Drought and Equity in California

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The Environmental Justice Coalition for Water
Water Justice for All

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The Environmental Justice Coalition for Water

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ABOUT THE ENVIRONMENTAL JUSTICE COALITION FOR WATER

The Environmental Justice Coalition for Water (EJCW) works within a Community-to-Capital framework, connecting the most pressing needs of our disadvantaged community partners to our network of partners and agencies statewide. Since 1999, EJCW's work has been rooted in the communities most affected by environmental injustice. Issues and solutions are identified through regional chapters and statewide work groups. EJCW is positioned in the state capital, in order to connect communities with state agencies to bring about change multilaterally through advocacy, education, training, litigation, community organizing, and capacity-building, and by providing technical assistance. EJCW aims to effectively influence the intersections of water justice and environmental justice, community health, and human rights issues from community to global levels.

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Acronyms and Abbreviations

ACS – American Community Survey

AGUA – Association of People United for Water (or la Asociación de Gente Unida por el Agua)

CA HSC – California Health and Safety Code

CalEPA – California Environmental Protection Agency

CBC – Cumulatively Burdened Communities

CCF – Centum Cubic Feet (100 cubic feet)

CDPH – California Department of Public Health

CUWA – California Urban Water Association

CWS – Community Water System

DAC – Disadvantaged Community

DWR – Department of Water Resources

ESA – Endangered Species Act

GAMA – Groundwater Ambient Monitoring and Assessment Program

GPCD – Gallons Per Capita Per Day

IHS – Indian Health Service

LWS EAR – Large Water System Electronic Annual Reports

MCL – Maximum Contaminant Level

MHI – Median Household Income

NOAA – National Oceanic and Atmospheric Administration

OES – Office of Emergency Services

PFMC – Pacific Fishery Management Council

PWS – Public Water System

SDWIS – State Drinking Water Information System

SSWS – State Small Water System

SWAMP – Surface Water Ambient Monitoring Program

SWRCB – State Water Resources Control Board

U.S. EPA – United States Environmental Protection Agency

USBR – United States Bureau of Reclamation

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EXECUTIVE SUMMARY

Water is essential for life, yet not everyone in California has access to safe, affordable water. Five years of drought has highlighted these inequities. Recent reviews of the impact of the ongoing drought found that cities and farms, despite feeling the effects of curtailed water supplies, demonstrated great resilience overall (Cooley et al. 2015; Hanak et al. 2015). Small water suppliers and natural systems have not fared as well. Some small systems struggled to provide safe water to their customers, thousands of household wells ran dry, and endangered fish reached the brink of extinction (Braxton Little 2016; Moyle 2014; State of California 2016). Across California, those on low or fixed incomes have struggled with the rising cost of water (Cooley et al. 2016).

In this report, we examine three major impacts of the ongoing California drought. The first two, supply shortages and rising costs, affected people's access to safe, affordable water in their homes. We also investigated the impacts of the drought on salmon and, by extension, commercial and tribal fishermen reliant on salmon for income, food, and cultural traditions. We found that low-income households, people of color, and communities already burdened with environmental pollution suffered the most severe impacts. The good news is that there are solutions to these problems, some of which are already being implemented. We conclude with a set of policy recommendations to improve our ability to cope with drought and minimize its inequitable consequences in the future.

During the drought, some small systems struggled to provide safe water to their customers, thousands of household wells ran dry, and endangered fish reached the brink of extinction.

DOMESTIC WATER SHORTAGES

Despite a great deal of public attention on drinking water shortages since the drought began in 2012, this is the first statewide summary of reported water supply vulnerabilities. Using information collected by state and local agencies, we classified water systems as "drought-impacted" if they reported actual or near shortages, received emergency drought funding, or, in the case of tribal water systems, were identified by United States Indian Health Services (IHS) as "high risk." We examined water systems serving more than 25 people year round or at least 15 connections (referred to as public water systems) and those serving fewer than 25 people year round, such as private wells (referred to as non-public water systems). We found that:

1. Most (76 percent) of the 149 drought-impacted public water systems were small, serving 1,000 connections or fewer. This is similar to the overall percentage of small water systems in California. Drought-impacted public water systems served an estimated 480,000 people—approximately equivalent to the population of Sacramento.
2. Drought-impacted public water systems were widespread, with at least one found in 39 of the state's 58 counties, but were concentrated in the San Joaquin Valley, the North Coast, and the Central Coast. There were no reports of drought-impacted systems in the easternmost portions of the state or in the San Francisco Bay Area.
3. From January 2014 through early August 2016, the state received nearly 4,000 reports of shortages from households served by small, non-public water systems. Household shortages were reported in 38 of 58 counties across the state but were concentrated in the southern San Joaquin Valley. Tulare County accounted for 42 percent of reported household water shortages.
4. A large proportion of drought-impacted public water systems and household outages were in Disadvantaged and Cumulatively Burdened Communities.[1] Of the 92 drought-impacted public water systems for which we know the location, two-thirds served a disadvantaged community, and nearly one-third served a cumulatively burdened community. Similarly, of the household shortages reported in Tulare County, two-thirds were in a disadvantaged community, and nearly 90 percent were in a cumulatively burdened community.

1 Disadvantaged Communities have a median household income of less than 80 percent of the state median. Cumulatively Burdened Communities are those that rank in the top quarter of census tracts in the state for environmental burdens and socioeconomic vulnerability.

To improve the drought resilience of domestic water supplies, we recommend that state and local agencies enact the following measures:

1. Establish a statewide, quantitative metric for measuring water supply reliability for public water systems;
2. Require water shortage contingency plans for all public water systems and establish regional plans for non-public systems;
3. Increase oversight of new private wells;
4. Systematically collect information on water shortages for public and non-public water systems;
5. Identify areas where private wells and other non-public water systems are likely to run dry in future droughts;
6. Identify areas where water system consolidation can resolve supply problems.

DROUGHT CHARGES AND WATER AFFORDABILITY

The cost of water can go up during a drought if, for example, the water utility must purchase more expensive supplies, increase treatment for lower quality water, or pump groundwater from greater depths. Moreover, as water use declines due to mandatory or voluntary restrictions, water utilities may implement a temporary drought charge to cover their costs, most of which are fixed. Such price increases can exacerbate affordability concerns for low-income households. In examining the impact of drought charges on low-income households in 2015, we found that:

1. More than half of the utilities analyzed increased the price of water regardless of the amount a household used, resulting in price increases for all single-family households.
2. About one-fifth of the utilities levied drought charges by increasing the price of water used

in excess of some threshold. While the intent was to avoid increasing prices for basic water use, even relatively efficient households with many members still experienced an increase in the price of water.

3. Approximately one-fifth of the utilities only added drought charges if a household exceeded a customized water budget based on household size, raising the price of water only for wasteful use.
4. Drought charges exacerbated affordability concerns for low-income households. Single-family households earning less than $25,000 a year paid an average of 1.8 percent of their household income for basic water service without drought charges. This amount increased to 2.1 percent with drought charges, exceeding State of California and United States Environmental Protection Agency affordability thresholds. The effect was even more extreme for households earning less than $10,000, raising costs from 4.4 to 5.3 percent of income. These households have little or no disposable income, so any increase in water costs poses a major problem.

To reduce the inequitable impact of drought charges on low-income households, we recommend the following:

1. Ensure drought surcharges are not applied to basic water use, preferably by calculating household water budgets based on the number of people in a residence;
2. Provide technical and financial assistance to water utilities, especially the smallest ones, to implement drought charges that do not unfairly burden low-income households;
3. Target water conservation and efficiency programs to low-income households by offering, for example, point-of-sale coupons, targeted education and outreach, and direct-install programs;

Source: Photographereddie

4. Develop low-income rate assistance programs within current legal constraints and reform Proposition 218 to allow greater latitude in funding such programs;
5. Wherever possible, require meters and sub-meters to allow for more equitable drought charges based on volumetric water use;
6. Develop approaches that effectively target hard-to-reach customers, such as renters and residents of multi-unit buildings, for rate assistance and conservation programs.

DROUGHT IMPACTS ON SALMON FISHERIES

Water disputes in California are sometimes framed as “fish versus people,” but this perspective overlooks those who rely on fishing for their livelihoods and traditions. While the link between drought and the collapse of endangered fish stocks has been extensively documented (Hanak et al. 2015), surprisingly little research has traced the relationship between drought, low river flows, and the health of commercial and tribal fisheries in California. Salmon populations decline during droughts because of reduced stream flows and higher water temperatures, which lead to disease outbreaks, more competition from invasive fish species, and higher risk of predation. Habitat loss from human activity has compromised their capacity to survive and rebound from droughts. There are many factors contributing to the decline of salmon, of which drought is just one.

We examined the available data and information on trends in commercial and tribal fishing over time. We found that:

1. The commercial salmon fishing fleet has declined dramatically over the last three decades, from 6,000 vessels in 1982 to just over 1,000 vessels in 2014. Many factors have contributed to the decline, including fewer salmon, income insecurity brought about by events such as the fishery closure of 2008-2009, rising costs of fishing, and loss of support infrastructure (such as fuel docks).
2. From 2014 to 2015, Sacramento winter-run Chinook salmon had the poorest survival for juvenile fish on record due to drought conditions and water diversions from the Sacramento River, resulting in an abbreviated 2016 fishing season for much of the state.
3. Extremely low flows in the Klamath River, caused by drought and water diversions for irrigation, contributed to an outbreak of fungal infections in salmon in 2014 and 2015. The subsequent poor reproduction will impact fishermen two to five years later, when eggs hatched in 2014 and 2015 return from the ocean as mature adults.
4. Declines in salmon populations, made worse by drought, have meant that tribes cannot obtain the fish that are an essential part of their diet and an integral part of their spiritual and cultural traditions.

To reduce the impact of drought on salmon fishermen, we recommend the following:

1. Expand the goal of emergency drought responses beyond preserving endangered species to include protection of commercially-fished salmon species.
2. Manage stream flows to better serve the needs of fish.
3. Restore habitat to improve salmon resilience to drought.
4. Provide income assistance and insurance protection for fishing communities during drought emergencies.
5. Create mechanisms for meaningful and timely tribal engagement with local, regional, state, and federal agencies.
6. Evaluate ways to re-operate California hatcheries to achieve parallel goals of sustaining commercial fisheries and assisting in the recovery of naturally-spawned salmon runs.
7. Assess the use and effectiveness of instream flow regulations to protect salmon populations.
8. Develop integrated, comprehensive datasets tracking salmon populations and their environment throughout the state.

Inequities in access to water in California existed before the drought began in 2012, but lack of water made the outcome of these inequities more severe. Low-income families, those who are disproportionately burdened by multiple sources of pollution, and those who depend on aquatic ecosystems for their livelihood and traditions are highly vulnerable to problems of supply shortages, rising unaffordability, and insufficient streamflows. Unless we act, drought's impacts on these communities will become more severe as climate change progresses, given that scientists predict longer, more severe, and more frequent droughts. We offer the Drought and Equity report and the recommendations within as a tool for community members and decision-makers to improve the resilience of all Californians, including the most vulnerable, to future droughts.

INTRODUCTION

California recently suffered the driest four years in state history, and despite somewhat wetter conditions since late 2015, 75 percent of the state remains in drought conditions as of December 2016 (U.S. Drought Monitor 2016). Cities and farms, despite feeling the effects of curtailed water supplies, have by and large demonstrated great resilience (Hanak et al. 2015; Cooley et al. 2015), but small water suppliers and natural systems have not fared as well. Some public water systems struggled to deliver safe water to their customers, thousands of household wells ran dry, and endangered fish reached the brink of extinction (Moyle 2014; Braxton Little 2016; State of California 2016). And while urban water suppliers maintained clean water delivery during the drought, many of their low-income customers struggled with the rising cost of water (Cooley et al. 2016).

In this report, we examine three major impacts of the drought. The first two—shortages and price hikes—affected people's access to safe, affordable, adequate water in their homes. The third arena we investigate is salmon fishery performance during the drought, and how it affected commercial and tribal fishermen reliant on salmon for income, food, and cultural traditions. We selected these topics based on input from a diverse set of stakeholders. While we were unable to explore them in-depth in this report, the impact of drought on farmworkers, water quality, and subsistence fishermen (beyond the tribes we discuss in Section 3), are also critical issue areas that deserve further analysis.

Our goals were to synthesize available information from the state, media outlets, and non-governmental organizations (NGOs) and develop recommendations on how to mitigate the impacts of future droughts. This report is intended to provide information to community groups to advocate for their own interests, as well as to inform policymakers and other decision-makers interested in crafting more effective drought response strategies, particularly to address the needs of the state's most vulnerable communities.

This project was conceived of cooperatively by the Pacific Institute and the Environmental Justice Coalition for Water (EJCW). To oversee the project, we convened a nine-member California Drought and Equity Advisory Committee representing a range of perspectives and interests:

Sara Aminzadeh, *Executive Director, California Coastkeeper Alliance*

Colin Bailey, *Executive Director, Environmental Justice Coalition for Water*

Carolina Balazs, *Visiting Scholar, University of California, Berkeley*

Wendy Broley, *Staff Engineer, California Urban Water Agencies*

Amanda Fencl, *PhD Student, University of California, Davis Center for Environmental Policy and Behavior*

Kelsey Hinton, *Program Associate, Community Water Center*

Gita Kapahi, *Director, Office of Public Participation, State Water Resources Control Board*

Brittani Orona, *Environmental Justice and Tribal Affairs Specialist and Native American Studies Doctoral Student, University of California, Davis*

Brian Pompeii, *Lecturer, California Polytechnic State University, San Luis Obispo*

Tim Sloane, *Executive Director, Institute of Fisheries Resources*

The Advisory Committee helped determine the scope, identified project outcomes, developed recommendations, and reviewed the report. Profiles of the Advisory Committee members and their organizations are given in Appendix IA.

This report builds on previous work by the Pacific Institute and EJCW focused on the San Francisco Bay Area, which brought together eight community partners to identify drought impacts and concerns and develop a set of recommendations for addressing them. This work was summarized in a report on Drought and Equity in the San Francisco Bay Area (Cooley et al. 2016), and culminated in a day-long summit in July 2016 that brought together representatives of Bay Area community organizations, water managers, local government, and water and justice nonprofits.

The report is divided into three sections. Section 1 highlights domestic water shortages both in public and the non-public systems that serve very few people, such as private wells. Section 2 examines drought surcharges, and how they affected water affordability for low-income households. Section 3 examines the impact of the drought on commercial and tribal fishermen reliant on salmon for their livelihood and cultural traditions. We conclude each section with recommendations for mitigating impacts of future droughts for the impacted communities.

SECTION 1.
DROUGHT AND DOMESTIC WATER SHORTAGES

OVERVIEW

With the recent passage of the Human Right to Water (CA Water Code Section 106.3), California has declared that access to sufficient water for cooking, consumption, and sanitation is a basic human right. Yet, water shortages for basic household needs have been widely reported over the last several years due to the ongoing drought (Braxton Little 2016; SWRCB 2016a; Becerra 2014; Lurie 2016). Since 2012, thousands of households reported that their wells have run dry, while hundreds of public water systems have applied for financial assistance to address dwindling or contaminated supplies. The state spent $66 million on emergency drought responses related to drinking water from July 2013 to June 2016 for programs such as delivering water to households, deepening wells, and consolidating water systems (Legislative Analyst's Office 2016). Addressing the underlying vulnerabilities in domestic water supplies is all the more urgent given that droughts are likely to become longer, more frequent, and more severe due to climate change (Dettinger et al. 2011).

Despite growing public concern and several state and local programs to address water shortages, the scope and severity of the statewide problem are not well understood. Rural, low-income, primarily Latino communities in the San Joaquin Valley such as East Porterville deservedly received a great deal of media attention when families' private wells ran dry and residents had to survive without running water, often for years (Box 1-1). But outside the intense coverage of the worst-affected communities, the overall extent and severity of water shortages during the drought is not well understood. Water utilities resorted to hauling in tanks of water and delivering bottled water as stopgaps while they identified long-term solutions to water shortages, but these problems were often only reported in the local paper, if at all. Here we pull together a number of datasets to gain a statewide perspective on domestic water shortages during the ongoing drought. Where did shortages occur? What types of water systems were impacted? What were the demographic and socioeconomic characteristics of the impacted communities? Our goal is to better understand which water sources were most vulnerable to drought, so we can improve the resiliency of domestic water supplies in future dry periods.

METHODS

Categories of Water Systems

We divided water systems into seven categories based on size, type of customers, and how they are regulated. This is consistent with the approach used in a recent Department of Water Resources report, *Californians Without Safe Water and Sanitation* (DWR 2014a). A public water system is defined in

Box 1-1.

Experiences of Tulare County Residents Living With Water Shortages

On Dec. 12, 2016, California Drought and Equity report authors, and Kelsey Hinton of Community Water Center and the Drought and Equity Advisory Committee, addressed a meeting of the AGUA Coalition (la Asociación de Gente Unida por el Agua, or the Association of People United for Water). AGUA is a regional, grassroots coalition of impacted community residents and allied non-profit organizations dedicated to securing safe, clean, and affordable drinking water for the San Joaquin Valley. It works closely with the Community Water Center.

We presented a summary of the report findings and recommendations, and asked meeting attendees to add their recommendations or tell us experiences that should be documented. Here are some of the responses.

> *"I've lived without water for two years, seven months. It's important to point out the urgency to get long-term solutions more rapidly than we're getting them now."*

> *"I've been to at least two meetings where people address the Board of Supervisors of Tulare county, and a Supervisor says, 'Well my well went dry too, and I had to drill a new well.' But there's a big difference between that and someone whose well went dry, and then they had to go without water for more than two years."*

> *"Many agencies got money to help, but maybe what is missing is a group, like the AGUA coalition, that even when the money runs out, they continue to work on this issue. People have submitted applications to agencies for money, but the money has already run out, and then the organization just shuts down. People have problems where they submitted original documents to an agency that ran out of money and haven't gotten them back so they can't put in a new application. So agencies need to stick around."*

> *"Our community has been without clean water for more than 10 years. Then who do we call? We call the county, they're closed, or they give you a different number… nobody knows who to call."*

the California Health and Safety Code (CA HSC) as a system that has "15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year" (CA HSC § 116275). The California State Water Resources Control Board (SWRCB) oversees approximately 8,000 public water systems in the state that deliver drinking water to the vast majority of the population. The U.S. Environmental Protection Agency (U.S. EPA) regulates the 125 tribal water systems in the state.

Systems too small to meet the threshold for a public water system are referred to as non-public water systems.[1] There are three types of non-public water systems: state small water systems, local small water

1 A public water system has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year (CA Health and Safety Code Section 116275(h)). In this report, we use the term "non-public water system" to refer to any system that has fewer than 15 service connections and serves fewer than 25 individuals daily.

systems, and private domestic wells (or surface diversions). Water quality of state small water systems is regulated at the county and local level; water quality in local and private systems has relatively few regulations. Table 1-1 summarizes the seven categories of water systems.

Table 1-1. Categories of Water Systems in California

Name	Definition	Estimated Population Served (2016)[1]	Drinking Water Quality Regulating Agency	Typical Customer Type
Public Water System	15 or more service connections or serves at least 25 individuals daily at least 60 days out of the year (CA HSC § 116275(h))			
Community Water System	At least 15 service connections used by year-long residents or regularly serves at least 25 year-long residents of the area served by the system (CA HSC § 116275(i))	41,300,000	SWRCB	Residential areas; can also include non-residential areas in addition to homes
Transient Non-Community Water System	Does not regularly serve at least 25 of the same persons over six months per year (CA HSC § 116275(o))	981,000	SWRCB	Restaurants, campgrounds, parks, motels and other non-residential areas
Non-Transient Non-Community Water System	At least 25 of the same persons over six months per year (CA HSC § 116275(k))	412,000	SWRCB	Schools, workplaces
Tribal Water System	At least 15 connections or 25 people daily, serving a federally recognized tribe	224,000	U.S. EPA	Facilities on tribal land
Non-Public Water System	Fewer than 15 service connections or serves fewer than 25 individuals daily at least 60 days out of the year			
State Small Water System	At least five, but not more than 14, service connections and does not regularly serve drinking water to more than an average of 25 individuals daily for more than 60 days out of the year (CA HSC § 116275(n))	Data not available	County and local health departments	Small number of people served in any type of location
Local Water System	2-4 service connections[2]	Data not available	N/A	"
Private Domestic Well (or Surface Diversion)	1 service connection[2]	600,000 – 2,000,000 use wells; population served by surface diversions unknown	N/A	"

1. Population served figures are approximations made by the water utilities. Note that the populations served by the different types of water systems overlap. Numbers rounded to three significant figures. Data from Safe Drinking Water Information System (SDWIS) (SWRCB 2016c), except domestic wells from DWR (2013), and Tribal Water Systems from U.S. EPA(2016).

