of a barrier. The PAD includes three noteworthy fields that will assist readers with the task of reviewing barrier severity information. One field includes a simple numerical ranking, consistent with Section IX of DFG's California Salmonid Stream Habitat Restoration Manual, attached as Appendix C(2). A second field indicates who conducted the severity ranking, providing readers with a "paper trail" to evaluate the quality of the source data. A third and more general field indicates the severity of a barrier. This field is more suited to data sources or previous assessments not conducted in accordance with Section IX, or where severity ranking is anecdotal, subjective, or less precise than more contemporary assessment techniques.

Much of the data collected for the purposes of this report were collected prior to development of accepted assessment techniques, such as Section IX, or even prior to the most recent field assessment protocols such as FishXing or the Conception Coast Protocol. In these instances, the data assembly team has applied best professional judgment to assess severity, and has provided qualifying notes where applicable in a fourth field. In many cases severity is unknown, and the field accurately represents that lack of information.

It is recommended that all severity rankings be reviewed on a watershed basis and that fish passage improvement project proponents substantiate project development in concert with all known severity ranking protocol. The Conservancy will give special consideration to existing severity rankings in the course of reviewing project development and funding requests, and will encourage other funders to do likewise.

Watershed Context

The data layer created by this project can be overlaid with a multiplicity of other data layers portraying stream survey results, habitat quality and type, fish survey data, and a variety of other factors. Thus, project proponents and reviewers can make thoughtful choices for project implementation based on the aquatic resources proximate to the barrier, as well as the historic conditions of proposed project areas. Projects should be evaluated in the context of the watersheds where they are found. A less severe barrier low in the watershed may be a higher priority for modification than a severe barrier higher up. Identifying the quantity and quality of the habitat to be gained is also crucial for selecting proposed projects.

Regional Ranking

The ranking and prioritization of fish passage improvement projects inevitably raises a host of largely unanswerable questions, ranging from the partially scientific to the wholly philosophic. One such debate concerns whether to direct limited recovery funds to watersheds where there are few fish and where extirpation is likely if not actual, or whether to fund recovery projects where populations are relatively robust, but higher return rates are promising. This debate is especially pronounced between northern and southern California. Populations of anadromous fish are extremely low in central and southern California, so much so that they were listed earlier than northern populations, and their recovery outlooks are bleak relative to populations in northern California. Some argue that this warrants more investment in restoration, while others argue the converse. Not surprisingly, an organization's proximity to a given watershed tends to result in advocacy for its recovery, regardless of that watershed's ecological condition.

Although initial costs seem high, County governments realize substantial, long-term savings in maintenance costs from fish passage improvement projects, such as this installation of a fish-friendly, natural-bottom culvert at Jordan Creek, Del Norte County.

Acknowledging the difficulties inherent in prioritizing one region over another, this report attempts to present coastal fish passage barrier data as clearly, plainly, and equally as possible, thereby promoting locally generated projects throughout the State's coastal watersheds, and adequate rationale for such investments. The Conservancy expects that assembling this barrier data will lead to the development of an ongoing and equitable distribution of recovery investments throughout the respective ranges of species, achieving a widespread and successful recovery.

The Coastal Conservancy's guidelines for project selection are flexible enough to allow for a wide range of projects suitable for consideration and funding. Readiness; leverage of local funds; cooperation with other agencies and non-profits; innovation and development of demonstration projects; resolution of more than one issue such as species protection, agricultural preservation and flood control; and need and urgency are but some of the factors the Coastal Conservancy takes into account when considering projects for funding. The Coastal Conservancy is extremely flexible in its consideration of projects, and can review and fund proposed projects in a relatively short time frame.

Project Implementation

Environmental Document Preparation and Permitting

Planning for the implementation of a fish passage improvement project is exempt from the California Environmental Quality Act (CEQA). Moreover, due to recent CEQA amendments small habitat restoration projects may also be categorically exempt from CEQA review. Culvert replacement conducted in accordance with published guidelines of the Department of Fish and Game or NOAA Fisheries, the primary purpose of which is to improve habitat or reduce sedimentation, is an example of a small project subject to this exemption. Project proponents and lead agencies should review new CEQA language sections [Appendix D(1]), and consult with permitting agencies to determine eligibility for this exemption. The new language may be found at http://ceres.ca.gov/topic/env_law/ceqa/guidelines/art19.html.

