Straightforward Answers to Straightforward Questions

regarding

Oregon's Water Temperature Standard and its Application: Causes, Consequences, and Controversies Associated with Stream Temperature

An excerpt from:

Independent Multidisciplinary Science Team. 2004. Oregon's Water Temperature Standard and its Application: Causes, Consequences, and Controversies Associated with Stream Temperature. Technical Report 2004-1 to the Oregon Plan for Salmon and Watersheds, Oregon Watershed Enhancement Board, Salem, Oregon (pp. 14-20).

Full report is available at http://www.fsl.orst.edu/imst.

STRAIGHTFORWARD ANSWERS TO STRAIGHTFORWARD QUESTIONS

Here, we give short answers to questions that are asked frequently about stream temperature and Oregon's temperature standards. For more detailed information, see the main body of this report[1].

1. What is the purpose of Oregon's water quality standards?

The purpose of water quality standards is to formally describe the level of water quality necessary to protect aquatic life and desired human uses of water bodies. The Clean Water Act is a federal law, but it delegates authority to states and tribes to set water quality standards appropriate to their areas. The standards include 1) descriptions of the aspects of water quality to be protected (beneficial uses) and 2) thresholds that indicate potential problems in water bodies (water quality criteria). In simple terms, the criteria serve as a signal to warn that aquatic health may be problematic. As we describe in more detail later, once a stream passes these thresholds, the state or tribes can begin to examine: 1) if there is a problem, 2) potential causes of the problem, and 3) what actions can be taken to protect aquatic life and human use of streams. The purpose of the water quality standards is not to punish individual landowners, but to indicate when a stream may no longer be able to support beneficial uses and where different management practices may be needed to improve water quality.

2. Are temperature standards the most critical part of Oregon's management of water quality related to temperature?

No. The most important part of Oregon's water quality management is what happens on the ground---the many actions of citizens that influence the environment and water temperature. Standards establish a framework to protect water quality, and assist in the evaluation of watershed conditions and appropriate management actions.

Management actions are generally determined by community or watershed planning processes and guided by regulation. Regulations have been effective for controlling discharges from pipes. However, community involvement and coordinated management are essential to minimize temperature increases from cumulative ("non-point") sources across Oregon's landscape. Developing an analysis of the sources of elevated temperature (a "TMDL") and a water quality management plan for a basin are the most critical steps in the process leading to actual land management.

3. What is the TMDL process?

The term total maximum daily load (TMDL) was derived from the idea that one could calculate the maximum amount of a pollutant that could be added to a lake or stream without causing harm to aquatic life and human uses. This total amount could then be divided up, or allocated, among all polluters. In the case of stream temperature, heat is considered the pollutant that is added to a stream through human activities and land use.

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In order to allocate allowable levels of each pollutant, the State carries out a multiple step process. This "TMDL process" is based on community involvement, development of local information, and application of sound scientific tools. The TMDL process is designed to apply water quality standards to the landscape through three steps. DEQ:

- Compiles a list of stream segments with impaired water quality needing TMDLs,
- Prioritizes watersheds for TMDL development, and
- Works with stakeholders to develop a TMDL analysis and a water quality management plan for each watershed (EPA 2003b).

4. What are Oregon's temperature standards?
Oregon revised its temperature standards in December 2003. The standards are designed to protect salmonids and other aquatic life. Water bodies must not be warmer than:
- 16.0 ºC (60.8 ºF) for core cold water habitat use,
- 18 ºC (64.4 ºF) for salmon and trout rearing and migration,
- 20 ºC (68 ºF) for migration corridor use,
- 20 ºC (68 ºF) for redband trout (*Oncorhynchus mykiss* subspecies)and Lahontan cutthroat trout (*O. clarki henshawi*) use,
- 13 ºC (55.4 ºF) for salmonid spawning, egg incubation, and fry emergence,
- .12 ºC (53.6 ºF) for native Oregon bull trout (*Salvelinus confluentus*) spawning and rearing, and
- 16.0 ºC (60.8 ºF) for native Oregon bull trout migration, foraging and sub-adult rearing.