2. Definition given in "Californians Without Safe Water and Sanitation: California Water Plan Update" (DWR 2014a).

Analysis 1: Drought-Impacted Public Water Systems

We identified drought-impacted public water systems using three statewide datasets:

- Community water systems and non-transient non-community water systems serving schools that had applied for assistance from the SWRCB as of July 2016, due to drought-related impacts on drinking water supply or quality that could not be addressed with their existing funding (SWRCB 2016e);
- A SWRCB survey in December 2015 of community water systems with 15-3,000 service connections on their ability to provide water if the drought continued through 2016 (SWRCB 2016d); and
- a July 2015 assessment of tribal water systems for multiple factors linked to drought vulnerability, such as changes in supply and availability of an alternative source of water (IHS 2015).

These datasets have a number of limitations. To our knowledge there is no single, comprehensive dataset on public water system shortages during the ongoing drought. The list we compiled reflects a best effort with available data and should be viewed as a preliminary, and likely incomplete, assessment of public water systems that have experienced drought impacts that actually, or nearly, resulted in shortages. A more careful, consistent means of collecting information on drought shortages would enable a more thorough understanding of vulnerable water systems. Nonetheless, the list provides an indication of where the known problems are concentrated, as well as a minimum number of systems affected by the drought.

Once we compiled a master list of drought-impacted systems, we mapped the locations of the systems and quantified the number serving vulnerable communities. We used two definitions of a vulnerable community, following definitions used by state agencies. A Disadvantaged Community (DAC) is a census block groups with a median household income under 80 percent of the state median household income (Department of Water Resources (DWR) 2016). A Cumulatively Burdened Community (CBC) is a census tract that ranks in the top quarter of tracts in the state for environmental burdens and socioeconomic vulnerability (California Environmental Protection Agency (CalEPA) 2014).[2]

We give further details on datasets used in the analysis of drought-impacted public water systems in Appendix 1A.

Analysis 2: Water Shortages in Households Served by Non-Public Water Systems

We also looked at shortages in households served by water systems too small to be regulated as public water systems. These data are likely an undercount of the true number of household shortages.[3] But as with the data on drought-impacted public water systems, they indicate where the known problems were concentrated, as well as a minimum number of households affected. In Tulare County, we had sufficiently detailed data on household shortage locations to map them, and calculate how many were in DACs and CBCs.

2 This definition takes into account 20 factors in the categories of pollution exposure indicators, environmental effects indicators, sensitive population indicators, and socioeconomic indicators. Two of the factors relate directly to water quality: groundwater threats and drinking water contaminants.

3 Household shortages may not be included in the statewide dataset for a number of reasons, including: not all counties had reporting mechanism in place; people that are financially able to deepen or drill a new well themselves are unlikely to communicate a problem to the officials; and people may choose not to report a shortage because they prefer to avoid interaction with government officials.

RESULTS AND DISCUSSION

Drought-Impacted Public Water Systems

For our first analysis, we identified 127 community water systems with potential or actual drought impacts to their water supply between 2014 and 2016 (Table 1-2), and an additional 22 non-community water systems facing supply vulnerabilities. Most of the community water systems (72 percent) were small, serving 1,000 connections or fewer. This is consistent with the fact that 77 percent of community water systems in California are small. The drought-impacted systems in our list served approximately 480,000 people.[4] A complete list of the 149 drought-impacted systems is provided in Appendix 1B.

Drought-impacted systems were found in most California counties (Figure 1-1a). The greatest number were in Madera (24) and Tulare (12) counties. There was also a relatively large number of drought-impacted systems in Mendocino County (13). The impacts correspond roughly to

4 Population served was calculated by adding the population served listed either in SDWIS (SWRCB 2016c) or the U.S. EPA's list of tribal water systems (U.S. EPA 2016). This number is an approximation of population served, and individuals can be served by more than one system in their home versus other places they visit.

Table 1-2.

Drought-Impacted Public Water Systems in California

	A	B	C	D	E
	Data Source			Total Drought-Impacted Systems[3]	Estimated Population Served[4]
	Applications for Drought Assistance Funding	Small Supplier Conservation Report	Tribal Systems at High Risk Due to Drought		
Community Water Systems	**87**	**34**	**12**	**127**	**473,000**
No. Connections:					
1-1,000	57	29	10	92	18,200
1,001-3,300	15	2	2	18	34,300
>3,300	15	3	0	17	421,000
Non-Transient Non-Community	**13**[1]	**3**	**NA**	**16**	**5,550**
Transient Non-Community	**NA**[2]	**6**	**NA**	**6**	**1,660**
				Grand Total: 149	**480,000**

1. Of non-transient non-community systems, only systems serving schools were eligible for funds.
2. Transient non-community systems were not eligible to apply for funds.
3. Columns A-C do not necessarily sum to the total in Column D because duplicates appearing in both Columns A and B were eliminated.
4. Rounded to three significant figures. Figures may not sum to total due to rounding errors.

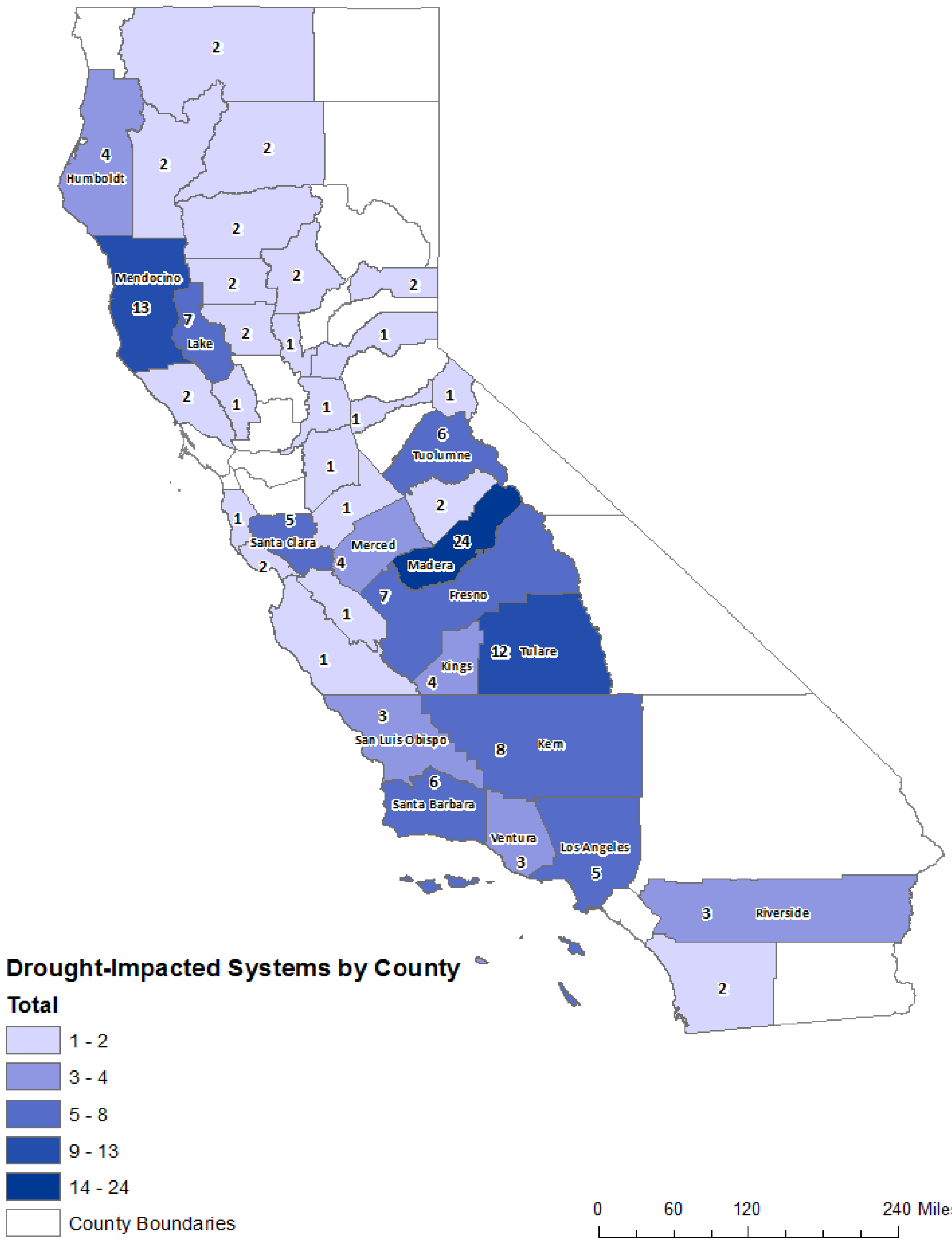
Note: Columns A-C summarize three sources of information on drought-impacted public water systems in California.

Sources: Column A based on data from SWRCB (2016e), Applications for Drought Assistance Funding. Column B based on data from SWRCB (2016d), Small Supplier Conservation Reports. Column C based on data from IHS (2015), July 2015 Drought Vulnerability and Risk Assessments for Tribal Drinking Water Systems. Column E based on SDWIS (SWRCB 2016c).

the state's hydrologic regions, with no impacted systems found in the eastern regions of North and South Lahontan, nor in the San Francisco hydrologic region. The greatest concentrations were in the San Joaquin River, Tulare, North Coast, and Central Coast hydrologic regions. The population served by impacted systems shows somewhat different patterns. The five counties

Figure 1-1a.

Number of Drought-Impacted Public Water Systems in Each County



Notes: Numbers and shading indicate drought-impacted public water system in each county, with darker colors signifying greater numbers. Blank counties had zero drought-impacted systems reported in the datasets surveyed.

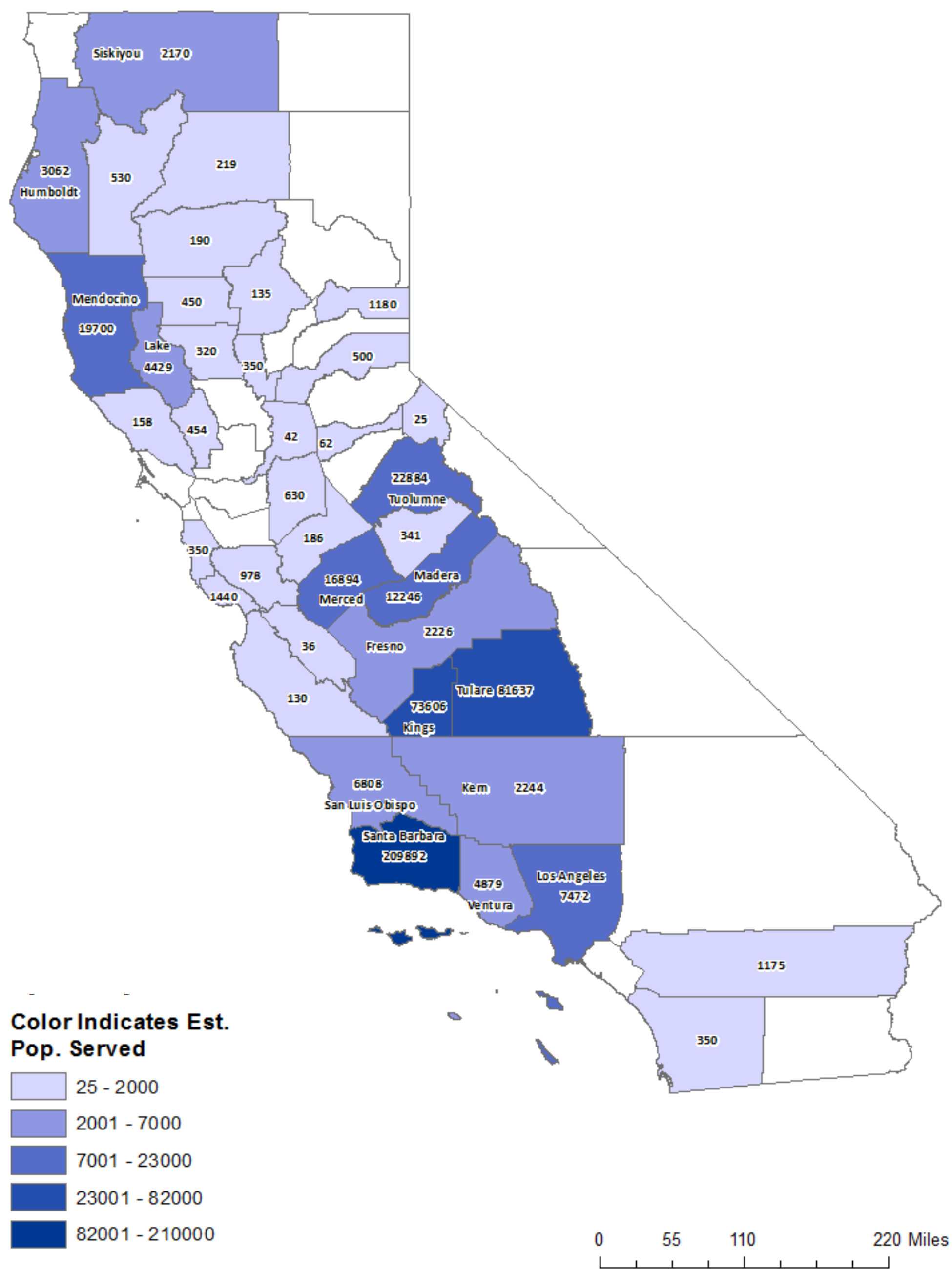
Sources: Data compiled in Appendix 1B, from SWRCB (2016c), SWRCB (2016e), SWRCB (2016d), IHS (2015).

with the greatest number of people served by drought-imapcted systems were Santa Barbara (estimated 210,000 people served), Tulare (82,000), Kings (74,000), Tuolomne (23,000), and Mendocino (20,000) (Figure 1-1b).

A large proportion of drought-impacted community water systems were located in low-income and disadvantaged communities. The publicly available map of California's public water systems only gives information for some of

Figure 1-1b.

Population Served by Drought-Impacted Public Water Systems in Each County



Notes: Numbers and shading indicate the estimated number of persons served by drought-impacted public water system in each county, with darker colors signifying greater numbers. Blank counties had zero drought-impacted systems reported in the datasets surveyed.

Sources: Data compiled in Appendix 1B, from SWRCB (2016c), SWRCB (2016e), SWRCB (2016d), IHS (2015).

Source: Slobo

the state's systems, so we were able to map only 97 of the 144 drought-impacted community water systems. Of those, 65 (67 percent) served a DAC, while 28 (29 percent) served a CBC.

Among the 122 public water systems that applied for emergency drought funding, nearly half received funding to haul in water via truck, or deliver bottled water to customers. These systems had reached acute emergencies in which they could not provide safe, sufficient tap water. In total, 52 systems fit this description: 27 received funding to haul water, 24 for bottled water, and 1 for both. The remaining funding was directed to long-term solutions to drought emergencies, such as well overhauls, new wells, new interties to neighboring systems, and new filtration devices. In most cases, whether the underlying problem was one of quality or quantity was ambiguous. In only one case did the project description explicitly mention that the water system's well had run dry. On the other hand, there were 20 project descriptions that indicated that the project intended to address quality concerns; usually the funded project included at least bottled water delivery, and sometimes a long-term solution as well, such as a new filtration device. A portion of the emergency drought assistance funds were explicitly for "contaminated drinking water supplies exacerbated by drought conditions" (CA Budget Act of 2014, Statutes of 2015). This funding was intended to address concerns that drought was causing contamination of water supplies. However, the relationship between drought and the quality of water Californians drink is complex, and we could not find evidence that the quality of drinking water in the state deteriorated because of drought (Box 1-2).

Water Shortages and Non-Public Water Systems

For our second analysis, we looked at shortages reported by households served by non-public water systems. From January 2014 through August 8, 2016, the state received 3,749 reports of shortages in households served by non-public water systems (serving under 15 connections/25 individuals). Most of the reports were concentrated in the counties that are in the San Joaquin Valley, with

Box 1-2.

Drought and Drinking Water Quality

We did not directly seek to document impacts of drought on drinking water quality in this report. However, our Advisory Committee members flagged this as a key concern for public health during droughts. Water systems can experience supply problems either because of an insufficient volume of water, or an insufficient amount of clean water. Emergency drought funding criteria include the intertwined nature of water quality and quantity, making funds available both for supply shortages and for contamination of drinking water exacerbated by drought (Assembly Bill 91, Statutes of 2015, Section 31). Here we review the available literature on the potential link between drought and declining water quality, and its impacts on DACs.

Droughts may cause significant changes in water quality and adversely impact drinking water supplies. For example, warmer surface water temperature, reduced flows, and high nutrient concentrations have resulted in algal blooms in lakes and reservoirs throughout California. These potentially toxic blue-green algae, or cyanobacteria, were the cause of poorer taste and smell of drinking water supplied to East Bay residents in 2015 (EBMUD 2015). Treatment processes can remove harmful substances, and thus these blooms have not been linked to health concerns. A major water quality problem that needs to be carefully managed during drought is the potential for salt water to intrude further into the Sacramento-Bay Delta, contaminating not only water distributed throughout the state via the State Water Project and Central Valley Project, but also water used by Delta farmers and water districts in nearby Contra Costa, Alameda, and San Joaquin counties (DWR 2014b). Other surface water quality indicators relating to the drought such as nutrient concentrations, dissolved oxygen, and organic carbon have shown mixed responses (Mosley 2015).

Communities most vulnerable to degraded water quality because of drought are likely to be those depending on non-public water systems, including private domestic wells and those served by water systems with less than 15 service connections, as these sources are not as intensively regulated or monitored. Up to two million California residents rely on private domestic wells, and unknown numbers use water from local and state small systems (SWRCB 2015b). Private domestic well owners and non-public water system operators are responsible for maintaining their water supplies and ensuring that water quality meets drinking water standards, but problems are likely to remain undetected or unaddressed due to the lack of financial and technical resources.

Drought conditions may exacerbate existing water quality problems. Given that the presence and concentration of arsenic are related to hydrologic and biogeochemical processes, higher evapotranspiration rates can increase arsenic concentrations in surface water and shallow groundwater (Beard, Fujii, and Shanks 1994; Gao, Tanji, and Bañuelos 2007). The drilling of deeper wells as a response to water shortages may cause releases of arsenic from sedimentary rocks. However, there is limited understanding of arsenic transport in sediments in all of California's key groundwater basins. Uranium, another naturally-occurring element, may also increase its concentrations in groundwater during a drought. Jurgens et al. suggested that changes in the chemistry of recharge water and increases

Box 1-2. (*Continued*)

Drought and Drinking Water Quality

in the rate of downward groundwater flow have led to uranium concentrations above drinking water standards in both domestic and public wells. Higher recharge temperatures have been found to correlate with uranium levels (Jurgens et al. 2010). Moreover, uranium contamination is linked to nitrate, which plays a role in increasing the solubility of uranium in water (Nolan and Weber 2015). This secondary uranium contamination is expected to worsen in areas with high agricultural activities and groundwater dependence.

Despite some evidence of drought's negative impacts on water quality, further research is needed to document and assess the mechanisms and implications of these impacts. While drought can alter the quality of water supplies, water systems have methods to remediate the problem by treatment and mixing with higher-quality sources. Little is still known about the extent of drought impacts on the quality of water that reaches customers' taps, how many people receive lower-quality water during a drought, and how reduced water quality during drought affects minorities or socio-economically disadvantaged communities across the state. Some limited data and monitoring programs already exist. Water quality reports required under the Safe Drinking Water Act may be used to track water quality changes during the drought, but they do not include very small drinking water systems and private domestic wells. SWRCB's Surface Water Ambient Monitoring Program (SWAMP) and Groundwater Ambient Monitoring and Assessment Program (GAMA) can provide relevant resources to monitor water quality and trends. However, they also have limited temporal and geographic scopes. Data on groundwater levels are generally lacking or of poor quality, although efforts are being made under the Sustainable Groundwater Management Act (2014) to standardize and expand groundwater data collection and monitoring activities. In addition to data gaps, the complexity of hydrologic and biogeochemical processes presents another challenge in drawing clear relationships between the drought and water quality issues. More attention should be given to determining these linkages, especially in relation to drinking water supplies, to protect communities from unsafe drinking water.