However, prior to implementation of restoration projects, project proponents must, consistent with CEQA, conduct a thorough analysis of the proposed project in preparation for permit applications. Project design and planning will involve initial time commitments ranging from several days of field-engineering work to years of reconnaissance work for larger dam modification or removal projects, both of which are typically followed by the preparation of an environmental document analyzing the proposed project and its anticipated effects. Planning grants are often necessary to develop a project proposal to the level where funding can be secured for implementation. Few sources provide planning grants, and the Coastal Conservancy is one of few that also provides funds for project design.

Appendix D(1) contains the California Salmonid Stream Habitat Restoration Manual's list of permits that may be required for passage improvement projects, as well as excerpts from CEQA Guidelines as amended on 7 September, 2004.

Post-Project Monitoring

Project proponents are encouraged to incorporate post-project monitoring provisions in their project proposals. The Conservancy's objective in making this recommendation is to inform future project design, development, implementation and maintenance, thereby improving project effectiveness over time.

Regional Management Objectives

The Coastal Conservancy has established regional management objectives for the purposes of this report, as well as for ensuing projects. These are presented below. Please note that while the PAD provides some perspective on the relative numbers of different types of barriers in different coastal regions, the PAD is being updated continuously. Therefore, project proponents should review the PAD for updates frequently.

North Coast

For the purpose of this report, the North Coast extends from the Oregon state line to the Golden Gate Bridge in San Francisco Bay, excluding San Francisco Bay. This corresponds to the Conservancy's boundaries, and also reflects the boundaries used by the State in consideration of the listing of coho salmon as an endangered species.

North Coast - Regional Issues

Relative to the balance of the State, the North Coast region is rich in anadromous fish resources; however, relative to the region's historic population levels, anadromous fish stocks have collapsed. Aquatic habitat has been affected by a variety of land management practices, particularly timber harvest practices, water diversion structures, and road and stream crossings. As a result, anadromous fish populations have declined, such that coastal chinook and northern California steelhead populations were listed as threatened under the federal Endangered Species Act on November 15, 1999 and August 7, 2000, respectively.

In the North Coast, the preponderance of potential barriers identified in the PAD is road and stream crossings, followed by logjams and other natural barriers. Diversions are also prevalent, and they may or may not prove to be temporal barriers to fish passage and limiting factors to overall habitat quality.

North Coast - Existing Analyses and Efforts

The North Coast leads the State in the wealth of data concerning fish habitat issues, including the assessment of barriers to fish passage. DFG has conducted numerous habitat assessments, population surveys, and

studies of various types over the years. DFG has also recently funded a number of barrier assessments for the intersections of county roads and streams. The results of these assessments and prioritizations are already in use to improve fish passage on numerous coastal streams. *These results identify 65 high- and 16 moderate-priority barriers requiring immediate modification or removal to improve fish passage.*

Private concerns, such as industrial timberland owners, have also conducted thorough investigations of watersheds located within their landholdings. Most of these entities have been responsive to Conservancy requests for information about barriers and have demonstrated a willingness to join the Conservancy and others on future habitat improvement projects.

Statewide, the assessment of barriers to fish passage has progressed furthest in the North Coast region. An assessment of county road and stream crossings has been conducted for each northern county, including Siskiyou, Trinity, Del Norte, Humboldt, Mendocino, Sonoma, and Marin. In addition, Caltrans has conducted a preliminary assessment of Caltrans-managed road and stream crossings in its District 1 region, which roughly corresponds to the Conservancy's North Coast boundaries. Some private efforts were conducted, too, and some of these are included in this report.

Nevertheless, significant gaps in our understanding of the scope of the barrier problem remain, even in this well-examined area. For example, in the Humboldt County Roads Assessment, 104 stream crossings were identified, but only 67 were surveyed. This may have been due to access problems, or cases where existing structures such as bridges clearly provided passage already. Nevertheless, it demonstrates the need for additional surveys. More significantly, there are countless private roads throughout the State, many of which are unknown, that almost certainly possess culverts and other impassable barriers constructed where the road crosses the stream. Conservancy-commissioned field surveys have demonstrated that marching up a stream and cataloguing all barriers is the only sure way to capture all impediments to fish passage. It is worth noting that it is helpful to ascertain, with precision, the status of every potential barrier within a watershed, for any single barrier can diminish the efficacy of other fish passage improvement projects within the watershed.