The numbers are based on the different temperature requirements of salmonids during different seasons and life stages. The State has specified both times and locations where the standards apply on maps and in tables.

For other waters, the standards also limit the increase in temperature allowed from human activity to 0.3 ºC (0.5 ºF). These rules apply to:
- Natural lakes,
- Oceans and bays,
- Waters that support cool water species, and
- Designated rivers and streams that are colder than the numeric standards above and are important to endangered and threatened species.

The standards also describe how the State will implement the standards and how to treat streams that are "naturally" warmer than the criteria (see more discussion in No. 17). There are exclusions from the standards in cases of extremely low streamflow or high air temperatures. The standards also allow a small increase (0.3 ºC; 0.5 ºF) in water temperature caused by human activities. The exact language of the standards can be found on the Department of Environmental Quality web site at http://www.deq.state.or.us/wq/standards/WQStdsTemp.htm.

5. Are Oregon's temperature standards (1996 and 2003) scientifically sound?
Yes. Oregon's 1996, and now the 2003, temperature standards are based on several technical reviews by regional and national scientists. Reviews since the development of the 1996 standards

have only added additional support. Standards are reviewed and revised on a regular basis to incorporate more recent scientific information. The revision and adoption of new standards by the Oregon Environmental Quality Commission is an appropriate step to keep water quality standards up to date with the current state of knowledge. While there are many questions about how to best implement the standards, the standards are scientifically sound and provide a reasonable framework for developing watershed management plans. Oregon's TMDL process and temperature standards are some of the most well-reasoned and well-developed approaches in the United States. We conclude that the standards were based on the best science available at the time.

6. How can trout and salmon live in streams that exceed the criteria in Oregon's water temperature standards?
Trout and salmon can exist in water ranging from just above freezing to 75°F (~24°C) depending on how long they are exposed. Some salmonids can even survive temperatures above 75°F for short periods of time. This means they can survive, but short-term survival is not the same as growing and reproducing effectively. For example, people can tolerate extreme heat in a hot tub or sauna for a short time period, perhaps up to a few hours. If a person had to stay in a hot sauna for days or weeks, their health would be threatened. Similarly, people could survive for days, perhaps longer, at air temperatures well over 100° F (~38°C), yet they could not perform life-sustaining work for any period of time. Similarly, salmonids can persist for extended periods of time in warm streams, but are extremely vulnerable to other threats.

Temperatures in the high 60s to mid-70s ºF [approximately 18–24 ºC] can harm salmon and trout. More food is required and growth can be decreased, ability to compete with warm water fish is reduced, and risk of predation is increased. In addition, fish are more susceptible to disease and stress at high temperatures. Salmonids also sometimes avoid the highest temperature water in the stream. Just as people will sit in the shade on a hot day, salmon and trout are often found in colder portions of the streams (deep pools, close to the bottom, near cooler seeps and tributaries). Oregon's temperature standards include provisions to protect these "coldwater refugia".

Some evidence suggests that fish can cope with high temperatures if the daily highs do not persist too long and/or the daily lows are sufficiently low; however, the ways fish adapt to or cope with fluctuating temperatures are not yet well understood.

7. Other than fish, why is stream temperature an important ecological issue?
Stream temperatures are often seen as primarily directed at fish -- but in reality are a surrogate to overall stream health. Temperature influences many processes in a stream, including nutrient cycling and productivity. Temperature is also important because it influences the metabolic rates and physiology of aquatic organisms, including fish. In addition, cold water is able to absorb more oxygen than is warmer water; therefore, the question of oxygen-richness of water is directly linked to water temperature. Likewise, many processes influence temperature. For example, elevated temperatures are often linked with other signs of stream degradation including loss of riparian vegetation and wider than expected stream channels.

8. What environmental factors affect stream temperature?
There are a number of physical and biological features that influence water temperature: shade, streamflow, elevation, subsurface water flows, wind, climate and weather (e.g., air temperature, humidity, cloud cover), time of year (day length and sun angles), watershed orientation, and streambank entrenchment.