Water quality issues have been shown to disproportionately affect minorities and residents of lower socio-economic status for community water systems that are subjected to federal and state drinking water regulations. (Balazs et al. 2012) found that community water systems serving predominantly low-income and socially disadvantaged groups have high arsenic levels in drinking water and are more likely to receive a Maximum Contaminant Level (MCL) violation.

1,571 (42 percent) in Tulare County alone (Figure 1-2). In Tulare County, these numbers generally reflect households that needed deliveries of bottled water and tanks of non-potable water hooked up to their plumbing. Typically, households that could resolve the problem on their own by drilling or deepening a well did not report a shortage to the county (A. Fencl, PhD Student, UC Davis, personal communication, Dec. 13, 2016). A list of all shortages by county is provided in Appendix 1C.

Figure 1-2.

Household Water Supply Outages Reported by County

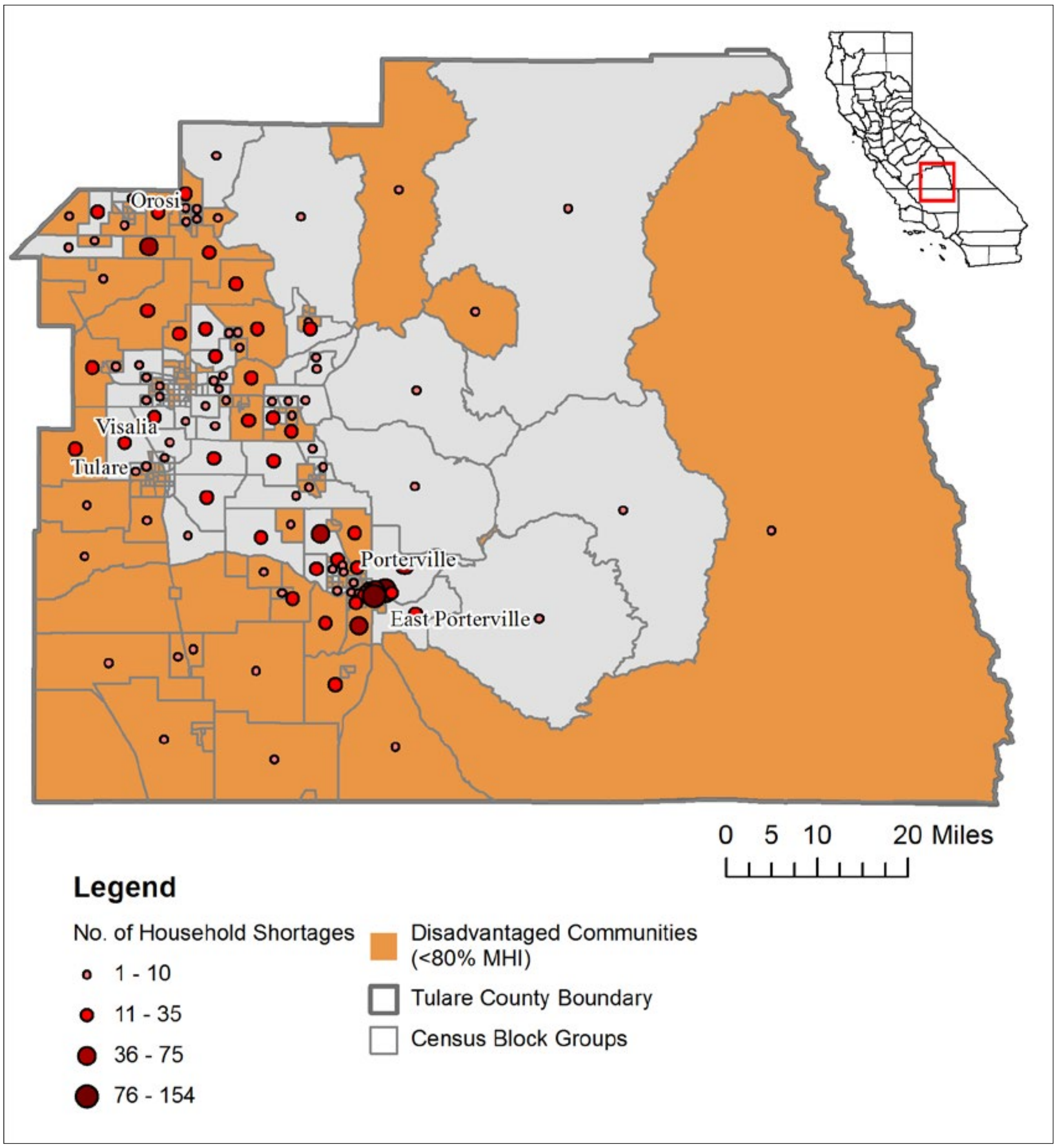
Notes: Map shows cumulative reports of household water supply shortages by county from July 2014 to August 2016. Counties with "no reports" may represent zero shortages, or simply a lack of data collection and reporting. Households reported dry wells and surface water supply shortages. Figures include active outages, active supply problems, resolved outages, and outages where interim solutions have been implemented. Only eleven counties report interim and/or permanently resolved outages.

Source: Reproduced from the State of California Household Water Supply Shortage Reporting System (State of California 2016).

For Tulare County (the only county for which detailed data are available), we mapped the number of reported shortages (Figure 1-3). The outages all occurred in the western and central portion of the county. Sixty-six percent of the reported shortages occurred in a DAC, and 89 percent occurred in a CBC. Households in DACs will likely need financial assistance to resolve their water shortage. Drilling a new individual domestic drinking water well in the San Joaquin Valley is prohibitively expensive for a low-income household, costing between $25,000 to $35,000 in 2016 (Susan Atkins, Self Help Enterprises, personal communication, July 28, 2016). Median

Figure 1-3a.

Household Water Shortages in Tulare County by DAC Block Group



Notes: Tulare County with census block groups classified as disadvantaged in orange, non-disadvantaged shown as grey. Household shortages reported to Tulare County Office of Emergency Services shown as red dots. Larger dots indicate more shortages in a census block. Dots are located at the center of the block group where the shortage(s) they represent occurred.

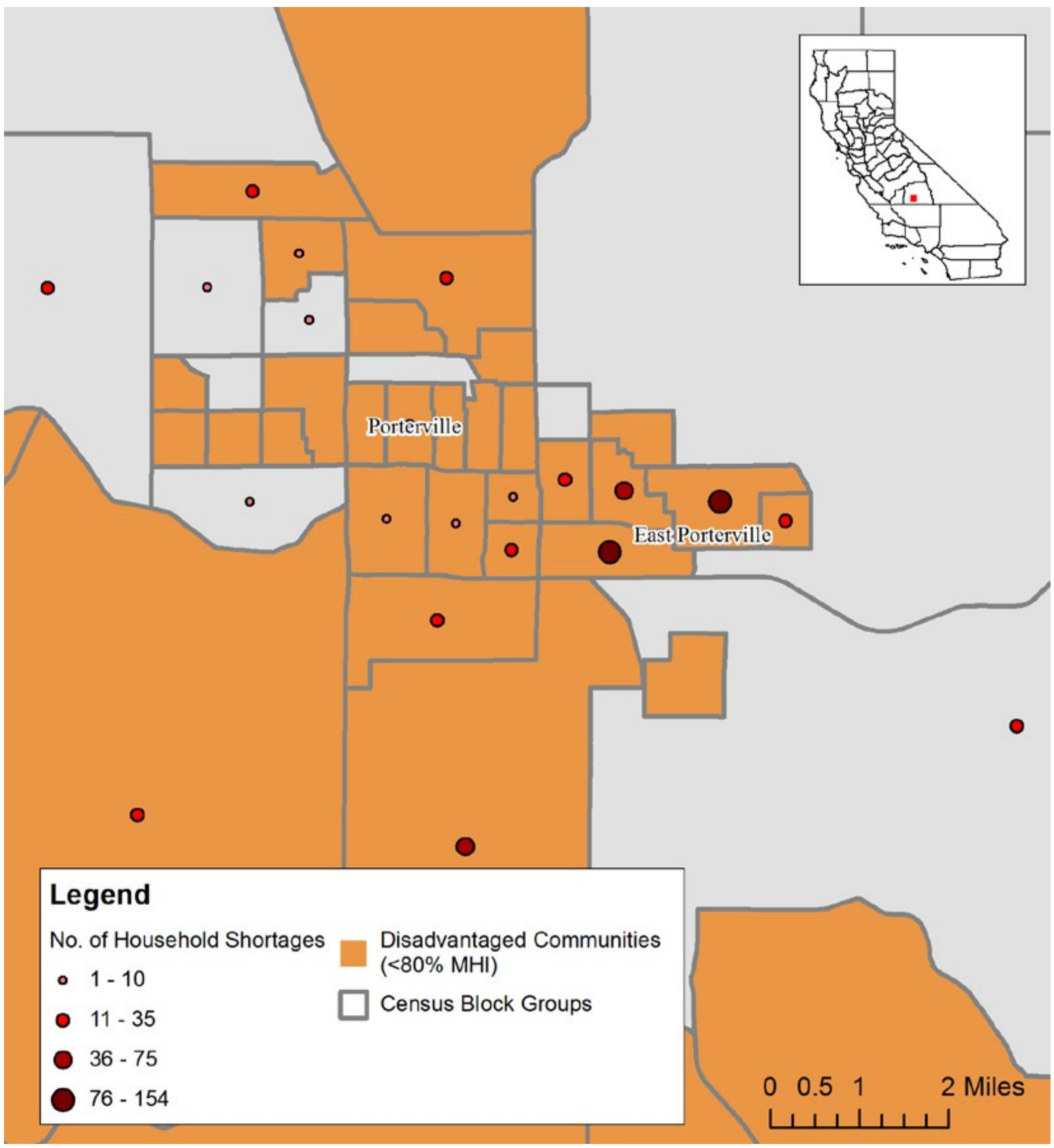
Sources: Data on household shortages from Tulare County OES (2016); data on DACs from DWR (2016a).

household income in a DAC was $49,191 in 2016 (DWR 2016a). Many of these communities are already known to be sensitive populations and to be heavily burdened by other environmental problems, underscoring the urgency of resolving their water shortages, which can aggravate public health problems (CDPH and TCHHSA, 2015).

While most reported well shortages occurred in DACs and CBCs, it is unclear what drives the pattern, and whether the link is anything but a coincidence. There are a number of non-exclusive possible causes for the clustering of shortages in central Tulare County, and their overlap with DACs and CBCs. Some possible drivers for the

Figure 1-3b.

Detail of Household Water Shortages in East Porterville, Tulare County, by DAC Block Group



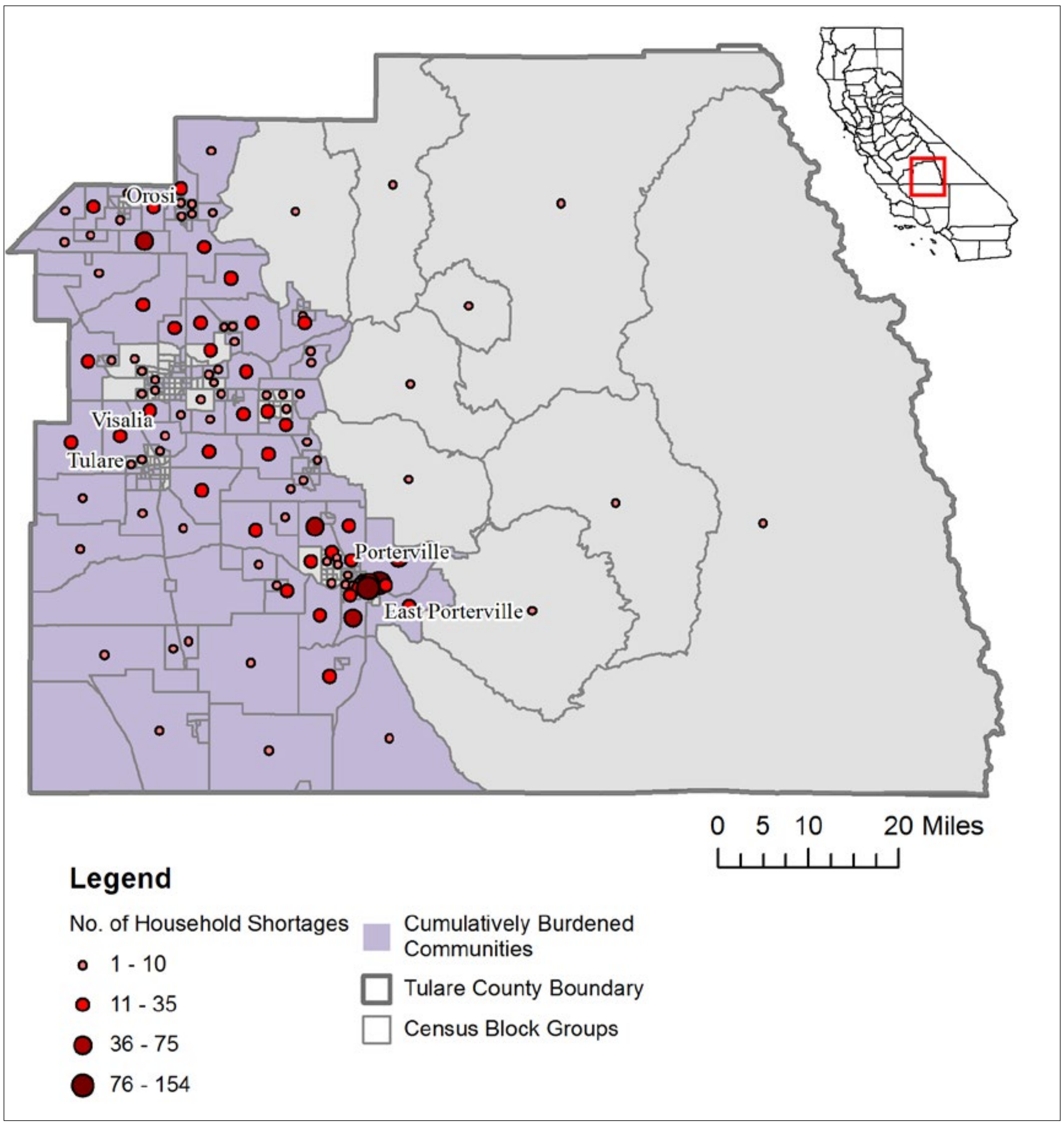
Notes: Tulare County with census block groups classified as disadvantaged in orange, non-disadvantaged shown as grey. Household shortages reported to Tulare County Office of Emergency Services shown as red dots. Larger dots indicate more shortages in a census block group. Dots are located at the center of the block group where the shortage(s) they represent occurred.

Sources: Data on household shortages from Tulare OES (2016); data on DACs from DWR (2016a).

spatial pattern of shortages are hydrogeological. Many of these wells are quite shallow and susceptible to short-term fluctuations in the water table, or tap low-permeability fractured hard rock aquifers that are vulnerable to drought (DWR 1991; Jones 2014; DWR 2016b). The clusters of shortages may simply occur in the areas with the greatest density of wells. On the other hand, there could be systematic reasons for the correlation. Low-income communities and communities of color in the Central Valley rely disproportionately on private wells because adequate public services were not developed in those communities (Bliss 2016). The outages in domestic wells may also

Figure 1-3c.

Household Water Shortages in Tulare County by CBC Block Group



Notes: Location of household shortages reported in Tulare County (red dots) and disadvantaged census block groups (purple shading). Larger dot indicates more shortages. Dots are located at the center of the block group where the shortage(s) they represent occurred.

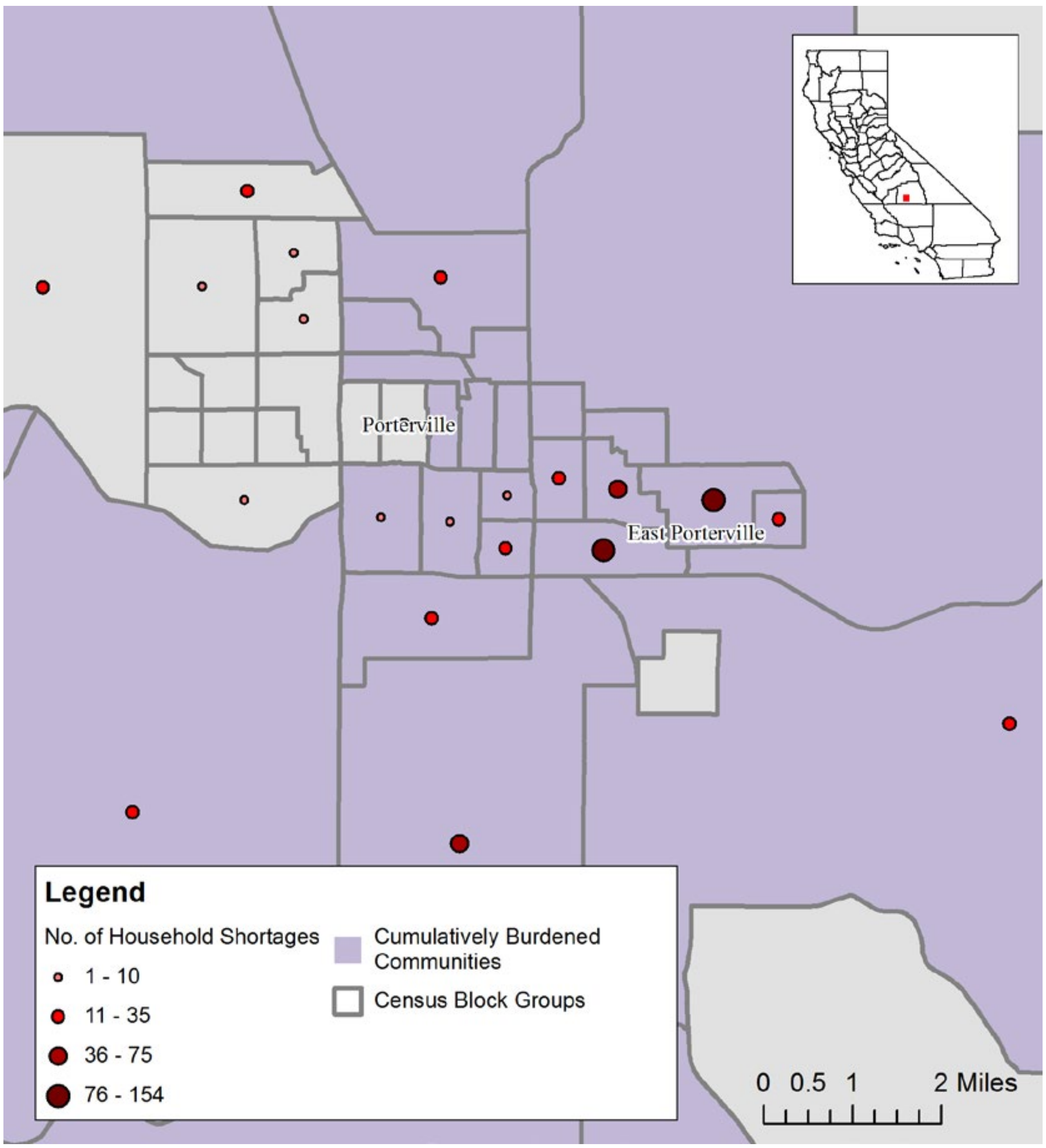
Sources: Data on household outages Tulare County OES (2016). Data on CBCs from http://www.calepa.ca.gov/EnvJustice/GHGInvest/.

be at least partially caused by rapid pumping by deeper irrigation wells.

Reporting bias could also be a factor: residents typically reported a shortage when they were seeking bottled and hauled water deliveries; those with the financial means to resolve their water shortage were less likely to report a shortage. To fully understand the drivers of household outages would require a complex study beyond the scope of this report.

Figure 1-3d.

Detail of Household Water Shortages in East Porterville, Tulare County, by CBC Block Group



Notes: Location of household outages reported in Tulare County (red dots) and disadvantaged census block groups (purple shading). Larger dots indicate more shortages in a census tract. Dots are located at the center of the block group where the shortage(s) they represent occurred.

