CLIMATE CHANGE

It's here and it's real, what does it mean for our angling future?

Climate change has already begun to alter our nation's lakes and rivers in many of the places you love to fish. Physical and biological systems are responding in kind. As precipitation patterns change and snow melts earlier, watersheds become drier and wildfires grow in frequency and intensity. Peak stream flows occur earlier in the year, base flows are lower, and aquatic insects and fish change their behaviors. This fact sheet describes some of the observed changes that are especially relevant to our coldwater fishery resources.

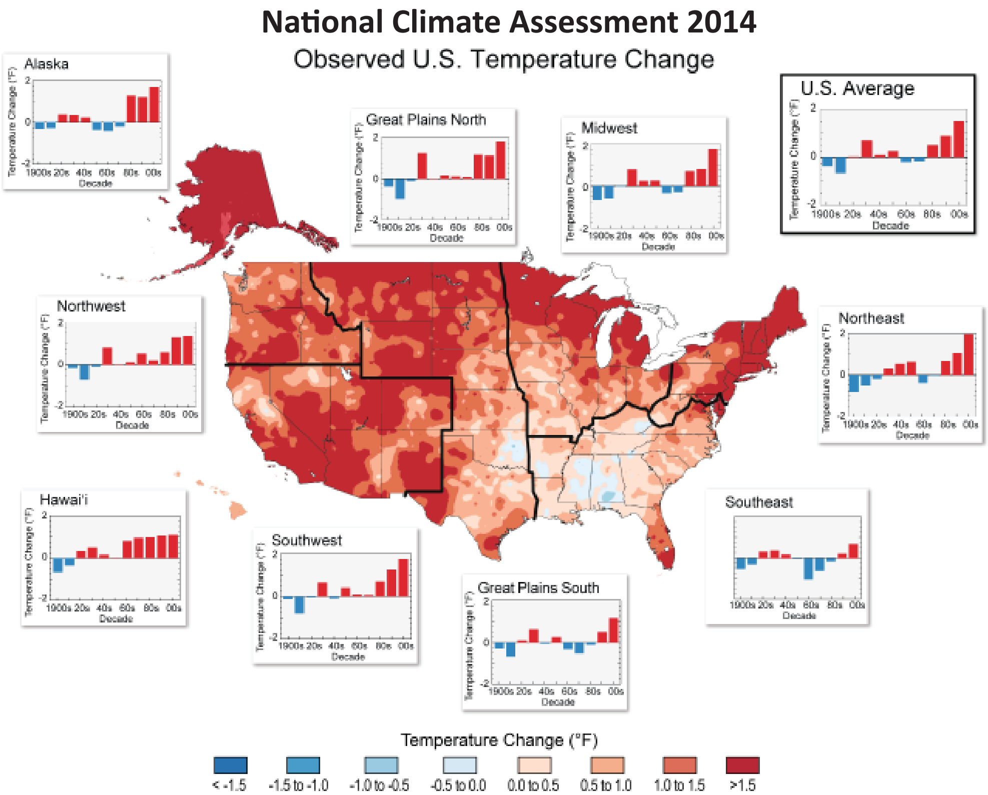

Fig 1. Across the U.S., temperatures have increased steadily since 1900.

GLOBAL WARMING

Air temperatures around the globe have increased significantly in recent years. According to the Intergovernmental Panel on Climate Change's latest report (IPCC), "Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The period from 1983 to 2012 was very likely the warmest 30-year period of the last 800 years in the Northern Hemisphere… and likely the warmest 30-year period of the last 1400 years".[1] The U.S. is no exception to these trends. "U.S. average temperature has increased by 1.3°F to 1.9°F since record keeping began in 1895; most of this increase has occurred since about 1970. The most recent decade was the nation's warmest on record"[2] (Fig 1).

TROUT UNLIMITED

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BOULDER GLACIER: GLACIER NATIONAL PARK

Fig 4a. photo by George Grant and courtesy of Glacier National Park Archives.

Fig 4b. photo by Jerry DeSanto and courtesy of K . Ross Toole Archives.