9. Which of these factors are influenced by human actions?
People change stream temperatures either at single points (e.g., warm water from pipe discharges into streams) or by human activities that accumulate over larger areas such as watersheds. In this second category, people affect stream temperatures by 1) altering the shade and vegetation along a stream, 2) changing the width and depth of a channel, 3) changing the amount of flow in the stream, and 4) altering the exchange between the surface water in the stream and the water flowing through its streambed and banks.

10. Do land uses (urbanization, agriculture, forestry, livestock grazing) influence stream temperature?
Yes. All of these land uses, depending upon where and how practiced, typically affect the four factors listed in the previous question, and therefore influence stream temperature.

11. Does shade from riparian vegetation influence stream temperatures?
Yes. IMST looked for every possible "real-world" experimental study on the influence of removing riparian vegetation on stream temperature. Of the 48 studies we found, 45 showed that when you removed riparian vegetation, stream temperatures increased. In these 44 studies, the stream temperatures increased from as little as 1.09 ºC [2 ºF] to as much as 12.7 ºC [22.9 ºF] after vegetation was removed.

The relative influence of shade on stream temperature is greatest for small streams and decreases as streams increase in width, depth, and velocity. For example, one would not expect riparian vegetation along the Columbia River to significantly influence the temperature of the mainstem river. In fact, most of Oregon's stream miles are made up of small streams. Stream size is taken into account in the analysis of stream temperatures in Oregon's TMDL process.

12. Can shade cool a stream?
No, not directly. Shade cannot cool a stream by physically transferring heat energy from water to the surrounding environment. Water temperatures decrease when heat energy is transferred from the water to the surrounding environment via evaporation (liquid becoming a gas), convection (mass movement of heat within a liquid or gas), and conduction (heat transfer by substances coming in direct contact with each other). Temperature indicates the direction heat energy will move; heat will move from the warmest to the coolest substance. Temperatures will also decrease when heat in the water is diluted by cool water inputs from ground water or precipitation.

The major source of heat added to streams is from solar radiation (both direct and indirect). Shade blocks radiation from reaching the surface of the stream and decreases the amount of heat added to the water. With increasing amounts of heat blocked and not allowed to reach the water's surface, cooling via evaporation, convection, and conduction will be more effective. If shaded reaches are long enough, the amount of heat leaving the stream will be greater than the amount entering the stream, causing water temperatures to decrease. Therefore, shade from riparian vegetation or topography plays a key role in lowering stream temperatures.

13. Can the changes in temperature provided by shade really benefit salmonids?
Yes. The amount of influence shade exerts on salmonid health varies in relation to the combination of features at play on a given day and in a given location. Most studies indicate that removing shade increases stream temperatures by several degrees over the course of 24 hours, and causes wider variation in stream temperatures. These small changes in temperature can affect salmonids, especially if the water temperatures are near the critical point for invertebrate production and/or fish health.

14. In addition to providing shade, what else does riparian vegetation contribute to stream ecosystems?
Vegetation provides a myriad of features germane to stream form and function in addition to providing shade. These features include, but are not limited to:

- Roots that stabilize stream banks and protect the banks from erosion;
- Potential sources of large and small wood for pool formation;
- A source of detritus (decaying material) and terrestrial insects necessary for biological food chains;
- Creation of instream and riparian habitat for fish and other aquatic organisms;
- Encouragement of infiltration of precipitation into soil and groundwater;
- Allows soils to act as a sponge storing water and releasing it later in the season, and
- Encouragement of subsurface water flows and exchange of water in the stream with the area underneath the stream bed (called “hyporheic” exchange);
- Riparian plants that take up nutrients from soil solutions, which is important for maintaining water quality; and
- Creation of temperature and humidity microclimates that slow stream heating.

Riparian areas also provide many critical functions and habitat for wildlife communities and terrestrial ecosystems.