Sources: Data on household outages in Tulare County from OES (2016). Data on CBCs from http://www.calepa.ca.gov/EnvJustice/GHGInvest/.

Conclusions and Reccomendations

We found 149 public water systems, serving an estimated 480,000 people, reported drought-related impacts to their supplies. These systems were concentrated in the southern San Joaquin Valley, as well as the North Coast and Central Coast regions. We estimated that approximately two-thirds of these public water systems served a DAC, and one-third served a CBC. Of the nearly 4,000 shortages in households served by non-public water systems, most were concentrated in the San Joaquin Valley, with 42 percent of the reports in Tulare County. Of the shortages reported to the county, 66 percent were in a DAC, and 89 percent were located in a CBC. Our findings demonstrate that, while they were concentrated in the San Joaquin Valley, shortages in both public and non-public systems were more widespread geographically in the state than has been represented in media reports. Supply problems during the drought were frequently found in DACs and CBCs, suggesting that in many cases these systems have insufficient capacity to resolve their problems without outside technical, managerial or financial support. We recommend that the state undertake a more uniform, thorough effort to document which public and non-public systems experienced near or actual supply shortages. This data would allow an analysis of the characteristics that made systems more vulnerable to drought, and inform efforts to improve future resilience.

RECOMMENDATIONS TO IMPROVE DROUGHT RESILIENCE OF DOMESTIC WATER SUPPLIES

Mitigating Impacts of Drought on Domestic Water Supplies for Communities

1-1. Establish a Quantitative Metric for Measuring Supply Reliability in Public Water Systems

Assessing supply reliability is an important step in identifying public water systems that need improvements to prevent shortages in future dry years. The data to inform a quantitative "supply reliability" metric should be collected for all public water systems. At present, there is relatively little scrutiny on supply reliability for water systems too small to meet Urban Water Supplier[5] reporting requirements, even though smaller suppliers struggled most during the drought. Data collected and quantified should include at least the following:

- Predicted production to demand ratio in an average year, as well as droughts lasting one, three, and five years.
- Any recent shortfalls in supply that resulted in an inability to deliver enough water for consumption, cooking, and sanitation to residential customers, drops in pressure or outages, or water hauling, along with the dates of any such events, and the volume of the shortfall.

1-2. Require Water Shortage Contingency Plans of All Public, State Small[6], and Local Water Systems[7]

Small and rural communities tend to be the most vulnerable to drought, yet often lack comprehensive plans to cope with the impacts. At present, only urban water suppliers are required to prepare and file water shortage contingency plans with DWR and stress tests with the SWRCB. We recommend that the state require all public water

5 Urban Water Suppliers are defined as "providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually." (CA Water Code Section 10617). Urban Water Suppliers report information on supply reliability under the SWRCB's Emergency Urban Water Conservation Requirements, as well as DWR's Urban Water Management Plans.

6 A State Small Water System has 5-14 service connections and does not regularly serve drinking water to more than an average of 25 individuals daily for more than 60 days out of the year.

7 A Local Water System has 2-4 service connections.

systems to file water shortage contingency plans, and that the state provide technical and financial assistance as needed in preparing the plans. At the regional level, counties should draft a water shortage contingency plan template appropriate for state small and local water systems and require the systems within their jurisdiction to modify the plan as necessary and adopt it. The IHS' California Area Office's work with tribal water systems to develop drought contingency plans can serve as a model of how to work with small water systems to develop water shortage contingency plans.

1-3. Increase Oversight of New Wells

Thousands of households reliant on private wells and surface diversions lost access to water during the drought, while those with the resources to drill deeper wells continued to pump groundwater at record-breaking rates. Counties should place restrictions on new well permits in basins where domestic water wells are at risk of outages. The Sustainable Groundwater Management Act begins to go into effect for high and medium priority basins subject to critical conditions of overdraft in 2020, and for other high and medium priority basins in 2022. Until then, counties, in collaboration with other well-permitting authorities, should exercise their authority to regulate groundwater use by issuing permits on the condition that the applicant demonstrate that water is available to serve the well.

Further Study and Data Collection on Domestic Water Shortages

1-4. Collect Information on Well Depth from Drilling Permit Applications

At present, well permits collected at the county level do not always include well depth information. Including this information would enable county officials to flag and require modifications to

Shortages in both public and non-public systems were more widespread geographically in the state than has been represented in media reports.

drilling plans for new wells likely to overdraft an aquifer that supplies domestic wells.

1-5. Systematically Collect Data on Private Supply Shortages

We know from voluntary reporting compiled by the state[8] that there have been thousands of private domestic well shortages and surface diversions during the ongoing drought. However, the data set on private supply shortages is incomplete and inconsistent because reporting is voluntary and handled differently across counties. We recommend that the state develop a mandatory, standardized system for reporting private supply shortages to the counties that can be compiled into a statewide dataset. Likewise, the U.S. EPA and IHS should collect data on shortages in private well and surface diversions on tribal lands.

1-6. Identify Geographic Areas at Risk of Groundwater Supply Shortages

High-quality data on household outages would enable an analysis of the causes of wells shortages or failures. Factors to consider are the rate of groundwater decline, the type of aquifer, the proximity, depth and demand of nearby wells, and nearby land uses. A more complete understanding of the causes of well outages and failures could enable predictions of where future outages are

8 See the State of California Household Water Supply Shortage Reporting System at https://mydrywatersupply.water.ca.gov/report/publicpage.

likely to occur, and allow proactive planning to find reliable water sources before shortages occur.

1-7. Identify Public Water Systems at Risk of Future Supply Problems

Can we identify characteristics of public water systems that made them more likely to experience supply impacts during the ongoing drought? In various reports and media outlets, observers have pointed to myriad factors such as system size, region, groundwater versus surface water, diversity of supplies, and ability to transfer water from other systems as indicators of drought resilience. We recommend a rigorous assessment of the common factors in systems that experienced supply impacts during the ongoing drought. This can inform further discussion about systems likely to experience problems in the future, and how to prevent shortfalls.

1-8. Identify Areas with High Potential for Consolidation or Extension of Service

The SWRCB has supported voluntary system-level consolidations, and as of 2015 has the authority in certain circumstances to mandate consolidations. High-quality data on public water systems that experienced supply problems and private supply shortages would enable the state to identify areas that could benefit the most from consolidation, either by connecting many households reliant on private wells or surface diversions into a new public water system, or by connecting them to an existing public water system that has the capacity to serve them.

SECTION 2.
DROUGHT CHARGES AND WATER AFFORDABILITY

OVERVIEW

Affordability is a central element for ensuring basic access to water—a human right recognized by the state of California—yet many Californians struggle to pay their water bills. Studies in select regions of the state have found that the cost of water for 20 to 50 percent of households with average water use exceed the U.S. Environmental Protection Agency's affordability thresholds for water and wastewater (Christian-Smith et al. 2013; United States Conference of Mayors 2014). Rising water costs are exacerbating water affordability concerns. Hanak et al. (2014) found that water bills in California's urban areas increased two to three times faster than inflation between 2000 and 2010 to cover infrastructure and other system costs. To make matters worse, Proposition 218, a ballot measure approved by California voters in 1996, prevents publicly-owned water utilities from using water-rate revenue to subsidize low-income customers (Box 2-1).

Water rates tend to rise during a drought, worsening affordability concerns. Costs may increase, for example, if a water utility must purchase more expensive drinking water supplies, install or upgrade treatment technologies for lower quality water, or pump groundwater from greater depths. For example, the East Bay Municipal Utility District drew from a more expensive emergency supply in both 2014 and 2015 (Figueroa 2014; Figueroa 2015). Administering conservation programs can also increase costs for utilities. As water use declines during the drought, water sales may become insufficient to cover the utility's operational costs, most of which are fixed. In response, water utilities may implement temporary drought surcharges, fees, and/or penalties to help cover their costs.

Raising rates or charging additional fees during a drought has important benefits, as it maintains the financial viability of water utilities, and can be an effective means of incentivizing conservation and efficiency. On April 1, 2015, following the lowest Sierra snowpack ever recorded, Governor Jerry Brown issued Executive Order B-29-15, which established a mandatory statewide water conservation target of 25 percent. It also stated:

> *"The Water Board shall direct urban water suppliers to develop rate structures and other pricing mechanisms, including but not limited to surcharges, fees, and penalties, to maximize water conservation consistent with statewide water restrictions."*

While raising per-unit costs is a key component of drought response plans for water utilities, it is nonetheless important to consider the potential equity impacts of raising water prices. Fixed increases in water costs represent a greater proportion of the annual income for low-income households. High water bills may interfere with a family's ability to pay for other necessities, or cause them to fall behind on their water bills. Late charges can accumulate, or worse, utilities can shut off service for lack of payment. Service disconnections are three times more likely to impact the lowest income households than the average household (Cromwell 2010). Lack of water can lead to health problems, loss of custody of one's children, eviction and foreclosure, and even criminal charges (Jones and Moulton, 2016).

Low-income households tend to use less water, so designing rates, and drought charges, to keep costs low for low-volume users will benefit most low-income households (Mayer et al. 1999; Mini 2013; Rubin 2005). However, there are some complicating factors at play. First, low-income households tend to have more members, and thus larger water bills despite having relatively low per-person use (Saunders 1998). Second, other researchers have argued that low-income customers face financial challenges in upgrading their homes to be efficient, and therefore may be unable to keep their water use low (Cromwell 2010). Repairing leaks and upgrading fixtures and appliances is costly. Furthermore, many low-income customers are renters without the authority to alter their homes.

In this section, we examined available data on drought charges imposed in 2015, including information on the structure of those charges. We evaluated the impact of the structure of drought charges on meeting basic water needs. We then undertook case studies on three water utilities, estimating the monthly bill, with and without drought charges, for an average-size household using 55 gallons per capita per day (GPCD). We also examined the percentage of income that the water bill would represent for households in each of nine income brackets to understand the additional cost burden imposed by drought charges on households, some of which were already paying unaffordable rates.

While increasing costs is a key component of drought management, it is important to consider the equity impacts of raising prices.

METHODS

There are varying definitions of what constitutes affordable water. A common approach adopted by regulatory agencies has been to compare the average residential water bill to the median household income (MHI) for a given region. The California State Water Resources Control Board (SWRCB) uses average residential drinking water costs in excess of 1.5 percent of median community household income as a threshold for affordability, while the U.S. EPA uses a threshold of 2.5 percent (U.S. EPA 1998; SWRCB 2016b). This approach is referred to as "macro-affordability" because it gives a sense of average affordability for an entire region without assessing the burden of water bills for sub-groups within that region. Some have criticized the macro-affordability approach because it masks the cost of water for those that deviate from average income or water use. By contrast, micro-scale indicators of affordability disaggregate households by income group, family type (e.g., household size), or geographic sub-region (Herrington 2003). Past work in California has assessed affordability across the range of income levels within a region (United States Conference of Mayors 2014; Christian-Smith et al. 2013). Others have called for researchers to look at actual, rather than average, water bills by income, because income is negatively correlated with water use (Osann 2016). To our knowledge there has not yet been an analysis in California that parses out affordability for different water use levels by income or household size.

For this report, we sought to keep our analysis of affordability consistent with earlier work by the SWRCB while addressing some of the criticisms of traditional affordability metrics. Given that this report focuses on California, we used the SWRCB's definition of affordable water as 1.5 percent of household income. However, rather than looking at affordability for median-income households, we divided single-family households into nine income brackets. Additionally, rather than basing water bills on average water use, we estimated water bills, with and without drought charges, for meeting basic water needs (defined below). This approach is a useful starting point to observe how additional charges imposed during drought altered costs for low-income households, and how those charges can be structured to incentivize conservation while minimizing impacts on low-income customers for basic water needs.

As with affordability, there is no single definition for the volume of water necessary to meet basic water needs. The California Human Right to Water declares that all humans have a right to water adequate for human consumption, cooking, and sanitary purposes (CA Water Code § 106.3). In their resolution adopting the Human Right to Water as a core value, the SWRCB pointed to two numbers in California laws and regulations: "The Water Efficiency Act of 2009 identifies 55 gallons per capita per day as a provisional conservation standard for 'indoor residential water use' by 2020" (Wat. Code, § 10608.20, subd. (b)(2)(A)). Similarly, a prior SWRCB emergency regulation established an exemption from a prohibition on diverting water, under specified circumstances, up to a maximum of 50 gallons per capita daily in order to meet 'minimum health and safety needs' (Cal. Code Regs., tit. 23, § 878.1, subds. (a)-(b) [operative March 30, 2015 and repealed Dec. 29, 2015]). By comparison, DeOreo et al. (2011) found that mean indoor household use in California was 63 GPCD in 2007-2009. Other studies suggest that homes equipped with high-efficiency appliances and fixtures would use between 32 GPCD (Heberger, Cooley, and Gleick 2014) and 36 GPCD (DeOreo et al. 2011). Table 2-1 reviews select standards and studies on indoor water needs.

For this report, we defined 55 GPCD as a reasonable volume for meeting basic water needs, based on the indoor water standard established by

Table 2-1.

Indoor Water Benchmarks—How Much Water Do People Need for Indoor Uses?

Gallons Per Capita Per Day (GPCD)	Description	Source
63	Mean water use in a sample of 700 homes in 10 service areas in CA from 2007-2009	DeOreo et al. (2011)
55	Provisional conservation standard for 'indoor residential water use' by 2020	CA Wat. Code, § 10608.20, subd. (b)(2)(A)
36	Mean water use in homes built with best available technologies as of 2010 for toilets, clothes washers, showers, and faucets	DeOreo et al. (2011
32	Theoretical water budget for home built using efficient appliances and fixtures and no household leaks	Heberger et al. (2014)

the California Water Efficiency Act of 2009. This is lower than the average per capita residential water use reported in DeOreo et al. (2011), but more generous than the efficient benchmarks identified by DeOreo (2011) and Heberger et al. (2014).

Structure of Drought Charges

Incomplete data are available on the number of water utilities that have instituted drought charges. We obtained state-collected data on surcharges, fees, and penalties from the SWRCB's 2015 Large Water System Electronic Annual Reports (LWS EAR) (SWRCB 2015a). The LWS EAR are annual reports from public water systems with at least 999 service connections. The 2015 database had records for 731 public water utilities (out of the 8,302 total public water systems in the state listed in the State Drinking Water Information System). All but 10 were community water systems.

In 2015, the report questionnaire asked water utilities two questions that provide some insight on drought charges: "Do you have other surcharges?" and if so, "What are the other surcharges?" The 2015 LWS EAR contained 725 answers to the question. Of these, one-third stated that they had other surcharges and used terms such as surcharges, fees, and penalties to describe them. We did a keyword search for the term "drought" in the surcharge description and found 28 water utilities that reported imposing a drought charge. We believe this is only a sample of water utilities that imposed drought charges and not a complete count. For the 28 utilities reporting drought charges, we used the water utilities' websites or contacted them via phone to determine the structure of the charges. We made up to four phone calls to a supplier and were able to obtain the relevant information for 27 of the 28 utilities.

Given that the structure of drought charges varied widely by utility and customer type, we focused on drought charges imposed on single-family households and categorized each system according to how the utility determined the minimum volume of water at which to add an additional drought charge. Our goal was to determine whether households using less than 55 GPCD would pay drought charges in each service area. The classifications we used were:

a. Threshold type (fixed or customized): Whether the threshold volume for paying a drought charge was fixed or customized according to estimated household needs. In addition, there were two types of customized thresholds:
   i. Customized by household size: The threshold was calculated based on the number of residents in the household;
   ii. Customized by prior use: The threshold was calculated as a percentage of prior use (e.g. every household was asked to reduce their pre-drought water use by a given percentage).

b. Threshold volume: The monthly threshold volume of water at which a customer paid a drought charge.

In cases where billing was bimonthly, we divided the threshold for imposing a drought surcharge by two to make it comparable with those utilities billing on a monthly basis. The results of our survey were then used as the basis for an assessment of the impact of drought charges on affordability.

Impact of Drought Charges to Affordability

Of the 27 water utilities for which data are available, we provide detailed case studies for three. We chose the two utilities with the greatest proportion of their service area in a Disadvantaged Community (DAC): Elsinore Valley Municipal Water District and the City of Glendale Water and

Power.[1] For comparative purposes, we selected at random one of the two utilities that had none of its service area in a DAC, the City of Benicia.

For each supplier, we estimated the water bill for a single-family household using 55 GPCD with and without drought charges for the main city that they serve. We used the data from the United States Census Bureau (United States Census Bureau 2010; United States Census Bureau 2014) to find mean household size and household income for the Cities of Lake Elsinore, Glendale, and Benicia, and calculated monthly indoor water needs for that household. Table 2-2 summarizes this information.

Using the University of North Carolina, Chapel Hill Water & Wastewater Residential Rates Affordability Assessment Tool (UNC—Chapel Hill Environmental Finance Center 2016), we estimated the proportion of income a mean-size single family household would pay to meet monthly indoor water needs, and compared the water bill to household income in nine income categories, ranging from below $10,000 to more than $150,000 annually. We then calculated how drought surcharges affected the percentage of income spent on water for the three lowest income brackets ($24,999 annual income and below). We reported the mean change in the cost of paying for monthly indoor water needs along with the standard deviation.

1 DACs are areas with a median household income less than 80 percent of statewide median household income.

RESULTS AND DISCUSSION

Structure of Drought Charges

The 27 utilities for which we obtained data were all community water systems and were distributed across 11 counties. They were broadly dispersed geographically, but none were north of Sacramento County. One-third offered lifeline rates or low-income subsidies. Detailed information on drought charges for the utilities surveyed is provided in Appendix 2A.

Table 2-2.

Characteristics of Cities Profiled in Affordability Case Studies

	Lake Elsinore	Glendale	Benicia
Population[1]	51,821	191,719	27,450
Number of Households[2]	14,788	72,269	10,686
Median Household Income ($)[3]	63,303	52,451	89,094
Mean Household Size[2]	3.48	2.63	2.52
Basic Household Monthly Water Use (in gallons)[4]	5,800	4,400	4,200
Water Supplier	Elsinore Valley	Glendale City	City of Benicia
Public Water System ID	CA3310012	CA1910043	CA4810001

1. Data from 2010-2014 ACS: 5-year average.
2. Data from 2010 Census: Households and Families.
3. Data from 2014 ACS.
4. Calculated as 55 GPCD × mean household size.

Among the 27 utilities surveyed, we identified four categories of drought charge structures. Table 2-3 summarizes the types of drought charges found in our sample. Those with low, fixed thresholds raised costs for everyone, regardless of the volume of water use. The exact threshold was set at either 0 gallons per month or 750 gallons a month (1 CCF), presumably because 750 gallons is the minimum sensitivity of the water meter. In this case, all customers paid an additional drought charge. Those with high, fixed thresholds raised costs for those households using more than a given volume of water. The minimum volume ranged from about 6,000 to 9,000 gallons (8-12 CCF) per month, depending on the utility. In this case, households with large total water use—such as households with many members—experienced a rate increase. The third category of drought charges had customized thresholds based on prior use—that is, water prices went up unless the household reduced their water use by a given percentage. In this case, households that cut water use sufficiently avoided drought charges. The fourth category has a customized threshold based on household size, raising costs for water use only if per-person household use was high. This is also referred to as a budget-based approach for drought charges.

Understanding how the various drought charge structures will affect water bills for low-income customers is complex because it depends on multiple factors. Figure 2-1 demonstrates the interaction between drought charges, household size, and household income across three types of drought charge structures. We held per-capita water use constant to show how the various drought charge structures would raise costs by different amounts for households using the same amount of water per person. The first scenario shows the cost of water with an additional drought charge of $2.02 on every 750 gallons (1 CCF) (Figures 2-1a&b). The second scenario (Figures 2-1c&d) shows the cost of water if drought charges were levied only on households using at least 7,500 gallons (10 CCF) a month. Figures 2-1e&f show the cost of water if drought charges were levied only on households using more than 55 gallons per household member.

Fixed-threshold drought charges aggravated affordability concerns for low-income customers, and the effect is more pronounced for large households. Only utilities that customized the minimum threshold for levying a drought charge by household size avoid raising rates for large, efficient households with high total usage.

Table 2-3.