INCREASING TEMPERATURE AND DROUGHT: A TOUGH COMBINATION

For many parts of the western U.S., drought and increasing air temperature are spelling trouble for trout. Many rivers like the Madison approach stressful temperatures more frequently (Fig 2). Further south, TU biologists experience stream drying before their eyes in Lahontan cutthroat trout territory (Fig 3). Habitat for the Rio Grande cutthroat trout is being hit particularly hard by drought. According to recent surveys by scientists at the US Geological Survey and New Mexico State University, nearly two-thirds of remaining Rio Grande cutthroat trout populations in Colorado and New Mexico survive in streams with baseflows of less than 1 cfs.[3] Stream habitats are literally disappearing as extreme and persistent drought grips the region.

GLACIERS

Glaciers are disappearing across the West, and with them, the cold melt-water on which native trout such as bull trout and westslope cutthroat depend. At the current melt rate, glaciers will have disappeared from Glacier National Park by 2030, which will directly affect downstream fisheries (Fig 4a & 4b). Bull trout are responding by moving upstream.[4]

DRYING FORESTS & WILDFIRE

Since the mid-1980s as forests have dried and tree mortality has increased[5], there has been a marked increase in the duration and intensity of wildfires in the western U.S.[6] A recent study[7] estimates "human caused climate change contributed to an additional 4.2 million ha of forest fire area during 1984–2015, nearly doubling the forest fire area expected in its absence". While fire is a natural part of the western ecosystem in which fish have evolved, populations already affected by multiple human-induced stressors (barriers to movement, degraded habitats, non-native species) are less equipped to handle this changing environment.

Wildfires have been a common feature in the evolution of southwestern forests, but in recent years, the scope and intensity of wildfires have been unprecedented. In 2012, the Whitewater-Baldy Fire Complex roared through the core of remaining Gila trout habitat in New Mexico and destroyed several populations. Figure 5 shows the perimeter of the Whitewater-Baldy fire and remnant populations of Gila trout (yellow labels) and restored populations (white labels). The Whitewater-Baldy would become the largest wildfire in New Mexico history. In just the previous year, 2011, the Wallow Fire burned more than 841 sq. miles in Arizona and New Mexico, becoming the largest wildfire in Arizona history, and burning significant parts of Apache trout habitat on the Apache-Sitgreaves National Forest.

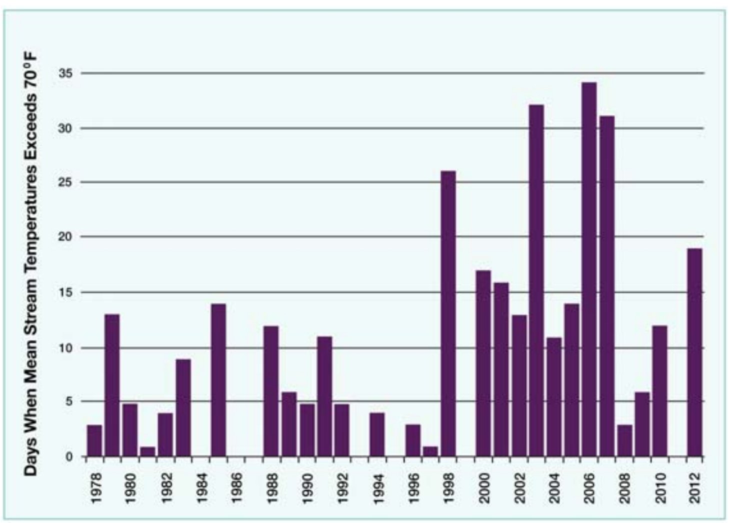

Fig 2. Increasing number of days when mean stream temperature exceeds 70° Fahrenheit in the Madison River near McAllister, Montana. Data courtesy USGS.

Fig 3. TU's field crew experiences stream drying as they attempt to sample Lahontan cutthroat trout.