15. Are air temperature and elevation more important than direct solar radiation in determining stream temperature?
No. Solar radiation, both direct and indirect, is the principal energy source that causes stream heating. Air temperature and elevation are only two environmental factors affecting stream temperatures. Solar radiation directly affects air temperatures. Elevation influences the amount of solar radiation reaching the earth’s surface and therefore, air temperatures. Summer air temperatures are often correlated with stream temperatures giving rise to the commonly held belief that air temperatures have a major and direct effect on the warming of streams. However, heat transfer from air to water is a slow process, and yields minimal heat input into the water compared with direct solar radiation. Air temperature influences the exchange of heat between water and air; heat will go from the warmer medium to the cooler medium. Oregon accounts for the effect of elevation when it models and evaluates stream temperatures in the TMDL process.

16. Once a stream is placed on the 303(d) list, can it ever be removed?
Yes. The 303(d) list is composed of all water quality limited waters that do not have a TMDL. The Clean Water Act, a federal law, directs states to create these lists. According to EPA, the federal agency that oversees the Clean Water Act, water bodies can be removed from the 303(d) list for three reasons:

- A TMDL has been developed for those waters;
- New information concludes that the listing was inaccurate; or
- A formal analysis proves that a designated use in a particular water body is inappropriate. In this case, the designated use is then changed.

Generally, once EPA approves a TMDL document, streams in that watershed are no longer listed on the 303(d) list. However, streams and stream segments are considered to be water quality limited until they meet all criteria in the State's water quality standards (temperature being just one set of criteria). DEQ continues to track all water quality limited streams in its Integrated Report.

17. How does DEQ treat streams that are naturally warmer than the criteria in the water temperature standards?
When carrying out the Clean Water Act, a stream that was historically naturally warmer than the temperature criteria does not need to be restored to a temperature lower than the natural conditions.

DEQ estimates natural conditions – or the range of temperatures before human influence – from current data, historical data, and stream temperature modeling. DEQ uses modeling because historical temperature data are often very scarce. The agency uses a model called Heat Source, and conducts its analysis when creating a TMDL for each basin. If DEQ determines that a stream was naturally warmer than the temperature criteria, the agency no longer considers the stream to be in violation of the standards. The "natural thermal potential" determined by modeling becomes the goal for a water body found to be naturally warmer than the criteria.

18. Is the Heat Source model used in Oregon's TMDL process scientifically sound?
Yes. Heat Source, the model used in the TMDL process for developing watershed management plans for stream temperature, is a scientifically sound model and incorporates the major physical factors that determine stream temperature. Sensitivity analysis of the model has been conducted, and we have encouraged the State to continue to explore the sensitivity of the factors in the model. The process used by the state of Oregon to assess stream temperature and address the human activities that affect stream temperature is based on sound scientific principles and is comparable to the best models available.

19. Have private landowners in Oregon been forced to take actions on private lands as a result of temperature standards and the TMDL process?
IMST asked the Oregon Department of Agriculture (ODA) if the Heat Source model or TMDL process had been used to force any landowner to take an action on their land to protect or restore stream temperature. We were told that the agency knows of no circumstances when the State of Oregon required an agricultural landowner to take a mandatory action to protect or restore stream temperature.

As acknowledged in the Oregon Administrative Rules (OAR 603-095-0440), riparian vegetation is known to play several roles that ultimately reduce stream heating (control of erosion that widens streams, moderation of solar heating, and infiltration of water into the soil profile), and state law requires that agricultural activities allow development of riparian vegetation to control water pollution.

If agricultural landowners believe that the Heat Source model has not described the vegetation on their lands accurately (and therefore effective shade at site-potential is inaccurate), landowners may present their concerns to ODA. Personnel from ODA then investigate the site to determine site-specific differences and work with landowners for a voluntary solution. In the rules, ODA is directed to seek voluntary adoption of Best Management Practices; ODA is to pursue enforcement actions only after reasonable attempts at voluntary solutions have failed (OAR 603-095-0030).

Forest landowners have had to take actions on private land in order to meet water quality standards. However, Oregon relies on a different process to carry out TMDLs on forest lands; compliance with the Forest Practices Act is considered to be compliance with the water quality standards. Enforcement actions have also taken place with violations of point source pollution of nutrients (e.g., excess nutrients from Confined Animal Feeding Operations).