North Coast - Research and Assessment Needs

Large numbers of road/stream crossings have been identified in the North Coast, but the vast majority of these are of unknown fish passage status. For example, the Big-Navarro-Garcia watershed has

4,000 inventoried road and stream crossings, but only 146 of those are known to be partial or total barriers (Figures 3 and 4). Most site types (dams, water diversions, fish passage facilities and non-structural sites) are similarly uncharted. Overall, 17 percent of the inventoried sites in the North Coast are known to be passage barriers. Identifying the passage status of as many of the inventoried sites in the North Coast as possible is a high regional priority.

North Coast watersheds vary widely with respect to what passage site types have been surveyed. For example, the Trinity and Russian river watersheds have extensive inventories of water diversions, but diversions have not been surveyed in any of the other watersheds (Figures 3 and 4). Figures 16 to 18 demonstrate that many potential road/stream crossings identified by Caltrans have not yet been surveyed to determine passage status. Future survey work in any given watershed should focus on passage site types for which data are currently lacking.

Bay Area

For the purposes of this report, the Bay Area Region includes all streams tributary to the San Francisco Bay, excluding the Delta. This region corresponds to the Conservancy's administrative boundaries, and is included in the NOAA Fisheries Central California Coast Evolutionarily Significant Unit (ESU) for steelhead.

Bay Area - Regional Issues

More densely developed than any other region analyzed in this report, the Bay Area nonetheless hosts remnant populations of anadromous salmonids, most notably the steelhead of San Francisquito Creek, Alameda Creek, and a number of other Bay watersheds. The industrialization and urban development of the region have severely diminished available habitat, but in areas where habitat remains, even in sparse pockets, populations of steelhead remain. The preponderance of potential barriers identified in the PAD are dams, road/stream crossings, non-structural barriers, and diversions that may or may not prove to be temporal barriers to fish passage and limiting factors to overall habitat quality.

Bay Area - Existing Analyses and Efforts

The establishment and activeness of local watershed groups, as well as more vigilant efforts by resource agency officials, has prompted the survey and analysis of all Bay streams for barriers and habitat types. That information, compiled by DFG and DWR, is included in this report.
There are at least eight high- and eight moderate-priority barriers requiring immediate modification or removal to improve fish passage.

Bay Area - Research and Assessment Needs

The three most prevalent passage site types in the Bay Area Region currently in the PAD are dams, road/stream crossings, and water diversions (Figures 5 and 6). For most of the watersheds, though, these sites have primarily unknown passage status (15 percent of the total Bay Area inventoried sites are known to be barriers). In order to evaluate fish passage in the Bay Area it will be necessary to determine which of these sites are barriers, and the degree to which they block fish passage.

Streams under roads are the rule in northern California. Conversely, roads under streams prevail in the southern part of the State. These crossings, sometimes known as dry-crossings, low-water crossings, or Arizona crossings, as well as the many debris basins — also pictured — are now receiving greater attention in an effort to improve fish passage for the endangered southern California steelhead.

Central Coast

For the purpose of this report, the Central Coast extends from coastal San Mateo to the Santa Barbara and Ventura County boundary. This corresponds to the Conservancy's administrative boundaries. The region encompasses the Central California range of coho salmon, listed as Endangered under the California Endangered Species Act and threatened under the federal Endangered Species Act. This region also encompasses portions of California's central, the entire south-central, and portions of the southern ESU for steelhead as defined by NOAA Fisheries. The southern ESU is listed as endangered under the federal Endangered Species Act.

Central Coast - Regional Issues

While not as rich in anadromous fish resources as the northern counties, the Central Coast has a number of important populations of coho salmon and steelhead. Habitat for both species has been degraded by a variety of uses, chief among them being agricultural practices, water diversions, timber harvest practices, and road construction. This development has resulted in so severe a decline of anadromous fish populations that coastal chinook and steelhead populations of the central and south Central Coast were listed as threatened under the federal Endangered Species Act on November 15, 1999 and October 17, 1997, respectively. In the Central Coast region, the preponderance of barriers identified in the PAD is dams, road and stream crossings, and non-structural sites.