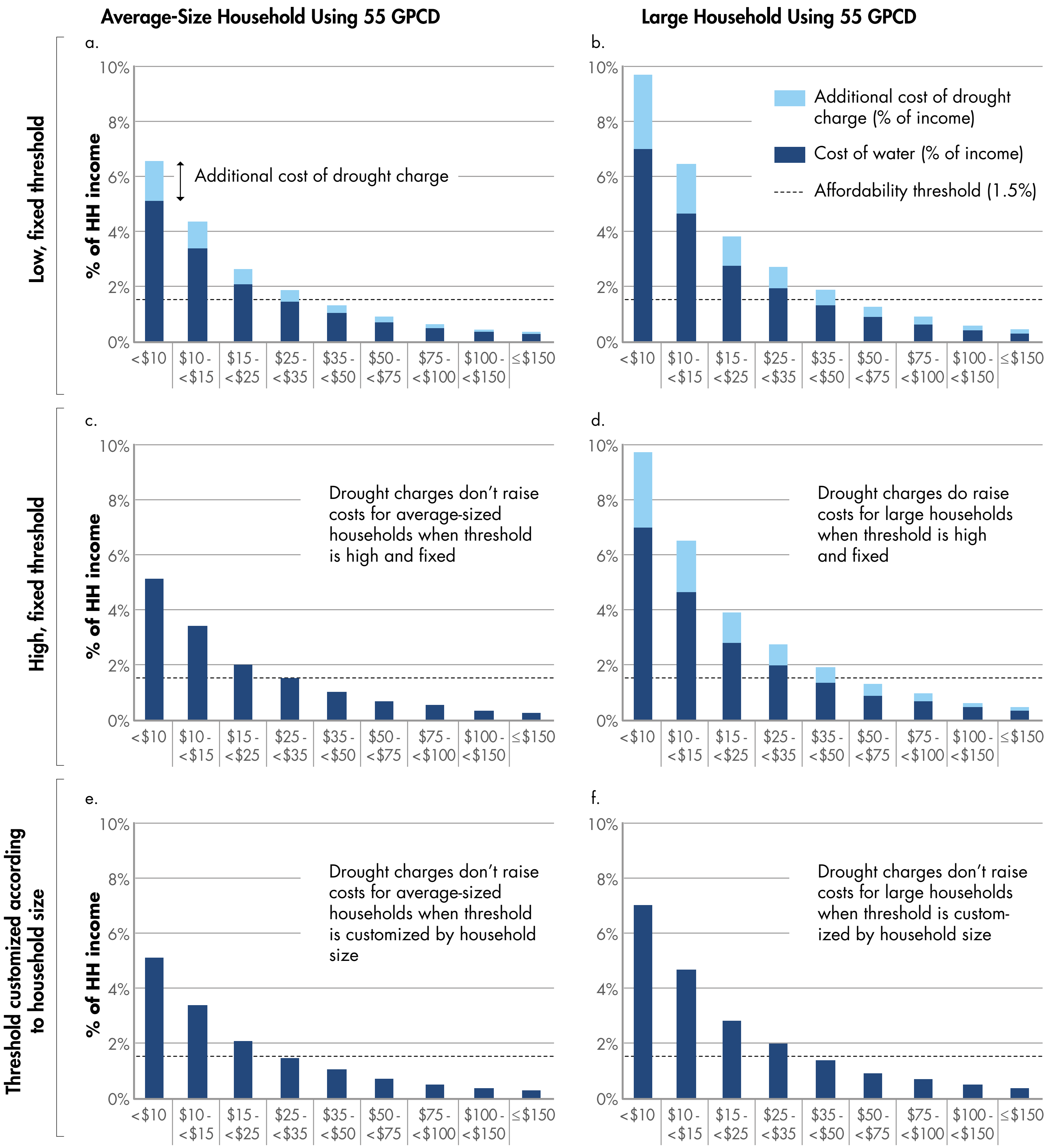
Four Types of Drought Charge Structures

Threshold Type	Volume Threshold	Change to cost of basic water needs	Num. of Utilities (%)
Low fixed threshold	750 gal (1 CCF) or less per month	Increased	15 (56%)
High fixed threshold	5,980-8,980 gal (8-12 CCF) per month	Increased for large households	5 (19%)
Customized threshold based on prior use	70% of household's Summer 2012 or Winter 2013 monthly use	Increased if the household already had relatively low baseline of use	1 (4%)
Customized threshold based on household size	Threshold increased by at least 1,680 gal (2.24 CCF) per month for each additional person	No change	6 (22%)

Notes: Abbreviations: gal = gallons, CCF = centum cubic feet. “Basic water needs” estimated as 55 GPCD.

Figure 2-1.

Cost of Basic Water Use Under Three Drought Charges Structures Across Income Levels and Household Sizes



Notes: All households assumed to use 55 GPCD. Household income in $1,000s. Left column depicts costs for average-size households, with 2.63 members. Right column depicts costs for large (top 10 percent) of households, with 5 members. Low, fixed threshold = 750 gal/household/month. High, fixed threshold = 7,500 gal/household/month. Data parameters were based on City of Glendale water rates and population census data.

Impact of Drought Charges on Affordability

We conducted three in-depth case studies on drought charge in Elsinore Valley Mutual Water District in Riverside Count, the City of Glendale Water and Power in Los Angeles County, and the City of Benicia in Solano County. All three utilities imposed fixed-threshold drought charges on households using 0 to 1 CCF per month, increasing costs for homes using even relatively small amounts of water. The effect of drought charges on water affordability, however, depended on the price increase and household income level.

For all three utilities, average-sized households earning the median income paid less than 1.5 percent of their annual income for their basic water needs, with or without drought charges. With drought charges, they paid $85 more annually for their basic water needs, or 0.15 percent (less than 1/600th) of their annual income.

If, rather than focus on the median income, we use finer-resolution data on income, the story is more complex. Here, the proportion of income spent on water, and the impact of drought charges on water affordability, was much higher for low-income households (Figure 2-2). Without drought charges, single-family households earning less than $25,000 annually, which represented 11-26 percent of households in the three service areas, paid an average of 1.8 percent (±0.31) of their income for basic water needs. With drought charges, however, households pay 2.1 percent (±0.49) of their income on basic water needs. Drought charges had an even greater impact on the lowest-income households. For example, in the City of Glendale, an average-sized household earning $10,000 a year and using 55 GPCD would pay an additional 1.4 percent of their annual income on drought charges alone, increasing the cost of basic water needs from 5.1 to 6.5 percent of their income.

Of the three utilities, only the City of Benicia - the utility with the fewest low-income customers—offered financial assistance to low-income seniors in 2015; that program was expanded to provide a discount for all low-income customers in November 2016 (City of Benicia 2016).

Overall, drought charges raised the proportion of income that customers spent on water by a small amount compared to the baseline cost of water. However, the surcharges have a much larger impact on the lowest-income households, underscoring equity concerns. To better understand affordability, water utilities should evaluate how the rate structure affects the cost of meeting basic water needs for low-income households and the potential for drought charges to exacerbate affordability concerns.

An unfortunate limitation of the dataset is that it only represented large water utilities. Work by the California Urban Water Association (CUWA) confirms that affordability is a serious problem in urban areas, even those that appear relatively affluent based on median household income levels. In an assessment of water affordability in 2014-2015 for 10 urban water utilities in California, CUWA found that nearly 21 percent of households earned less than $25,000 annually and spent an average of 4.5 percent of their income on water (CUWA 2016). Information about affordability in rural areas of California is limited. However, Christian-Smith et al. (2013) compared affordability in the urban Sacramento metropolitan area and rural Tulare Lake Basin and found that, while water was unaffordable for a large number of low-income customers in both regions, the problem was more widespread in the rural region. Additionally, some rural customers must also purchase bottled water due to water contamination concerns, further increasing water costs.

Figure 2-2.

Cost of Basic Water Use for Low-Income Households, With and Without Drought Charges, in Three Cities.

additional cost of drought charge (% of income)

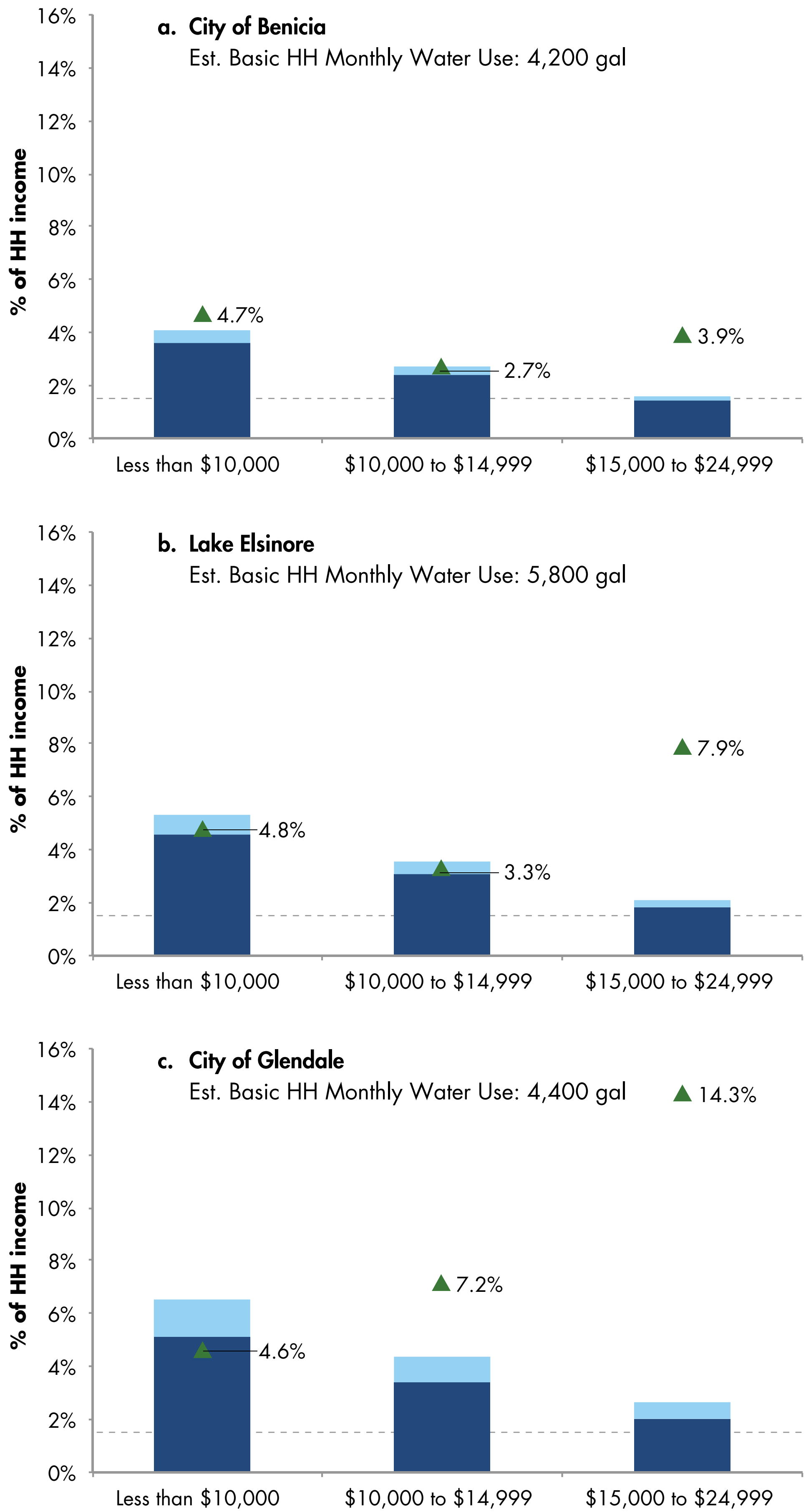
cost of water (% of income)

% service population

Affordability threshold (1.5%)

Notes: Vertical bars show the cost of 55 GPCD of water as percentage of income for a mean-size household in the three lowest income brackets for three water utilities with and without drought charges. Grey triangles show the percentage of households in each income bracket. Blue dashed line shows the affordability threshold for drinking water of (1.5 percent of annual income).

Source: Dataset available in Appendix 2B.



Box 2-1.

Proposition 218, Tiered Water Rates, and Customer Assistance Programs

Proposition 218, adopted as a California constitutional amendment in 1996, prohibits public water utilities from charging their customers more than the cost of providing water service. In order to implement tiers, water utilities must demonstrate that the price of water at each tier is justified by the cost of providing water service to that tier. This requirement prevents water utilities from using water-rate revenue to subsidize low income customers by offering them lower rates or providing financial assistance programs. Despite this limitation, a survey of customer assistance programs nationwide found 55 such programs in California (U.S. EPA 2016). Some were investor-owned utilities regulated by the California Public Utilities Commission, and as such are not subject to Proposition 218. Others have used alternative sources of funding such as state or federal grants, private charities, and property leases (Cooley et al. 2016).

An assumption of this analysis is that customers can meet their basic water needs for consumption, cooking, and sanitation with the 55 GPCD identified as a provisional conservation standard in California statute. While several studies indicate that reducing leaks and using modern fixtures and appliances can reduce water use well below 55 GPCD, low-income customers may not be able to afford these upgrades, may lack the ready cash to take advantage of rebate programs, and, if they rent, may not have the authority to make alterations to their home. As a result, imposing drought charges on inefficient water users should go hand-in-hand with programs to assist low-income customers to reduce their water use.

CONCLUSIONS AND RECOMMENDATIONS

Drought fees, penalties, and surcharges are considered an important strategy for coping with drought—both by encouraging customers to save water, and ensuring financial stability for water utilities. They can, however, raise water affordability concerns for low-income households that must be addressed. Prior studies have demonstrated that low-income customers tend to be relatively low water users. As a result, rate structures and drought charges that keep costs lower for basic water use tend to keep costs low for the majority of low-income households. There are three promising strategies for minimizing the impacts of drought charges on water affordability: (1) impose drought surcharges on water usage above some threshold, e.g., 55 GPCD, and adjust for household size; (2) target efficiency programs to low-income households; and (3) offer financial assistance programs to offset costs for low-income households. These strategies, however, can be challenging for utilities to administer, particularly small systems that have limited technical, managerial, and financial capacity. With awareness about the equity impacts of drought charges, and technical assistance for those that need it, utilities should be able to develop drought charges that do not make basic water needs unaffordable for their low-income customers.

RECOMMENDATIONS TO IMPROVE DROUGHT COST EQUITY

Mitigating Impacts of Drought Charges on Water Affordability for Low-Income Customers

2-1. Keep per-unit water costs low for low water users during droughts

An unintended consequence of drought charges can be to increase the cost of meeting basic indoor water needs for low-income customers. To minimize the cost burden of drought charges on efficient, low-income households, water utilities should adopt drought charges that keep per-unit costs down for low water users. Specifically, we recommend that public water systems:

- Waive drought charges on water consumed at or below the amount necessary to meet basic water needs.
- Calculate each household's threshold for incurring additional drought charges based on household size to avoid unfairly penalizing large households (commonly referred to as variances).

2-2. Target conservation and efficiency programs to low-income customers

Water utilities should offer conservation and efficiency programs that enable low-income customers to keep their water use low enough to take advantage of cost structures that charge less per unit for low water users. These programs should include renters and residents of multi-unit homes who do not directly pay a water bill, as the cost of water is generally passed on to them through their rent or other fees. We recommend that utilities:

- Use strategies to reduce up-front costs for home efficiency upgrades to encourage participation by low-income households. Low-income customers are less likely to participate in rebate programs. They are more likely to take advantage of point-of-sale coupons on efficient fixtures and appliances, and programs to distribute or directly install efficient fixtures free-of-charge.
- Make informational materials available in multiple languages, do in-person outreach as well as send written materials, and reach out to customers who do not receive bills (predominantly renters and residents of multi-unit homes).
- Target conservation and efficiency programs to tenants by distributing free fixtures that are simple to install, such as low-flow showerheads and faucet aerators.
- Target incentive-based conservation and efficiency programs to landlords by offering incentives for building audits, rebates, or tax deductions for efficiency upgrades and leak repairs.

2-3 Develop low-income rate assistance programs within current legal constraints, and reform Proposition 218 to allow greater latitude in funding such programs

The best option for minimizing cost increases during droughts for efficient, low-income households is to design drought charges in a fashion that minimizes cost increases for low water users. If that is not possible, then a rate assistance program targeted at low-income customers can counteract price increases for households in need. Low-income rate assistance programs generally do not enroll all the qualified customers, so ideally they should be used in addition to, not instead of, equitably designed rate and drought charge structures. Under Proposition 218, public utilities cannot use ratepayer fees to fund low-income rate assistance programs. Water systems can use other sources of revenue such as leasing land or donations.

2-4. Address structural problems that prevent water systems from enacting equitable drought charge structures

Underlying issues prevent water utilities from addressing the greater cost burden placed on low-income customers by their water bills, both with and without drought charges. Our first recommendation, to keep per-unit costs low for low water users during droughts, requires that water systems have adequate technical, managerial and financial capacity. Stakeholders in government, water utilities and non-governmental organizations should collaborate to develop this capacity by:

- Installing and maintaining water meters and sub-meters for all customers of public water systems. Most low-income customers are low water users, but their bills do not reflect their actual water use if they live in areas without meters for single-family homes or sub-meters for units in multifamily buildings.
- Supporting water systems in developing equitable drought charge structures, and adding information about equitable approaches to drought charges to existing state programs that provide technical education for small water systems. Small water utilities need greater technical capacity to develop more complex, equitable drought charges such as tiers, variances for large households, and bill discounts for low-income customers.

Further Study and Data Collection on Drought and Affordability

2-5. Collect and analyze data on how to target hard-to-reach customers such as renters and residents of multi-unit buildings.

Designing financial assistance and efficiency programs to effectively serve renters and residents of multi-unit buildings is challenging. Better understanding how existing programs have managed to target these hard-to-reach customers could inform best practices going forward.

2-6. Determine if low-income households have less efficient fixtures and appliances, or more leaks, and therefore use more water to meet their basic needs.

The energy sector has provided ample evidence that low-income customers are more cost-burdened, mainly because they use more inefficient household appliances. This research has galvanized efforts to improve energy efficiency in low-income homes because it benefits the customer and the environment. Similar research is needed in the water sector.

2-7. The state should collect complete information on drought surcharges, fees, and penalties.

Present data collection is limited in the type of water utilities reporting data, and, given the improbably small number that reported drought charges in 2015, it seems nearly certain that even among utilities that submit an LWS EAR, most are not reporting their drought charges.

2-8. Publicly release a complete, accurate map of all public water systems in the state

A complete map of water system boundaries would enable non-government entities to assess the cost of water in relation to local income levels.

SECTION 3. DROUGHT IMPACTS ON SALMON FISHERIES

OVERVIEW

Reports of drought impacts on California's fishing communities have been relatively limited. Many still frame water problems in California as "fish versus farms" or "humans versus ecosystems" (for example, Pollak 2016; Abcarian 2016). However, fish are essential to the well-being of communities that rely on them for food and income. We highlight salmon in this analysis due to its economic and cultural importance in many California riparian and coastal communities. A particular focus is given to the fall-run and Klamath spring-run Chinook salmon, which are the only remaining taxa that can be managed as a fishery. To examine the equity issues tied to drought impacts on salmon, we analyzed trends in the performance of commercial and tribal fisheries over the past several decades.

Ultimately, the current drought is not the only cause of the decline of California's salmon fishery; after all, salmon have coped with periodic droughts throughout their evolutionary history. However, salmon populations likely face greater difficulty surviving and rebounding from droughts given the barriers to migration to colder stretches of the river, loss of habitat, competition from non-native species, and water quality degradation (for example, Zeug et al. 2011; Jones and Nguyen 2010). In 2008, the United States District Court for the Eastern District of California issued a ruling that California water systems place wild salmon "unquestionably in jeopardy" (Jones and Nguyen 2010). Improving conditions for California's salmon, and the well-being of the communities dependent on them, will require improving management responses during short-term drought emergencies while addressing the underlying problems of habitat alteration and degradation, water allocation for the environment, and inequitable fishery access.

Salmon Natural History and Status in California

Many California rivers are breeding grounds for salmon. Chinook salmon (commonly known as King salmon) is the most abundant species in California and off its coast, but Coho, Pink, and Chum salmon are also found within the state. Chinook salmon are further divided into populations referred to as runs that migrate and breed during different seasons—namely fall, late-fall, winter, and spring, reflecting the long history of adaptation to California's seasonal flows (Hanak et al. 2011).