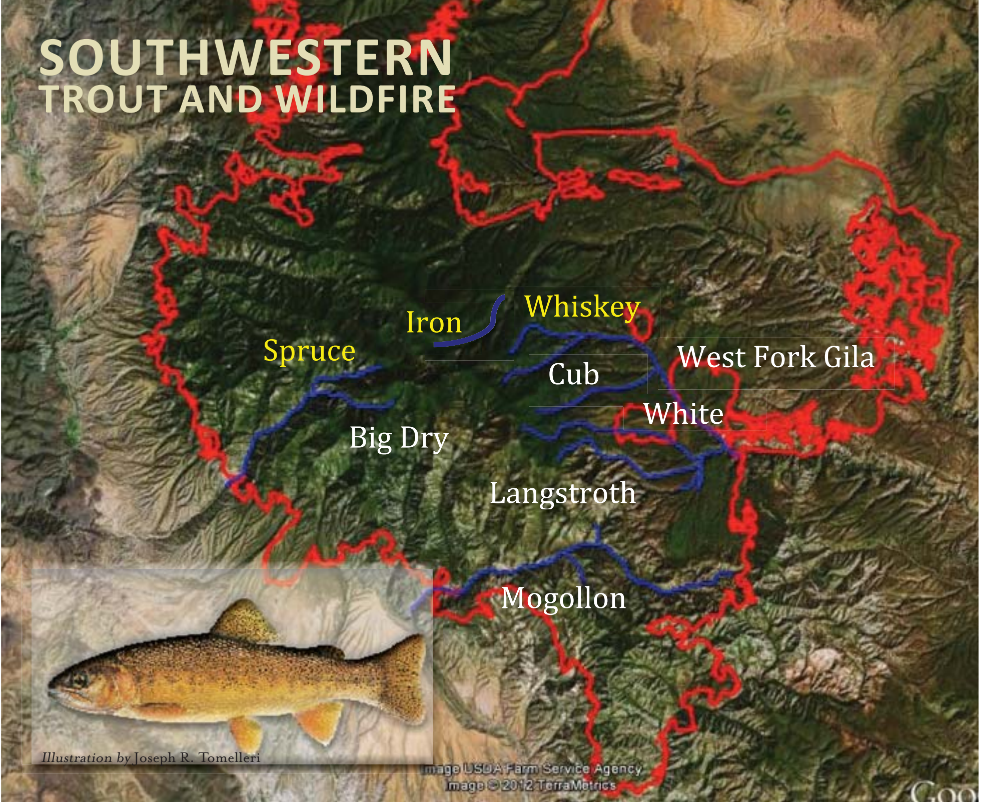

Fig 5. 2012 Whitewater-Baldy Fire Complex threaten Gila trout populations in New Mexico.

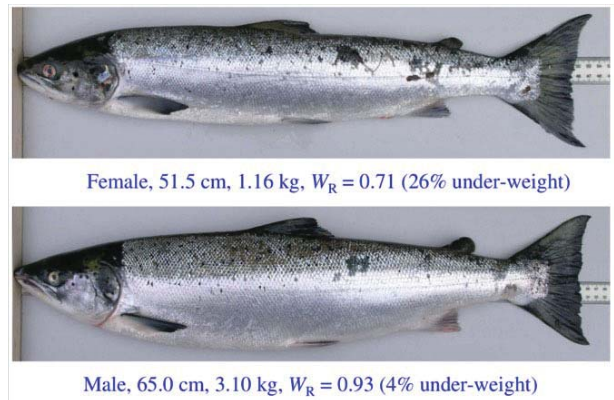

Fig 6. Atlantic salmon returning to Scotland are shrinking as ocean temperatures warm. The female at top is 26% underweight - typical of the "skinny grilse" returning in recent years - whereas the male at bottom fits the longer-term norm for body condition[6].

Fig 7. A normal pteropod (left), contrasted with a pteropod (right) with a weakend shell which was exposed to increased CO_2 levels in a lab to mimic conditions observed in the wild[7].

OCEAN WARMING AND ACIDIFICATION

As global temperatures rise, our oceans are also warming, affecting entire marine ecosystems. Altantic salmon abundances have declined over the past 30 years and returning fish have increasingly poor body condition, with more "skinny grilse" being observed in recent years[8] (Fig 6).