Central Coast - Existing Analyses and Efforts

Coho salmon south of San Francisco Bay were California's second group of anadromous salmonids to be listed under either the State or federal Endangered Species Act. The listing of this population as endangered under the California Endangered Species Act on

December 31, 1995 prompted early examination of salmonid habitat in this region. More recent examinations of Central Coast watersheds have also contributed to our understanding of salmonid habitat in this region.

Twelve separate watershed assessment and enhancement plans are in place or have been conducted in Santa Cruz County alone. Few gaps in our understanding of the scope of the barrier problems in the Santa Cruz region remain, though other poorly understood areas exist in the Central Coast. Throughout the region, as in other regions, substantial funding is needed to implement proposed recovery actions. *Some of these funds should be directed to modifying or removing the 91 high- and 76 moderate-priority barriers to fish passage in this region.*

The Conservancy has also conducted an assessment of barriers to fish passage in the Sisquoc River watershed. The results of that assessment are incorporated in this report and the accompanying database, and the full report is available from the Conservancy upon request.

Central Coast - Research and Assessment Needs

The Central Coast has the highest percentage of known passage status sites relative to inventoried sites: 61 percent of the inventoried sites are known to be passage barriers (Figures 7 and 8). Of the known barriers, non-structural sites and log jams present the largest number at 427 sites, followed by 329 road and stream crossings, and 246 dams. However, these known fish passage barriers are located in a relatively few watersheds while other watersheds lack identified barriers, such as the Carmel, Cuyama, Estrella, and Salinas rivers. The Central Coast also has the highest number of "other" site types, predominantly flood control channels and grade control structures.

South Coast

For the purpose of this report, the South Coast extends from the Santa Barbara/Ventura County line south to the Mexican border. This definition corresponds to the Conservancy's administrative boundaries, and approaches the boundary used by NOAA Fisheries in establishing an Evolutionarily Significant Unit (ESU) for the southern California steelhead, which extends from the Santa Maria River between San Luis Obispo and Santa Barbara counties.

South Coast - Regional Issues

The South Coast lacks salmon, but is home to the southernmost ESU of steelhead. The habitat of this steelhead population, the only steelhead population in California to receive endangered status under the federal Endangered Species Act, listed October 17, 1997, has been

largely blocked by the construction of numerous small, impassable dams, some of which have been rendered obsolete due to infilling by sediment. These dams not only have blocked the passage of steelhead and other freshwater life, they have greatly impaired natural beach replenishment processes by restricting the flow of sediment to the sea. Contact the Coastal Conservancy for more details on beach replenishment, as well as previous articles and reports on this topic.
Dams represent the third largest category of known barriers to fish passage of sites identified in the PAD, and many of these are in the South Coast region. The importance of dams in the South Coast is reflected in current efforts to identify candidates for modification or removal. Rindge Dam in Los Angeles County, like Matilija Dam in Ventura County, is a leading candidate for removal, and the Conservancy is working with a number of stakeholders to pursue this objective (see pp. 62 and 59, respectively, for project details). Road and stream crossings represent another large portion of the identified passage sites in the South Coast.

South Coast - Existing Analyses and Efforts

In the South Coast region, relatively few assessments of fish passage barriers have been conducted, partly due to the relative scarcity of anadromous fish resources downcoast of Point Conception. Steelhead, however, are found as far south as San Mateo Creek in San Diego County. The Conservancy recently funded a habitat and barrier assessment of streams tributary to the Santa Monica Bay to collect habitat and barrier data. The results from the Santa Monica Bay survey will be available in 2004. *There are 11 high- and 20 moderate-priority barriers requiring immediate modification or removal to improve fish passage.*

South Coast - Research and Assessment Needs

The overwhelming majority of potential barriers in the South Coast region are dams. Of 756 inventoried sites, 434 are dams (Fig. 9). Although passability at most sites is undocumented, it is probable that most are complete barriers to fish passage. For example, in San Diego County, there is not a single dam that incorporates fish passage specifications in its design (A. Greenwood, personal communication). Of the 142 dams with known passage status, 133 are total barriers to fish (Fig. 10).

Future of the Project and Recommendations

This report is a conservative and preliminary depiction of the scope and severity of the problem of barriers to fish passage in California's coastal watersheds. As this report went to press, the data team assigned to this project continued to receive important barrier data, which they continue to enter into the PAD. Concurrent with that effort, the team is examining data to avoid duplicate and incorrect entries to the PAD.