Salmon are an anadromous fish that spend part of their life in freshwater and the other part in the ocean. When salmon grow into small fish, they undergo a physical change, or "smolting," to survive in saltier water as they move downstream to estuaries, where ocean water blends with freshwater and food is abundant. Those born in California rivers typically migrate to the ocean in their first few months of life, while some linger behind until they are over a year old (Fry 1979). In the ocean, salmon may stay relatively close to the mouth of the river in which they were born or swim long distances to find another feeding ground. After two to five years at sea, mature salmon return to their native river to spawn and die, with most returning at age three.

Interacting environmental and human-related factors influence annual fluctuations in salmon abundance. For example, the survival and growth of salmon can be greatly affected by changes in freshwater flows, which in many cases are regulated by upstream dams (e.g., Shasta Dam on the Sacramento River). These flows, in turn, affect water temperature, availability of floodplain habitat, water turbidity, interactions with predators and competitors, and the ability of mature fish to migrate to spawning grounds. Sufficient flows of water during migration periods are crucial for both outmigration of juvenile salmon downstream and migration of mature salmon to spawn upstream. Temperature is a key factor affecting survival of salmon at every life stage. The optimal temperature for eggs and fry is about 48 to 55 degrees F. Smolts can thrive in warmer waters, optimally about 50 to 66 degrees F (McCullough 1999, cited in Moyle, Israel, and Purdy 2008, 127-128). Other water quality parameters, including dissolved oxygen, pH (Carter 2008), and turbidity (Bash, Berman, and Bolton 2001), are also important determinants of salmon growth and survival.

Historically, salmon are remarkably abundant and widely distributed in California, from the Central Valley up to the northern region and as far inland

Dams now block Central Valley Chinook salmon and steelhead from over 90% of their spawning habitat.

as the Sierra Nevada and Eastern Cascades (Myers et al. 1998). The Sacramento and San Joaquin river systems are California's largest salmon-producing rivers on the West Coast, followed by the Klamath River (Fry 1979; Rankel 1982, cited in Hardy, Addley, and Saraeva 2006). As recently as the 1930s, California's residents observed spawning salmon so thick that they looked like a sheet of silver glass as far as the eye could see (Levene et al. 1976, cited in NMFS 2012).

However, the salmon population has declined drastically over the past century, and many salmon taxa are heading toward extinction (Katz et al. 2013). Dams now block Central Valley Chinook salmon and steelhead from over 90% of their spawning habitat (NOAA 2014). For example, Coho salmon in certain reaches of the river and winter-run Chinook salmon are currently listed as endangered by the state and federal government (CDFW 2016).[1] Currently, the only salmon runs that can be harvested for subsistence, sale, or recreational purposes are the fall-run and Klamath-Trinity River spring-run Chinook salmon.[2]

A complex set of factors contributed to the widespread decline in California's salmon population. These include overfishing in the late 1800s and early 1900s (Clark 1929); extensive

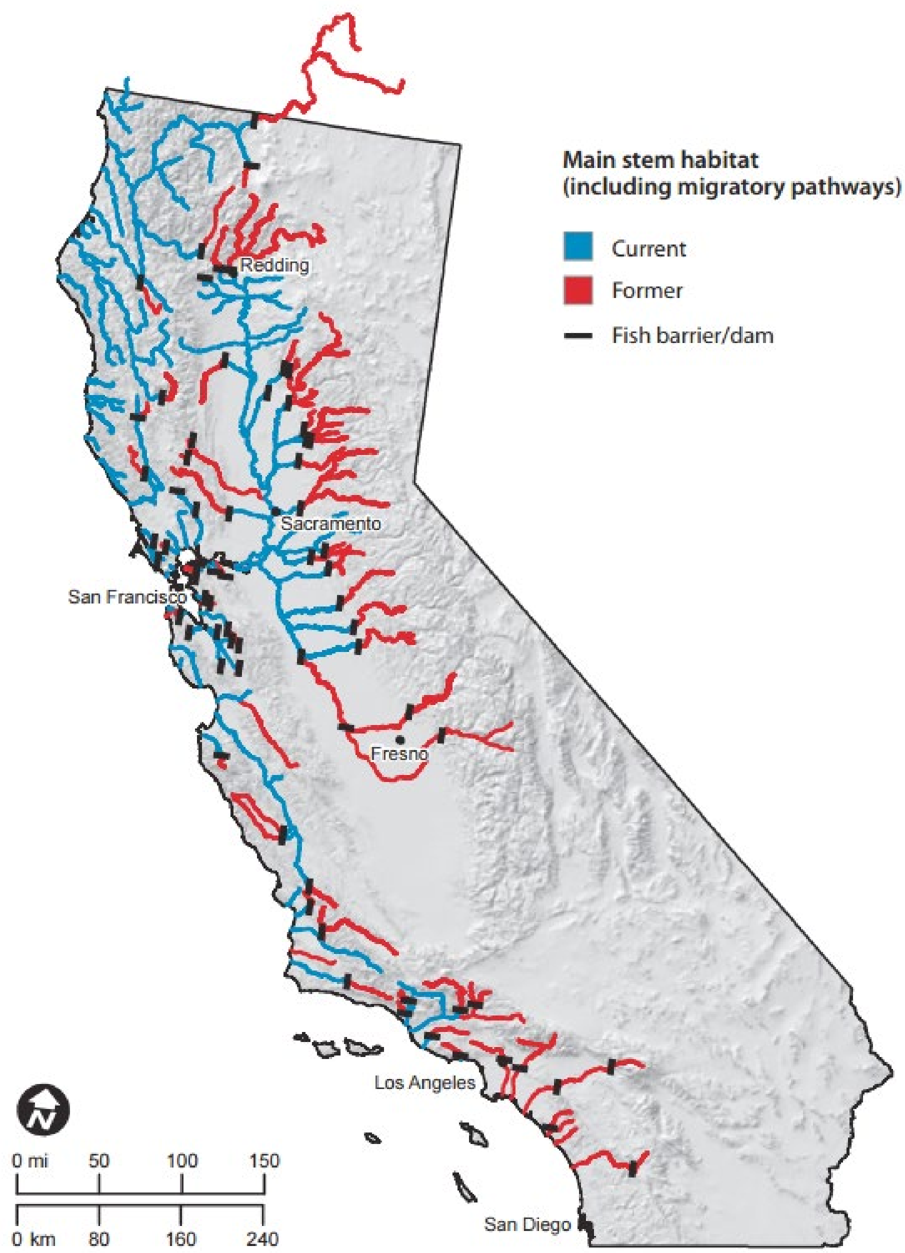
1 Threatened and endangered species status may be specific to certain areas. For example, Coho salmon is listed as threatened from Punta Gorda to the northern border of California, but it is listed as endangered from south of Punta Gorda to the U.S./Mexico border. Similarly, spring run Chinook salmon is only listed as threatened for the Sacramento River drainage.

2 Commercial harvest of Coho salmon has been prohibited since 1992.

hydroelectric and irrigation development in the mid-20th century (Lichatowich 1999; Hanak et al. 2011); habitat alteration and degradation (Figure 3-1); competition for freshwater; and invasive fish species that prey on young salmon and eggs or compete with salmon for food (Moyle, Katz, and Quiñones 2011). Additionally, while salmon hatcheries—facilities that artificially breed and rear salmon—play an important role in salmon recovery and help support sustainable fisheries, there remain concerns about the hatchery's long-term impacts on wild salmon stocks from interbreeding and reductions in the genetic diversity of wild salmon (Buhle et al. 2009;

Figure 3-1.

Habitat Loss and Current Extent of Salmon-Accessible Waterways



Source: Hanak et al. (2011).

Source: ImagineGolf

Chilcote, Goodson, and Falcy 2011; Araki, Cooper, and Blouin 2009). More recently, a dramatic decline in the Sacramento River fall Chinook salmon population in 2008 and 2009 was likely due to ocean conditions (e.g., temperature and nutrients affecting food availability), an inaccurate forecast of salmon escapement, ongoing degradation of freshwater and estuarine habitats, and heavy reliance on hatchery production (Lindley et al. 2009).

RESULTS AND DISCUSSION

Commercial Salmon Fishery Trends Over Time

DECLINE OF COMMERCIAL SALMON FISHERY

California's commercial salmon fishing communities were initially established around the mid-1800s. During the gold rush, settlers recognized the rich resources of the area and salmon fishing took off (Pomeroy, Thompson, and Stevens 2010; Smith and Kato 1977). San Francisco Bay and the Sacramento-San Joaquin Delta region were the first major fishery conducted by Euro-American immigrants in the state (Yoshiyama, Fisher, and Moyle 1998). Annual catches of the early Sacramento-San Joaquin in-river fishery were 4 -10 million pounds. An early estimate of the Central Valley Chinook salmon stock was 1-2 million spawning fish annually. The depletion of runs, however, led to legislation to restrict access to the fishery in 1980 (CDFG 2001). Presently, commercial salmon fishing in California is undertaken by small troll boats, usually with one or two people. As income from salmon is typically not enough for an entire year for most fishermen, they also harvest Dungeness crab.

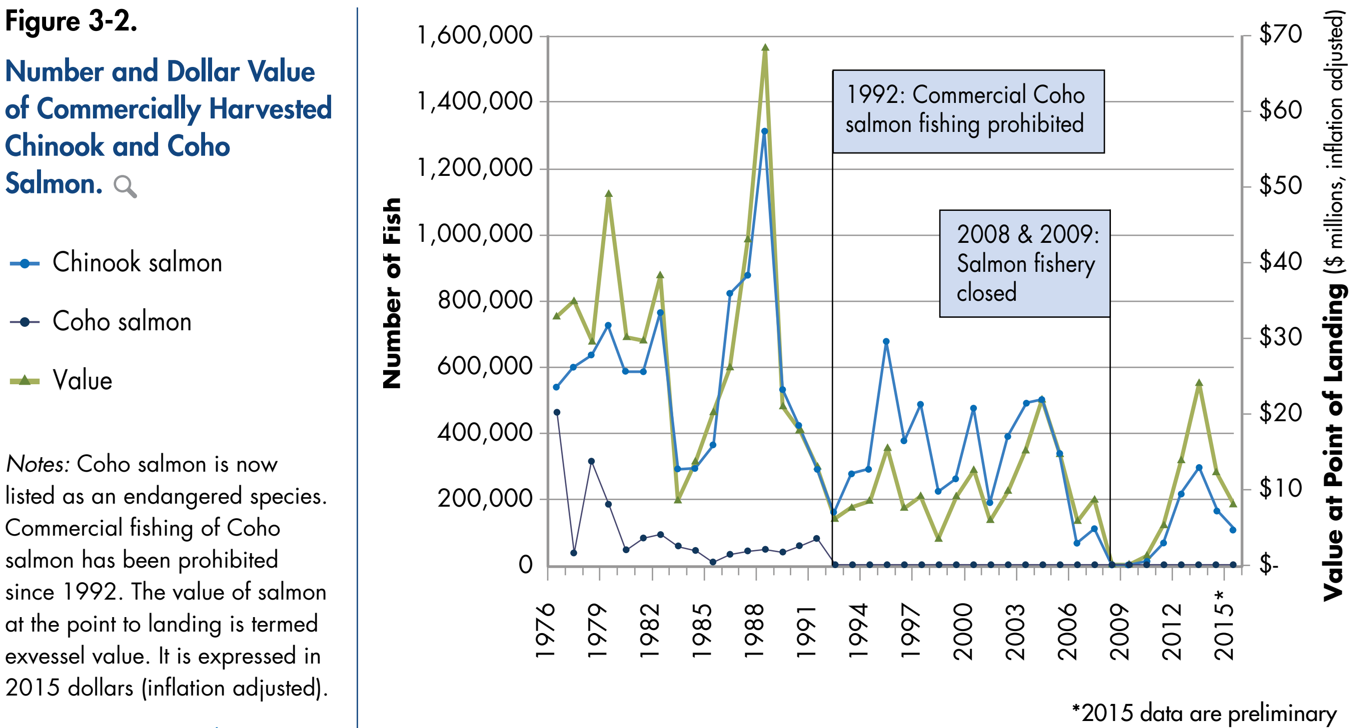
Data from the PFMC show that the number of salmon caught and landed in California has declined over the last 40 years. Between 1976 and 1980, fishermen caught an average of 830,000 fish annually. The harvest declined by 80 percent to 170,000 per year between 2011 and 2015 (Figure 3-2), a result of the fall in salmon abundance as well as regulations that limited salmon fishing to more sustainable levels.

Figure 3-2 also illustrates how the value of salmon catch to fishermen, referred to as exvessel value, has trended gradually downward over the past 30 years. For 2011 to 2015, the exvessel value averaged \$13 million per year—a 64 percent decrease from the 1976 to 1980 average of \$36 million per year. It should be noted that the rise in salmon prices in recent years to an average of \$6.15 per pound has helped mitigate the impacts of decreased salmon catch.[3]

3 We derived the average price from the PFMC's Review of Ocean Salmon Fisheries data. All values are in 2015 dollars.

Figure 3-2.

Number and Dollar Value of Commercially Harvested Chinook and Coho Salmon.



Notes: Coho salmon is now listed as an endangered species. Commercial fishing of Coho salmon has been prohibited since 1992. The value of salmon at the point to landing is termed exvessel value. It is expressed in 2015 dollars (inflation adjusted).

Source: PFMC (2016b).

Some of the decline in harvest was related to the number of commercial fishing days and areas opened to salmon fishing. Historically, California's (unregulated) commercial salmon season ran from April through October, but the fall in salmon abundance prompted the California Department of Fish and Wildlife (CDFW) to limit the number of commercial salmon fishing days. The CDFW also limits the extent of fishing grounds and shortens the commercial fishing season in certain years to avoid unintended by-catch of listed threatened and endangered species. In 2016, the Pacific Fishery Management Council noted that "long running drought conditions, coupled with suboptimal ocean conditions, have raised serious concerns for Sacramento River winter Chinook salmon." As a result, fishing seasons south of Point Arena, California, were shortened to minimize interactions with winter Chinook. Figure 3-3 highlights the curtailment of fishing seasons during recent drought years (2014-2016), with the greatest cut of 23% in 2016 compared to the 2001-2005 average.

OTHER SIGNS OF THE FISHERY DECLINE

Due to the pressures of a declining harvest and the rising cost of entry into the fishery and fishing-related inputs (e.g., ice and fuel), many fishermen have retired their permits.[4] As a result, the size of commercial salmon fleet has decreased dramatically over time (Dave Bitts, salmon fisherman, personal communication, Oct. 19, 2016).[5] Only one-sixth of the boats with salmon permits remained in 2014 compared to 1982, two years after the permitting program started (Figure 3-4). Despite a clear downward trend in total harvest, annual gross income per boat has fluctuated dramatically with no clear trend, perhaps a result of various counterbalancing

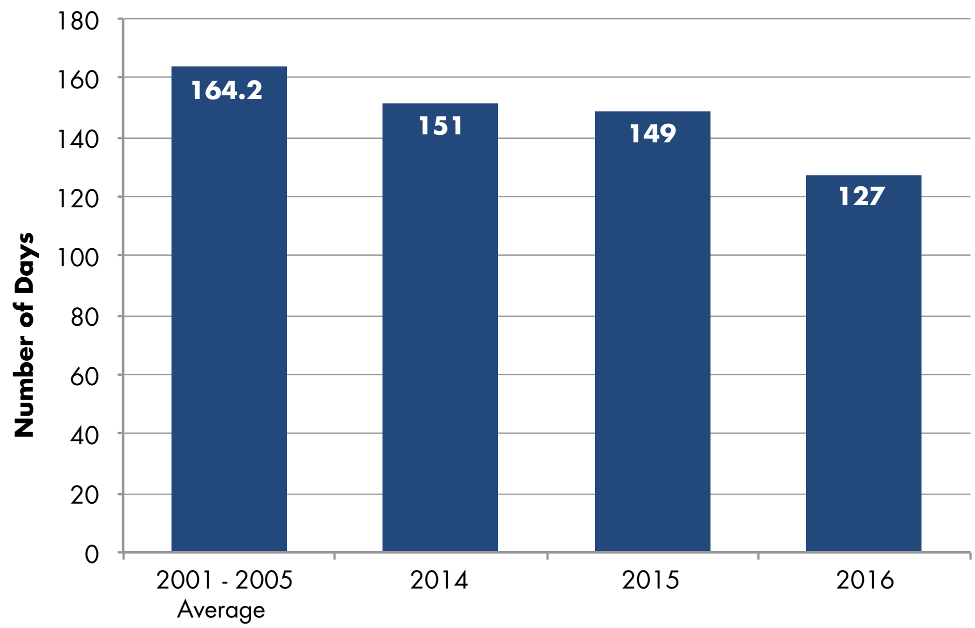
4 The entry cost is higher than before because an aspiring salmon fisherman must find a retiring fisherman to purchase the permit from.

5 The restricted access program, which came into effect in 1980, limits the number of fishing permits available. Permits may be transferable between fishermen or vessels. Under certain conditions, permits may be transferred from retired to new vessels (CDFG 2001).

Figure 3-3.

Length of Salmon Fishing Season.

Sources: 2001 – 2005, 2014, and 2015 data from PFMC (2014) and PFMC (2016b). Table C-1. 2016 data from https://www.wildlife.ca.gov/Fishing/Ocean/Regulations/Salmon.



effects: declining salmon stock, price changes, and less competition as the salmon fleet became smaller (Figure 3-5). Gross income from salmon bottomed out in 2008 and 2009 when the fishery was closed for two seasons, but it reached a record high of $35,000 per boat in 2013.[6] High income variability affects job security and reflects the fact that it is becoming more difficult to make a living as a salmon fisherman. In Morro Bay, for example, the salmon fishing community has gotten much smaller, and the average age of fishermen has been increasing as less young people enter the fishery (Lori French, salmon fisherman, personal communication, Oct. 18, 2016). We interviewed fishermen about their personal experiences to get their perspective on the challenges facing them (Box 3-1).

The salmon fishery not only provides income for those directly participating in the industry, but also supports the local economy by driving demand for goods and services in the community. During the current drought year (2012-2015), California's total (both direct and indirect) inflation-adjusted personal income from commercial salmon fishing was $27 million (PFMC 2016b).[7] The indirect economic impacts from the salmon fishery depend on the importance of the fishery to the community's economic base and whether other economic opportunities exist during a poor salmon harvest eason. Due to data limitation, we are not able to show any local or statewide trends.[8] However, it is expected that impacts from the decline in the salmon fishery could be quite dramatic for communities that heavily rely on salmon harvest.

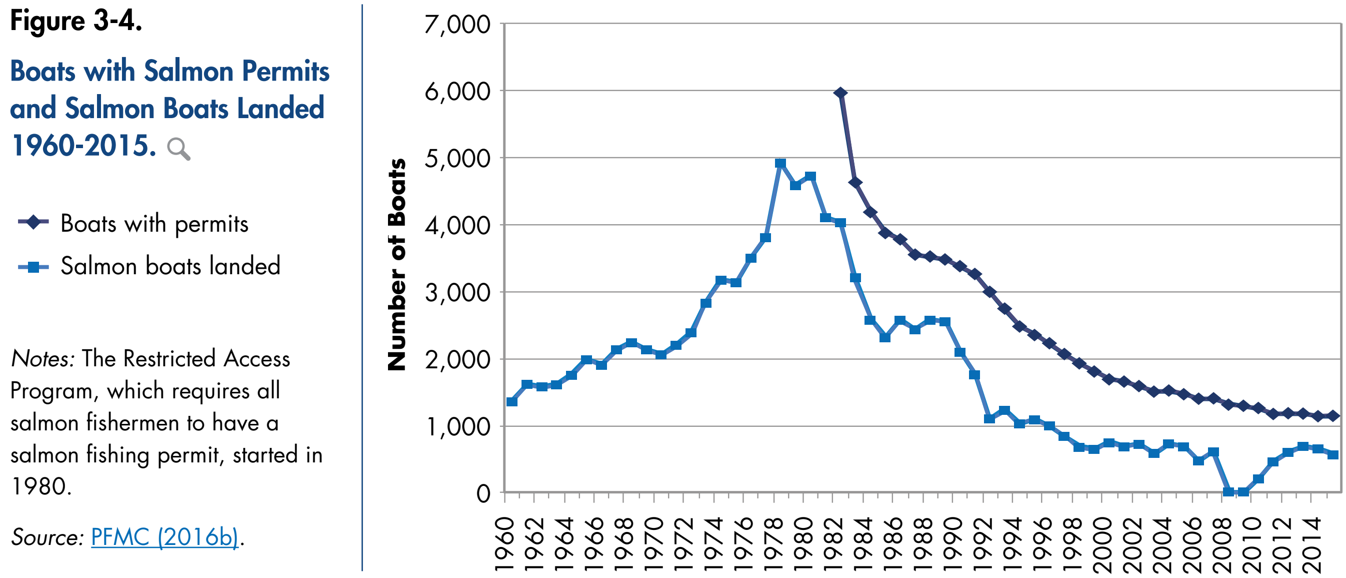
6 The average gross income between 2006 and 2015 was $17,000 per boat per year, not including years 2008 and 2009. The fishery closure was a result of a drastic salmon population decline due to unfavorable ocean temperature and food availability conditions, not the drought (Jones and Nguyen 2010).