Carbon dioxide emissions are not only warming but also acidifying our oceans. In the Pacific Ocean, the shells of tiny 'sea butterflies', or pteropods, which are an essential food source for ocean-migrating salmon, are literally being eaten away by increasingly acidic waters[9] (Fig 7). Acidification has also been attributed to recent commercial shellfish recruitment failures in the Pacific Northwest.

CHANGING BEHAVIORAL & LIFE HISTORY PATTERNS

Many aquatic species time their behaviors and life history patterns in relation to runoff, peak flows and changing water temperature. The timing of aquatic insect emergence, for example, is changing with earlier peak flows as snow melts earlier. The common stream mayfly, *Baetis*, has begun emerging earlier as a result of drought and warming water in Rocky Mountain streams[10] (Fig 8). Eastern native brook trout are also showing evidence of climate impacts, with delayed fall spawn-timing and fewer redds being constructed as temperatures increase.[11] Studies of salmon species have documented shifts to match changing stream flows and temperatures. A recent study of pink salmon in Alaska documents that average migration time is almost two weeks earlier than 40 years ago.[12] Changes in genetic characteristics point to selection against late migrators, suggesting the change is not just behavioral but that this population is actually evolving toward earlier migration timing.

AN UNCERTAIN FUTURE

While studies such as these give some insights into how fish and other organisms may be able to adapt to climate change, the outlook for most species that depend on coldwater systems is grim. Cutthroat trout across the West, for example, are expected to lose more than 50% of their remaining habitat by 2080.[13] The vital question still unanswered is if and how all the necessary moving parts – like flows, temperature, insect emergence and salmon migrations, and thermal tolerance – will come together as the pace of climate change quickens.

Fig 8. *Baetis bicaudatus* male imago, Rocky Mountain Biological Laboratory. Photo credit: Angus R. McIntosh[8].

A CALL FOR ACTION

One way to address the impacts of climate change is through adaptation projects that increase the resistance and resilience of stream systems.[14] Restoration projects that TU undertakes to restore degraded riparian areas, reconnect fragmented streams, and reduce stressors such as livestock grazing and invasive species help build resilience. Our collaborative work on streams in northern Nevada (Fig 9) is a good example. In California, TU is restoring high-elevation wet meadows and riparian habitats in an effort to keep rainfall at higher elevation for longer periods and reduce the effects of less snowpack. Dam removal in places like the Elwha and Penobscot increase resilience by expanding populations and available habitat. We need more adaptation projects, not only to help our trout and salmon survive rapid climate change but also to buy society time to find more lasting solutions.

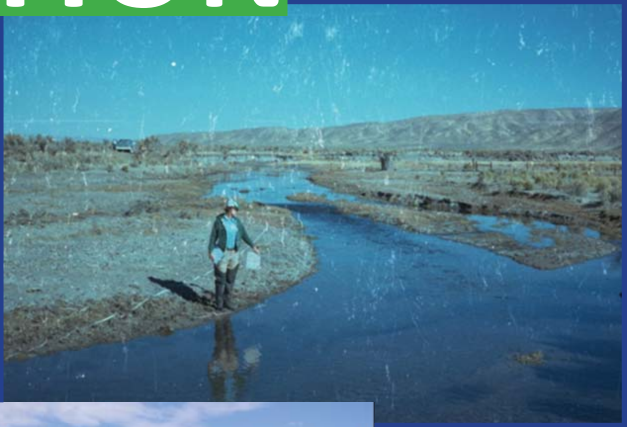

Fig 9. BLM monitoring photos of the mainstem Maggie Creek, NV, in 1980 and 2011 show obvious improvements in stream ponding, bank stability and vegetation, all of which have increased water retention and decreased sedimentation. These habitat improvements, largely due to improved grazing practices, and reconnecting the three main tributaries via culvert remediation, have benefited Lahontan cutthroat trout, which can now move throughout the system.

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