Despite the Conservancy's rigorous outreach effort, many data sources remain unexamined. Private lands, and additional regional agency offices and files of agency personnel are current targets of data collection efforts. The Conservancy's data team continues to schedule site visits to key regional offices in order to examine historical files for additional barrier data. Sites scheduled for additional visits include: DFG regional offices in Monterey and Long Beach. Additional site visits to Caltrans, NOAA Fisheries, SWRCB, and other agencies are planned.

Perhaps the most important data source remaining unexamined is the Caltrans dataset. It includes two to three thousand potential road/stream crossings in coastal counties, excluding Ventura County south, and thus as many as three thousand potential barriers to fish passage. These data await more thorough examination and analysis prior to entry into the PAD. Other untapped, but highly important data source include the DWR, private lands, the DFG's Streambed Alteration Permit records, and the SWRCB's identification of known water diversions. Containing roughly 32,000 records, the SWRCB's dataset is an especially valuable source of information for resource

managers trying to evaluate the severity of barriers as affected by instream flow reductions and diversions.

Following release of this report, the Conservancy will continue to form partnerships and seek Conservancy Board approval for strategic fish passage improvement projects developed consistent with Conservancy project selection guidelines and the 2003 Strategic Plan.

In order to promote and assist future barrier identification, assessment, and the prioritization of fish passage improvement projects, the following recommendations should be considered.

✣ Fund 1) implementation of fish passage improvement projects, and 2) the collection, analysis and management of fish passage barrier data for all watersheds important to the recovery of anadromous fish resources. The second task requires personnel commitments and the conversion of all datasets that are not yet in the PAD to a usable format and a focus on filling in gaps where data are missing in the PAD. Coordination of such efforts between the members of the Fish Passage Forum [see Appendix C(1)] and its partners will achieve cost savings and scales of economy through inter agency partnerships and other methods. The Forum and its partners should seek steady and continuous allocation of funding for fish passage improvement projects identified in this report, particularly from federal sources, such as the federal Department of Transportation and the Department of Commerce. There is substantial interest in fish passage improvement projects. Allocation of funding and effective prioritization of projects is the key limiting factor to the implementation of worthwhile projects. The Conservancy has established partnerships with numerous individuals and organizations statewide who are prepared to conduct fish passage improvement projects when funding is allocated.

✣ House fisheries management data, including this barrier data set, in the same, easily accessible location, such as DFG. Doing so would facilitate efforts to analyze watershed condition more readily, allocate restoration funding more efficiently, and monitor the results of restoration actions over time, all in the context of the many factors contributing to the overall condition of a watershed. Forum members are uniquely positioned to contribute to the development and management of a spatial database capable of providing this level of data tracking.

✣ Equip agency field staff with hand-held computers with GPS capability for the purpose of coordinated data entry into a standardized template. Future attempts to retrieve and analyze available data would be facilitated and enhanced by adopting such a template and means

for data entry. The varieties of paper field notes collected by regional biologists, and gleaned for data for the purposes of this report, do not lend them to conversion to an electronic medium, and are therefore not readily accessible either to the general public, agency colleagues, or even the biologists themselves. Therefore, the data are often left unanalyzed and unused. Providing field biologists with hand-held data entry systems and an established data collection framework whereby input data could be easily disseminated and analyzed could partly solve this problem. This will also vastly improve data quality by ensuring that a standard set of data is collected and by allowing the quality of that data to be checked at the point of collection by error-checking routines included in the data entry program. There are currently several programs in DFG that have successfully integrated hand-held computers with GPS into their field data protocols. The High Mountain Lake Survey has used the system for two years and the Sierra Meadows Survey has used the system for three years. DFG's enforcement branch has also developed a successful program in this area.

- Assess the passage status and severity of inventoried but unassessed passage assessment sites. These include sites owned or regulated by Caltrans, SWRCB, DWR's Division of Safety of Dams, private parties, and others. Inter agency agreements with sister agencies, such as that adopted in Oregon, and adapted for California, might be an effective means of achieving this objective.