7 Actual impacts will vary by community and its economic base. Direct impacts consist of personal income earned by those participating directly in the fishery, including vessel owners, crew members, and processing workers. Indirect impacts are related to services provided for the fishery, processing and recreational operations, wholesale, retail and restaurant sales of locally caught fish, fishing, harbor tourism, and income re-spent in the community (e.g., income of grocery store owners and health professionals).

8 The change in PFMC's methodology limits comparable data to the last six years. However, we cannot compare data from 2012-2015 (drought years) and 2010 or 2011 as the fishery was recovering from the closure during those years.

Figure 3-4.

Boats with Salmon Permits and Salmon Boats Landed 1960-2015.

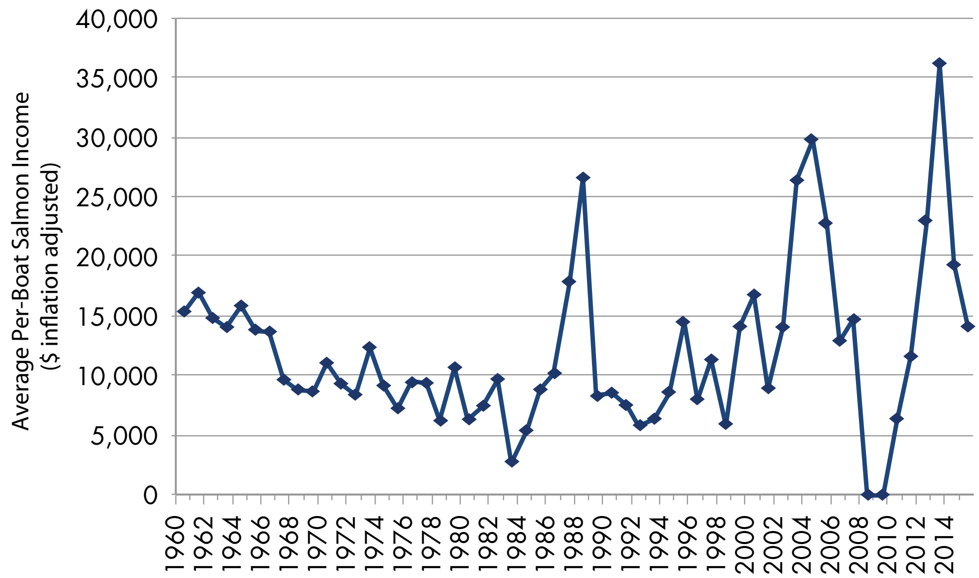


Notes: The Restricted Access Program, which requires all salmon fishermen to have a salmon fishing permit, started in 1980.

Source: PFMC (2016b).

Figure 3-5.

Gross Salmon Income 1960-2015.



Notes: Data only include the value per boat of Coho salmon up to 1991 since Coho salmon harvest has been prohibited in subsequent years. Average income from salmon per boat is based on total exvessel value (i.e., value of salmon at the point to landing) and the number of active fishing boats. Values are expressed in 2015 dollars (inflation adjusted).

Source: PFMC (2016b).

Box 3-1. The Salmon Fishery Through the Lens of Fishing Communities

We interviewed tribal members and four fishermen to gain better insights into broader impacts of the decline in salmon harvests. Summaries of their responses are provided below.

Brittani Orona (Hoopa Valley Tribe, Northern California)

Our whole culture revolves around fish and the watershed. My grandfather likes to say that we are 'River People.' Salmon feed us physically and spiritually. We rely on them for our World Renewal Ceremony by asking spiritual beings to help keep the world in balance and maintain healthy river and fish populations. There has definitely been a change in the rivers since I was young (about 20 years ago). Water quality has gotten worse and flows have reduced. The decline of salmon comes with economic depression, but more importantly it affects our spiritual health and how we live as Hupa people.

Box 3-1 *(Continued).*

The Salmon Fishery Through the Lens of Fishing Communities

Chook-Chook Hillman (Karuk Tribe, Northern California)

Unlike the Yurok and Hoopa Valley tribes, Karuk people do not have recognized tribal salmon fishing rights, and the only authorized fishing location is at Ishi Pishi Falls. Sport fishing licenses are available for sale, but it is a burden for tribal people because they cost money and fishing, to us, is not for sports. We have malnutrition and physical and mental health issues because we cannot be tribal people—being able to continue our traditional way of life.

Dave Bitts (Fisherman from Eureka)

I started fishing about 40 years ago and half of my income on average is from salmon and the other half is from Dungeness crab. I had an epiphany a few years back about the real value of the salmon fishery. We have been consulted when a natural gas industry was going to come in and it could impact the fishery. Having fishermen around gives Humboldt people a sense of place since they can buy fish locally and interact directly with us. It's our identity and we'd be culturally impoverished without the salmon fishery.

Larry Collins (Fisherman from San Francisco)

My wife and I first started fishing in 1983/84 and we were able to raise kids and pay off our house from salmon fishing. We consider fish, crabs, and other seafood as public trust resources and more attention should be given to protecting the fish's habitats. The fishery needs three things to succeed: (1) abundance of fish; (2) market; and (3) infrastructure to move fish to land, such as port, services for fuel and ice. In a bad harvest year, fishermen must live off their savings, and some people might decide to retire altogether.

Mike Ricketts (Fisherman from Monterey)

I have been fishing commercially for 40 years. Fishermen typically have one or two fisheries that they depend on, for example salmon and Dungeness crab. When we have a good salmon season, we fish less crab, and vice versa. Fishermen with a salmon fishing permit might not choose to fish salmon in a bad year because the overhead can be about $10,000 per year to start a boat up and cover the fuel, insurance, and other costs.

Lori French (Fisherman from Morro Bay)

The fishing community has gotten much smaller in Morro Bay and it's also graying out. Fishermen are getting older and the fishery is not attractive enough for younger people to enter. Salmon fishing is so uncertain that younger people don't want to risk it. For us, we are fishermen and we do not really have a backup plan in terms of what to do besides fishing. Typically, our main source of income is 80 percent Dungeness crab and 20 percent salmon, but it was probably 60-70 percent crab and 30-40 percent salmon some 30 years ago.

Impacts of the Drought on Salmon Fishery

Drought is a natural occurrence, and salmon populations in California have survived periods of water scarcity throughout their evolutionary history. The full effects of the current drought are yet to be determined; as of this writing, salmon that hatched and migrated to the ocean during the early part of the drought are just starting to return to spawning grounds. It is likely that alterations to their habitats, migration barriers, and competing uses of water, as mentioned in the previous section, have reduced their resilience to survive extended dry periods.[9] Lower streamflows and higher water temperatures associated with the drought have reduced the amount of cold water available for salmon during key life stages, such as for hatching, migration to the sea, and spawning (Shukla et al. 2015; Seager et al. 2014). Indeed, far fewer Sacramento Chinook salmon reached the ocean during the 2007-2009 drought years than the much wetter 2011 (Michel et al. 2015). Drought conditions, coupled with suboptimal ocean conditions, have also led to very low survival of the juvenile endangered winter-run Chinook salmon in 2014 and 2015 (PFMC 2016a; USBR 2015). These negative impacts likely hold true for the commercially fished salmon runs as well.

Biological stressors further contributed to salmon mortality during droughts. A review of the effects of temperature on salmonids shows that the parasites Ceratomyxa shasta and Ichthyophthirius multifiliis (commonly known as "Ich") are more virulent in warmer water (Carter 2005). The Klamath River system had an Ich outbreak in 2014 (Orcutt 2015), and up to 91 percent of Coho salmon juveniles were infected in 2014 and 2015 (Houston 2016a). Additionally, drought affects the overall health of the ecosystem and the food web that salmon rely on. Food is typically less abundant during drought, and salmon face more competition from invasive fish species that thrive in warm, altered habitats such as reservoirs and ponds (Moyle et al. 2013). The threats to salmon also increase as their predators, such as striped bass, can tolerate warmer water (CDFW 2010). Reduced flows also lead to higher risk of predation for juvenile salmon; less water lowers the turbidity and limits their camouflage ability. There is also less physical space for predator and prey to occupy as deep pools of cool water become shallower and warmer, and riffle stretches of river—important for the construction of salmon spawning nest and incubation—dry up (Tim Sloane, Executive Director, Pacific Coast Federation of Fishermen's Associations, personal communication, Oct. 12, 2016).

Water management decisions during the drought are critical for ensuring sufficient flows and temperature requirements for salmon; however, they have been the subject of debate and litigation following the low survival rate of juvenile winter-run Chinook salmon and mass die-offs of juvenile Coho salmon in 2014 and 2015.[10] For example, in 2015 the National Resources Defense Council and other environmental organizations took legal action against the United States Bureau of Reclamation (USBR), other federal agencies, and Central Valley water districts for not devoting enough water to the endangered winter-run Chinook salmon (Kasler 2015). In 2016, the Hoopa Valley Tribe and a group led by the Yurok Tribe also filed a separate lawsuit against the USBR and

9 See Bisson, Dunham, and Reeves (2009) for more details about freshwater ecosystems and resilience of Pacific salmon.

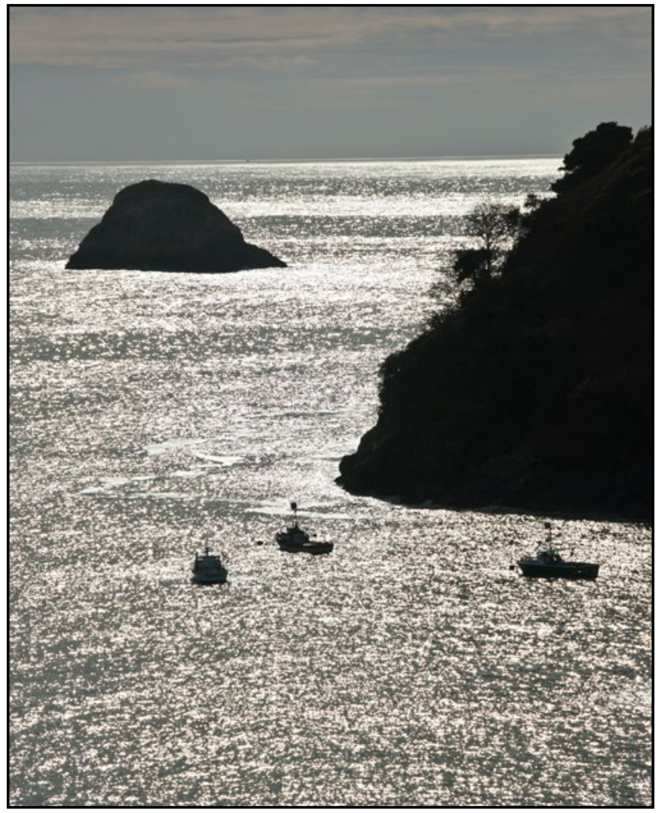
10 Documents regarding Sacramento River Temperature Management can be found on the SWRCB's website. NMFS biological opinions and actions, as well as the USBR's long-term plan for protecting salmon in the Lower Klamath River (and associated comment letters), can be found here and here, respectively.

the National Marine Fisheries Service (NMFS) for contributing to Ich infections and mortality of the endangered Coho salmon (The Eureka Times-Standard 2016; Houston 2016b).

Finally, climate change will likely compound existing problems and accelerate the decline in salmon population. Seasonal duration of lethally-warm stream temperatures at watershed outlets is expected to lengthen and the average annual stream temperature is projected to exceed 75 degrees F earlier in the spring (Null et al. 2013). Moyle et al. (2013) concluded that climate change will increase the vulnerability of spring-run Chinook salmon and Coho salmon in California, and ultimately lead to their total extinction by 2100 if conservation measures are not pursued.

FISHERMEN'S VIEWS OF DROUGHT IMPACTS

Responses from our interviews with salmon fishermen, conducted in October 2016, further revealed some devastating effects of the current drought. Dave Bitts, a fisherman of 40 years from Eureka, recounted that for eight of the 10 years between 1995 and 2004, fishermen could easily catch 50 fish per day. It is now very challenging to catch 10 fish a day and many people have to live off their savings or take on a different job. Lori French, who fishes with her husband in Morro Bay, revealed that during this drought, for the first time in her husband's life, he could not catch any fish in two consecutive days. Mike Ricketts, a fisherman from Monterey, similarly mentioned that conditions have been particularly devastating in the last couple of years. While many salmon fishermen also engage in the Dungeness crab fishery, the postponement and shortening of the crabbing season in late 2015 created a significant economic burden. According to Mike Ricketts, the decline in salmon harvest has also affected infrastructure that supports the fishery, such as fuel docks, ice stores, and markets, making each drought recovery more difficult than the one before. To address these impacts, Larry Collins, a fisherman from San Francisco, highlighted that it is important for the public to think of fish, crabs, and other seafood as public trust resources and give more attention to protecting fish's habitats.



Source: CampPhoto

Tribal Salmon Harvest

TRENDS OF DECLINE EXPERIENCED BY TRIBES

Salmon are an integral part of life for Native Americans in California and the Pacific Northwest (Shilling et al. 2014; Lichatowich 1999; Yoshiyama 1999; Gunther 1926). For centuries, Native Americans have relied on salmon not only as a source of sustenance, but also for its spiritual and cultural significance, as can be seen in the First Salmon Ceremony honoring the relationship between salmon and people (Gunther 1926). Presently, the Yurok and Hoopa Valley Tribes share a federally-reserved right to 50 percent of the

Klamath River Chinook salmon harvest surplus (Pierce 1998).[11]

Subsistence fishing has always been a major part of the tribes' livelihoods, but the current salmon consumption level appears to be much lower than it was historically. Shilling et al. (2014) conducted a survey of 12 tribes throughout California to examine traditional and contemporary fish usage, fishing areas, and barriers to fish use. Results showed that salmon was the most relied-upon fish in the North Coast and was traditionally used by all tribes interviewed, except for the Timbisha Shoshone in the Death Valley area.[12] However, the interviews suggested that use of fish has declined compared to historical rates, and especially more so in recent years.

Other evidence also points to a significant decline in tribal salmon harvest and consumption. The PFMC provides a systematic collection of tribal Chinook salmon harvest data dating back to 1987, although they are quite limited in temporal and geographic scope. From the PFMC's database, we found that the average number of salmon caught by the Yurok and Hoopa tribes combined from 1995-2015 was 21,000 for subsistence and 17,000 for commercial sale (more information on the subsistence and commercial tribal harvests is provided in Appendix 3A). As of 2010, the most recent year for which we have tribal population data, the number of salmon harvested for subsistence would correspond to 10 fish per year for a family of four, or about 20 to 38 pounds of salmon per person per year.[13] This estimate greatly contrasts with pre-contact consumption estimates by Hewes (1973), which indicated that the Yurok and Hoopa Valley tribes were consuming about 365 pounds of salmon per person per year. Fish consumption by the Karuk tribe has also dropped sharply (Table 3-1). A study by Norgaard (2005) showed that the lack of fishing rights, coupled with salmon population declines, impacted the health of members of the Karuk Tribe upstream on the Klamath River. Norgaard found that the Karuk Tribe experienced a loss of livelihood, diet-related illnesses, and poverty when their fish resources become degraded or destroyed. This experience is

11 Indigenous fishing rights allow tribal members to fish for salmon at traditional fishing sites and with traditional equipment, such as gill nets. The Yurok Tribe's allocation is 80 percent and Hoopa Valley Tribe's allocation is 20 percent of the tribal allocation (Pierce 1998).

12 Tribes that have been interviewed by Shilling et al. (2014) include Habematolel Band Pomo, Paiute, Big Valley Band Pomo, Scotts Valley Band Pomo, Kahia Band Pomo, Me-Wuk, Wiyot, Yurok, Yuki, Pit, Pomo, Nomlacki, Concow, Wailaki, Mattole, Northern Paiute, Timbisha Shoshone, Maidu, Mono, Monache, Wintun-Wailaki, Chumash, Chemehuevi, Mohave, Achomawi, and Atsugewi.

13 Authors' calculations based on Yurok and Hoopa Valley Tribal population from the US Census Bureau (2013). Table 19. American Indian and Alaska Native Population by Tribe for California: 2010. Estimated consumption per capita assumes that the dressed weight of salmon (i.e., weight after inedible or undesirable parts have been removed) ranges from 8 to 15 pounds per fish.

Table 3-1.

Estimated Present and Historical Karuk Tribe Fish Consumption

	Tribal Population	Est. Total Fish for Tribe (pounds)	Per Capita (pounds/person/year)
Pre-contact	1,500	675,000	450
Year 2003-04	3,300	<1,000	< 5
Year 2004-05	3,300	< 100	< 0.5

Sources: Adapted from Norgaard (2005). Pre-contact data from Hewes (1973).

likely shared by many Native American tribes in California.

CHALLENGES UNIQUE TO PRESERVING TRADITIONAL PRACTICES

Regulated environmental conditions are responsible for current limits on traditional fish consumption and harvest practices (Shilling et al. 2014). Dam construction, water diversions, and diseases, for example, contribute to the diminishing salmon population, but tribes also face fishing restrictions and many do not have indigenous rights to fish in traditional fishing sites (Chook-Chook Hillman, member of Karuk Tribe, personal communication, Sept. 27, 2016). Illegal, water-intensive marijuana cultivation in Northern California is another driver of reduced flows and environmental degradation. Marijuana's high economic value has attracted some tribal members to work in plantations (Crane-Murdoch 2015; Anderson 2015). These activities increase pesticide pollution in waterways, change the character of the creek, and further compromise water availability for salmon.

Multiple drought years have exacerbated existing problems relating to the overall decline in salmon abundance and the loss of livelihood. According to Chook-Chook Hillman, a Karuk Tribal member, the Klamath salmon runs narrowly escaped a complete collapse when the USBR approved emergency reservoir releases to protect juvenile and spawning salmon (personal communication, Sept. 27, 2016). Tribal activists fight almost annually for "emergency flows," which is especially critical during droughts (Brittani Orona, member of Hoopa Valley Tribe, personal communication, Nov. 23, 2016). As a result, tribes are currently asking for "preventive flows" to ensure the survival of the salmon population, which ultimately links to the survival of traditional cultures. The cultural wealth of tribes depends on the availability of salmon, which members use for ceremonies. When a tribal person cannot catch enough salmon to subsist, he or she must buy, trade, be given fish, or go without. It is highly probable that a continuation of the drought will result in more severe social, economic, and cultural impacts on tribal communities.

CONCLUSIONS AND RECOMMENDATIONS

A complex set of factors have contributed to the widespread decline in California's salmon population. Alterations to habitats, migration barriers, invasive species, and competing uses of water have likely decreased salmon's resilience in the face of extended dry periods. Droughts can impact salmon in many ways, principally via reduced flows and higher water temperatures. They also increase biological stress, lead to disease outbreaks, increase competition from invasive fish species, and augment predation risk. The diminished water supply during droughts intensifies competition for water between user groups, many of which are on unequal playing fields.