- Work with Forum members to craft "safe-harbor" guidelines that would encourage private landowners to participate in fish passage barrier identification and improvement projects. Current data collection efforts are hampered by existing legislation and policy requiring written landowner consent for entry. As a result of this limitation to agency staff, vast areas of coastal watersheds remain unexamined and inventoried for barriers to fish passage. At this time, the Coho Recovery Team members are attempting to draft "safe-harbor" language that respects private property owners concerns. That language is being prepared for possible recommendation to the California Fish and Game Commission in August, 2003 as part of the Coho Recovery Planning Process.

- Include barrier inventory or assessment components in the design of all future watershed assessment projects, unless it is demonstrated that such inventories or assessments have already been conducted. In some cases, previous watershed assessment projects have not included barrier assessment components. In light of the severe effect barriers can have on watersheds and their aquatic resources, this omission should not be repeated.

✣ Review barrier data in the context of other factors to help prioritize future restoration projects. Existing data management strategies have tended to present information out of context. By presenting barrier data in the context of other factors such as habitat condition, stream surveys, or restoration projects, this report can guide agencies, fishery advocates, and local watershed groups to priority projects likely to lead to habitat and population recovery. For example, stream restoration projects are available in a standardized spatial format compatible with PAD data. For a description of the restoration project dataset, see Appendix A(3). By presenting barrier data alongside restoration activities, habitat data, or even land use practices, resource managers and project funders will have one more useful tool for the effective prioritization of future restoration projects. Housing fisheries data in one easily accessible location as described above would greatly assist this effort.

✣ Launch an extensive public outreach campaign designed to educate barrier owners about the opportunities available for assistance with fish passage improvement projects, including funding and technical assistance. In the interest of establishing a proactive and coordinated fish passage improvement program that engages and educates site owners, while helping them to comply with State law, the Forum and its members are encouraged to conduct a review of relevant State Fish and Game codes relating to fishways and review the highly successful Pennsylvania Program outlined in this report.

✣ Promote the Fish Passage Forum as a clearinghouse and venue for the exchange of information and strategic planning for fish passage improvement projects. Doing so will increase efficiency and reduce costs of projects by promoting the directed collection of information and the appropriate prioritization of effort. For example, Fish Passage Forum members are already coordinating regional barrier inventories, such as DWR Bulletin 250 and this report, with other information sources. Forum members are exploring the concept of housing all available data under a single, Web-based program, as recommended above.

✣ Seek assistance from the American Fisheries Society with the update and publication of their 1983 publication Stream Obstruction Removal Guidelines in conjunction with DFG and NOAA Fisheries. Tailored to simple debris removal efforts, this earlier publication underscores how far the field of passage improvement has come since 1983. The talent and capabilities of the American Fisheries Society would be well suited to providing leadership in this area.

✣ Caltrans could greatly assist fish passage improvement project proponents by completing a California specific engineering design

manual for barrier/culvert modifications and remediation. Such an effort is now underway between Caltrans and other members of the Fish Passage Forum, but has not been released for review and comment at this time. This document would be most effective if incorporated into the State of California's Highway Design Manual, and accompanied with ample staff training to ensure appropriate implementation of effective fish passage improvement designs.

✣ Ratify the Fish Passage Forum's Memorandum of Understanding [Appendix C(1)(a)], and proceed with the implementation of assignments identified in the Forum's annual work plan [Appendix C(1)(b)]. The Forum has demonstrated its ability to serve as an invaluable resource in the coordination and implementation of fish passage improvement projects statewide. The Forum and its members should continue to coordinate efforts.

✣ Seek through the Forum and its partners continuous funding for fish passage improvement, including staffing and other program needs, for the collection of new data, the assessment of known sites, and, most importantly, the design and implementation of projects capable of improving fish passage at sites identified in this report. Both State and federal sources should be pursued, including State and federal highway funds, Salmon Recovery Funds, and any other funding sources, including those particularly related to the maintenance or improvement of infrastructure that impedes fish passage.

✣ Fish passage improvement proponents are urged to review the information in this report and accompanying PAD, particularly Table 2 on page 66, prior to initiating future inventory, assessment, and fish passage improvement efforts. The information distilled in this table will help guide the strategic selection of activities and watersheds requiring attention. For example, some hydrologic units require further inventory to identify potential barrier sites, some require assessment of known passage assessment sites, and some require both. A few appear to require neither, but would benefit from immediate implementation of fish passage improvement projects.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