The commercial salmon fishery has been experiencing an overall decline, and the salmon fishing community has been shrinking as a result of (1) a downward trend in salmon harvest over the past 40 years; (2) a lack of income security among salmon fishermen; (3) rising costs of fishing (e.g., fishing regulations and cost of inputs); and (4) the decline of infrastructure that supports the fishing fleet (e.g., fuel docks and ice stores). Native American tribes are also significantly impacted by salmon decline, as observed in their harvest and consumption patterns. Tribal salmon consumption was historically much higher than the present level, according to interviews with tribal members and our review of the literature. Tribes face unique challenges to preserve their traditional practices, including dam construction and operations, water diversions, fishing restrictions, the absence of fishing rights, and illegal marijuana cultivation. The ongoing California drought is seen by interviewed tribal members and fishermen as an additional stressor to an already stressed system, causing further decreases in fish harvest and income. For commercial fishermen, impacts contribute to the decline of the fishery and its capacity to remain financially viable. For tribes, the impacts threaten traditional livelihoods and cultural wealth.

RECOMMENDATIONS TO IMPROVE DROUGHT RESILIENCE OF THE SALMON FISHERY

Mitigating Impacts of Drought on Commercially Fished Salmon Runs

3-1. Enhance emergency drought response to protect anadromous populations that are important to fishing communities.

A small number of drought response activities directly address impacts on anadromous fish populations depended upon by tribes and commercial fishing communities. Efforts to ensure the protection of fish listed under the federal and California Endangered Species Act (ESA), such as improving flow conditions for winter-run Sacramento Chinook, may have positive spillover effects on non-threatened species. However, they leave out drought-affected rivers and tributaries that can no longer support threatened and endangered species. Strategies to enhance these responses include an improved management of reservoirs (e.g., on the Sacramento River) to prevent warm water releases that may harm salmon eggs and juveniles; emergency salmon rescue and transportation past compromised stretches of the river to coastal net pens during critical periods; and expanded Voluntary Drought Initiatives that have been carried out by NMFS and CDFW.

3-2. Reduce pressures on critical aquatic ecosystems.

The enforcement of the Reasonable and Beneficial Use Doctrine in California's water rights law is especially important during periods of water scarcity. More monitoring and enforcement activities are needed to prevent illegal water diversions (e.g., for marijuana cultivation). Additionally, statewide water conservation and efficiency measures, as well as expansion of alternative water supplies (e.g., stormwater capture and water recycling), can reduce pressures on critical aquatic ecosystems and, in some instances, improve river flows. Minimum environmental flows should be established and maintained in key waterways, especially during salmon migrating seasons.

3-3. Provide income and/or food assistance and insurance protection for fishing communities during drought emergencies.

Native American tribes and commercial fishermen greatly depend on the salmon fishery. According to interviews with tribal members and salmon fishermen, a poor salmon harvest year can create high economic and cultural burdens on fishing communities. State and federal agencies should recognize the inequitable impacts of the drought on these communities and provide income and/or food assistance during a drought emergency as appropriate. A federally supported fishermen's insurance program, similar to a crop insurance program, might be created as a risk management tool to protect fishermen against loss of income during times of extremely low harvest.

3-4. Build resilience and limit vulnerabilities of the salmon fishery.

Integrated management of water and fishery resources is key to improving the resilience of the salmon population. A statewide strategy for aquatic conservation is needed to coordinate efforts and track results. These efforts include:

- Engaging in physical habitat restoration projects to better approximate natural conditions, such as the San Joaquin River salmon restoration efforts and those outlined in the Golden Gate Salmon Association's Salmon Rebuilding Plan (Golden Gate Salmon Association (GGSA) 2016);
- Creating salmon sanctuaries or stretches of rivers and streams dedicated to salmon conservation;
- Adjusting dam operation and state and federal water projects to ensure minimum environmental flows, maintain water quality, and balance water uses;
- Improving federal and California ESA protections for listed salmonids during times of low water supply to avoid a repeat of the winter-run Chinook salmon's mass die-offs in 2014 and 2015. Such protections are likely to provide indirect benefits for the salmon fishery as well;
- Re-operating fish hatcheries to protect wild salmon population;
- Restoring access to cold-water habitat to improve resilience against droughts, such as creating more fish-friendly waterways and fish passage facilities; and
- Removing dams that no longer provide enough hydropower to justify operational, maintenance, and environmental costs. These dam removals can increase cold water spawning and rearing habitats for migrating fish. The new Klamath Basin Agreements are a recent example. Signed April 2016, the agreements have created a roadmap for four dam removals on the Klamath River by 2020, while helping irrigators to avoid potentially adverse financial and regulatory impacts from the dam removal.

3-5. Create mechanisms for meaningful and timely tribal engagement with local, regional, state, and federal agencies.

Indigenous communities are known as stewards of the land and the water. They have practiced sustainable management of natural resources for millennia and their perspectives and input should be considered in policy decisions that will ultimately impact their communities, such as dam operations and fishery management. Many government agencies have developed and/or adopted tribal consultation principles and practices with varying degrees of inclusivity and timeliness, but these engagements should be fully institutionalized into relevant agency operations. An example of improving this consultation process is the creation of a tribal policy advisory committee or office within all levels of government that deal with issues impacting Native Americans.

Further Study and Data Collection on the Salmon Fishery and Drought

3-6. Formalize integrated biological and environmental data systems for salmon populations throughout California.

Better and more integrated data is needed to strategize and optimize responses to protect important salmon runs. Current monitoring efforts, especially on non-threatened salmon runs, are limited; these data gaps hinder timely response to changes in flows, temperatures, and other factors that may harm spawning adult and juvenile salmon. Some efforts are already underway to support collaborative and coordinated monitoring activities to improve fish population and watershed health, such as the Klamath Basin Monitoring Program and the California Cooperative Anadromous Fish and Habitat Data Program. However, these programs still leave gaps in temporal and spatial coverage.

Formalizing these efforts would help to maintain consistency and availability of timely data and identify gaps that should be addressed.

3-7. Comprehensively examine drought impacts on the fishery from economic, environmental, and cultural perspectives.

A better understanding of drought impacts on the fishery from economic, environmental, and cultural perspectives can help identify and address inequity issues around fishery and water resource management in California. The declining salmon population is a complex legacy problem through which many factors intersect, including the loss of habitat and environmental degradation. The drought provides an opportunity to draw attention to salmon's diminished resilience to extended dry periods and its implications for fishing communities.

3-8. Evaluate ways to re-operate hatcheries in California to achieve both goals of sustaining commercial fisheries and assisting in the recovery of naturally spawned salmon runs.

Sustainable fishery management depends on genetically-diverse wild fish stock that is resilient and adaptive to the changing environment. However, hatchery fish, which are bred to thrive in hatchery conditions, are known to weaken the genetic makeup of the wild (naturally spawned) fish population as a result of interbreeding (Buhle et al. 2009; Chilcote, Goodson, and Falcy 2011; Araki, Cooper, and Blouin 2009). How can the hatchery be managed and re-operated to limit negative impacts on the wild population while continuing to support the fishery? What are the most effective and cost-efficient approaches? These questions have been explored to some extent and continued research is needed to improve the health of the fisheries.

3-9. Assess the use and effectiveness of instream flow regulations to protect the salmon population.

At present, much of the research on the impact of instream flows on salmon populations focuses on endangered and threatened species. Management decisions can be made more effective through a better understanding of the relationship between flows and fish populations that are harvested for subsistence, sale, or recreation. For example, pulse flows may be used as a measure to assist in salmon migration during a drought period. Further research is needed to understand flow-migration relationships on a per-tributary basis and to assess the effectiveness of flow regulation measures.

3-10. Examine potential impacts on stock sustainability and socioeconomic implications of expanding reserved indigenous fishing rights.

Native American tribes have relied on salmon for food and cultural uses for millennia, but only two out of over a hundred tribes have reserved rights to fish in traditional sites with traditional equipment. The issue of equity and fairness of fishery access should be explored with considerations to potential impacts on fish stocks as well as tribes and other groups with recognized fishing rights.

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APPENDIX INTRODUCTION A

DROUGHT AND EQUITY ADVISORY COMMITTEE MEMBERS AND ORGANIZATION PROFILES

Sara Aminzadeh, *Executive Director, California Coastkeeper Alliance*

Colin Bailey, *Executive Director, Environmental Justice Coalition for Water*

Carolina Balazs, *Visiting Scholar, University of California, Berkeley*

Wendy Broley, *Staff Engineer, California Urban Water Agencies*

Amanda Fencl, *PhD Student, University of California, Davis Center for Environmental Policy and Behavior*

Kelsey Hinton, *Program Associate, Community Water Center*

Gita Kapahi, Director, *Office of Public Participation, State Water Resources Control Board*

Brittani Orona, *Environmental Justice and Tribal Affairs Specialist and Native American Studies Doctoral Student, University of California, Davis*

Brian Pompeii, *Lecturer, California Polytechnic State University, San Luis Obispo*

Tim Sloane, *Executive Director, Institute for Fisheries Resources*

SARA AMINZADEH

As the Executive Director of California Coastkeeper Alliance (CCKA), Sara Aminzadeh develops and executes campaigns to ensure swimmable, fishable, drinkable waters for California's communities and watersheds, in concert with locally-based California Waterkeepers. In addition to her policy work as an attorney and advocate, Sara creates and mobilizes new coalitions for clean water. Sara founded and directs CCKA's Blue Business Council, the California business network for clean water, and the California Water Partnership, a coalition of environmental and environmental justice organizations dedicated to securing a sustainable and equitable water future for California. Sara frequently writes about human rights and climate change issues, most recently authoring a chapter Rising to the Challenge: California Climate Change Adaptation in the 2014 Oxford University textbook, Climate Change Impacts on Ocean and Coastal Law. Sara holds a Bachelor of Arts (BA) in environmental studies and political science from the University of California, Santa Barbara, and a Juris Doctor (JD) from the University of California, Hastings College of the Law.

California Coastkeeper Alliance

California Coastkeeper Alliance was founded in 1999 with the belief that a healthy ocean and coast and clean water is vital to California's economy, public health, and way of life. California Coastkeeper Alliance and California Waterkeeper organizations are members of the international Waterkeeper Alliance, a network of water advocates with more than 200 programs in 21 countries on 6 continents led by Robert F. Kennedy Jr. Using law, policy, science, and creative media, CCKA is an experienced advocate that advances statewide policies and programs for healthy and clean waters. CCKA and local Waterkeeper groups develop, implement and defend policies that meet the needs of California's distinct communities and ecosystems. Together, CCKA and its network of Waterkeepers provide the public with the tools and information needed to hold decision-makers accountable and to be effective local water stewards.

COLIN BAILEY

Colin Bailey is the Executive Director of the Environmental Justice Coalition for Water and is based in Sacramento, California. He is fluent in English and conversant in Spanish. He has his Juris Doctorate from UCLA with a certificate from the Program in Public Interest Law and Policy and a concentration in Critical Race Studies. An accomplished social justice attorney, Colin leads EJCW's effort to implement the human right to water and supports EJCW's statewide policy agenda, programs, outreach and education, and grassroots member organizations.In addition, he leads EJCW's work with the Environmental Water Caucus, Community Engineering Corps, Ecological Society of America, Sacramento Valley Water Justice Network, US Human Rights Network, and more.

The Environmental Justice Coalition for Water

The Environmental Justice Coalition for Water (EJCW) works within a Community-to-Capital framework, connecting the most pressing needs of our disadvantaged community partners to our network of partners and agencies statewide. Since 1999, EJCW's work has been rooted in the communities most affected by environmental injustice. Issues and solutions are identified through regional chapters and statewide work groups. EJCW is positioned in the state capital, in order to connect communities with state agencies to bring about change multilaterally through advocacy, education, training, litigation, community organizing, and capacity-building, and by providing technical assistance. EJCW aims to effectively influence the intersections of water justice and environmental justice, community health, and human rights issues from community to global levels.

CAROLINA BALAZS

Carolina has been a UC President's Post-Doctoral Fellow at the University of California, Davis (UC Davis), bridging the academic-community water justice research community. She is also a consulting Research Scientist with California Environmental Protection Agency's Office of Environmental Health Hazards Assessment (OEHHA). At OEHHA, she is leading the development of a "Human Right to Water" tracking tool for the state of California. Her doctoral research examined drinking water quality problems in California's Central Valley and the environmental justice implications. Following graduate school, Carolina worked as a Research Scientist at the Community Water Center, promoting community-based participatory research and developing community-led water justice solutions. She holds a Bachelor of Science (BS) in Environmental Science from Brown University and both a Master of Science (MS) and Doctor of Philosophy (PhD) from the Energy and Resources Group at the University of California, Berkeley (UC Berkeley).

WENDY BROLEY

Wendy Broley is staff engineer at California Urban Water Agencies (CUWA) and Water Reuse Leader at Brown and Caldwell. Wendy is a licensed professional engineer with over 14 years of experience in water and wastewater engineering and operations, membrane technology and biosolids solutions, as well as business development for both municipal and industrial markets. She is committed to the development of a diverse and resilient water portfolio for her clients using an integrated "One Water" approach to water management. With a specific focus on transforming the perception of wastewater treatment plants into "resource recovery facilities," Wendy has stepped into the role as Water Reuse Leader at Brown and Caldwell. Wendy started her career as a consulting engineer supporting the membrane operations of multiple advanced water treatment facilities for indirect potable reuse applications totaling over 100 MGD of production capacity. Mrs. Broley holds a BS in Chemical Engineering from University of California, San Diego (UCSD).

California Urban Water Agencies

CUWA's mission is to provide a forum for combining the expertise and resources of its member agencies to advance reliable, high-quality water supplies for the State's current and future urban water needs in a cost-effective manner for the public, the environment and the economy. CUWA's efforts are guided by its 11 member agencies and supported by an Executive Director. Member agencies' resources are pooled to study water management issues, develop consensus solutions among the urban water community, and engage with California water leaders.

AMANDA FENCL

Amanda Fencl has been a member of the Center for Environmental Policy and Behavior (CEPB) for four years as a PhD student in the University of California, Davis Geography Graduate Group. Her dissertation explores the ways that drought can exacerbate California's drinking water disparities. As a PhD student she interned with the Governor's Office of Planning and Research (OPR) on drought policy, and assists OPR's Local Drought Liaison with a project on household water shortages and drought vulnerability. Since summer 2015, she has worked with Dr. Julia Ekstrom at the University of California, Davis Policy Institute's Climate Adaptation Initiative to look at extreme event impacts on California's drinking water quality. She and Dr. Ekstrom have a state grant to understand drought impacts on and responses of small, self-sufficient drinking water systems. Her dissertation is supported through a National Science Foundation (NSF) Graduate Research Fellowship (2015-2018), a NSF Climate Change, Water and Society IGERT (2013-2015) traineeship, and University of California, Davis research grants. She was a Staff Scientist at the U.S. Center of the Stockholm Environment Institute (SEI) for 6 years and has a BA in International Relations and Environmental Studies from Tufts University.

Center for Environmental Policy and Behavior

The mission of the CEPB is scientific analysis of the interactions among policy institutions, human behavior, and political decisions in the context of environmental and natural resource conflicts. Through developing and testing theoretical models from social science, CEPB seeks to derive practical lessons that can be used to improve environmental policy. We focus on a wide variety of environmental problems and issues, including watershed management, climate change, forest management, marine/coastal systems, biodiversity, and agriculture. The CEPB team includes an actively engaged group of faculty and graduate students who come from diverse backgrounds. CEPB is co-directed by Dr. Mark Lubell and Dr. Gwen Arnold, housed in the Department of Environmental Science and Policy at University of California, Davis, and affiliated with researchers from other academic universities, government agencies, and other University of California, Davis programs and departments.

KELSEY HINTON

AKelsey Hinton joined the Community Water Center (CWC) in 2015. As the former AmeriCorps Fellow, now Program Associate, Kelsey works to build the capacity of CWC through communications, fund development and policy work in order to improve and expand programs to provide disadvantaged communities with access to safe and affordable drinking water. An Indiana native, Kelsey recently graduated from Indiana University's School of Public and Environmental Affairs (SPEA) with a degree in Environmental Management. Her senior thesis focused on the feasibility of direct potable water reuse in Las Vegas. She is currently pursuing her Master's of Public Affairs (MPA) with a concentration in Policy Analysis at SPEA and will graduate in May 2017.

Community Water Center

The CWC is a non-profit environmental justice organization based in California's San Joaquin Valley, whose mission is to act as a catalyst for community-driven water solutions through organizing, education, and advocacy. CWC's fundamental goal is to ensure that all communities have access to safe, clean, and affordable water. CWC helps build strategic grassroots capacity to address water challenges in small, rural, low-income communities and communities of color. For more information, visit CWC's website at www.communitywatercenter.org and follow us on Twitter at @CWaterC.

GITA KAPAHI

Gita Kapahi is the Director of the Office of Public Participation (OPP) for the State Water Resources Control Board (SWRCB), and has been since the office was created in late 2007. In this office she serves in many capacities, including ombudsman, tribal liaison, environmental justice coordinator, small business liaison, agricultural liaison, education and outreach coordinator, facilitator, and public participation consultant. She has been with the SWRCB for 24 years, first as an Environmental Scientist in the Division of Water Quality, then in the Division of Water Rights, serving as Chief of the Bay Delta Unit. Prior to that, she was a fisheries consultant to the Canadian Department of Fisheries and Oceans.

Office of Public Participation, California State Resources Water Board

The OPP responds to public inquiries about SWRCB programs. The SWRCB created this program to strengthen our efforts at involving the public in our decision-making process. The office intends to reach out to environmental justice and other communities and have better communication and interaction with tribal governments and others. Additionally the office will assist staff with designing and implementing effective stakeholder involvement processes, including translation and other services, to ensure all interested parties can participate in SWRCB activities.

BRITTANI ORONA

Brittani is an enrolled member of the Hoopa Valley Tribe. She graduated with a BA in History from Humboldt State University, has an MA in Public History from California State University Sacramento, and is currently a doctoral student at University of California, Davis in Native American Studies with a Designated Emphasis on Human Rights. Her research focuses on indigenous memory and meaning in land use and environmental justice initiatives in California. Brittani helped to coordinate an exhibit and oral history project about the removal of four PacifiCorp dams on the Klamath River. She has also acted as an exhibit consultant for the Autry Museum of the American West, the Maidu Museum and Historic Site, and the Goudi'ni Native American Arts Gallery at Humboldt State University on exhibits related to environmental justice and water rights. Brittani has worked at the California Government Operations Agency, California State Indian Museum, the California State Office of Historic Preservation, California State Archives, and the Maidu Museum and Historic Site.

BRIAN POMPEII

Brian Pompeii is a human-environmental geographer at California Polytechnic State University, San Luis Obispo (Cal Poly) with research interests in water resources, sustainability, vulnerability, hazards, and climate adaptation. His current research project explores how drought-strained surface water access has led to an increase in groundwater usage for industrial agriculture, and subsequently a disaster-level increase in domestic well failure in disadvantaged unincorporated communities in the San Joaquin Valley of California. He received his PhD in Geography from Arizona State University.

California Polytechnic State University, San Luis Obispo

Cal Poly is a nationally ranked, four-year, comprehensive public university located in San Luis Obispo, halfway between San Francisco and Los Angeles on California's Central Coast. It is a distinctive learning community offering academically focused students a hands-on educational experience that prepares them for today's scientific and technical world.

INSTITUTE FOR FISHERIES RESOURCES

TIM SLOANE

Tim is Executive Director for the Institute for Fisheries Resources (IFR), having begun his career with IFR and its sister organization, the Pacific Coast Federation of Fishermen's Associations (PCFFA), under the direction of William F. "Zeke" Grader, Jr. He advocates for clean, sustainable, and productive fisheries, protection of aquatic habitat, and workable fisheries management legislation. He is a member of the Marine Fish Conservation Network's National Policy Committee, and holds a seat on the Golden Gate Salmon Association Board of Directors. He received his BA in history from University of California, Berkeley, and a JD from Golden Gate University with a certificate in environmental law. He is a member of the State Bar of California.

Institute of Fisheries Resources

Established in 1993 by the PCFFA, IFR is responsible for carrying out the fishery research and conservation needs of working fishing men and women. Initially, IFR helped fishermen in California and the Pacific Northwest address salmon protection and restoration issues, with particular focus on dam, water diversion, and forestry concerns. Since 1998, IFR's range of programs has greatly expanded to encompass conservation projects and policy debates at the regional, national, and international levels. The IFR is dedicated to the protection and restoration of fish resources and the human economies that depend on them. By establishing alliances among fishing men and women, government agencies, and concerned citizens, IFR unites resource stakeholders, protects fish populations, and restores aquatic habitats.

The Environmental Justice Coalition for Water

Water Justice for All

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