Note to Bull Ttrout Temperature Peer Reviewers: Section 1 (pp 2-4) and Section 4 (pp 10-12) are pertinent to this review

Dissenting Opinion on Biological Threshold Numbers
proposed by
Regional Temperature Criteria Development Technical Workgroup

A majority of the Regional Temperature Criteria (RTC) Development Technical Workgroup has agreed on biological threshold water temperatures that are at the 'upper end of the optimal range' for support of specific species groups (guilds) and life-stages of salmonids. Don A. Essig of the Idaho Department of Environmental Quality has participated on this group representing Idaho. Mr. Essig dissented on several of these thresholds and was asked to prepare this written statement presenting the basis for Idaho's dissenting opinion, and supporting proposed alternate numbers.

The following summarizes the workgroup's proposed thresholds, identifies those that Idaho objects to, outlines the basic reasons for the dissent, and suggests alternative numbers. The thresholds put forth by the majority appear first in italicized Arial font, followed by Idaho's dissent in Times Roman.

The idea of the upper end of optimal was to select a temperature threshold that was on the upper side of the range of preferred conditions, yet cool enough to result in no adverse effect to populations of salmonids. It is important to keep in mind when reviewing the basis for proposed thresholds that the notion of no adverse effect to a population is not the same as no adverse effect to any individuals. Adverse effects to individuals are inherent in natural populations, as are they inherent in the practice of harvest. So long as accumulative adverse effects do not cause deaths to exceed births, the population will persist. While the life cycle of salmon and trout is complex, particularly for anadromous species, a common characteristic is that fish are very fecund. Each reproductive adult is capable of producing many (100s) more young than needed to replace themselves. This suggests that high egg to adult mortality is normal and anticipated in their reproductive strategy. Thus a focus on populations rather than individuals is warranted. This life cycle also suggests that the most important individuals are returning adults, the ones that have survived adversity. While raising questions regarding the philosophy of using optima as criteria, this dissent focuses on how optima are selected and how they need to be applied if they are to be practical.

I. RTC proposed thresholds for the Char Guild (Dolly Varden and bull trout)

Spawning/Incubation

7°C 7-Day Average of Daily Maximum (7DADM)
6°C Weekly Mean (WM)

The spawning threshold for bull trout would apply at the start of spawning

Juvenile Rearing

12°C Single Day Maximum

Sub-adult/Non-spawning adult

This life stage is to be protected by applying the Juvenile rearing threshold from the cold water guild. However, it was agreed that a specific statement was necessary in the guidance that notes this decision will need to be re-evaluated in a few years as ongoing field research into sub-adult bull trout is completed.

Idaho Response: In this guild Idaho is dissenting on the **juvenile rearing** number, believing a 7DADM of 13°C more closely represents the upper end of the optimum range. This opinion is based on recent controlled experiments (e.g. McMahon et al. 2001, 1999, 1998; Selong et al. 2001), field work by Gamett (1999) in the Little Lost River drainage, consideration of normal diurnal stream temperature ranges in the translation of lab studies to the field, and normal seasonal cycles of temperature. In our view, a 12°C single daily maximum, if met, would relegate bull trout to sub-optimally cold temperatures much of the time, and is not always best for the fish.

Growth was the focus of the recent controlled experiments by McMahon et al. While growth is not the only factor to be considered in maintaining healthy populations it is a good indicator of fitness in controlled experiments since it integrates all physiological factors in juvenile fish; fish that are chronically stressed or diseased do not grow well. Further, in the wild, growth during juvenile salmonids' first summer is a strong predictor of their survival to the next year (Cunjak and Power 1987, Smith and Griffith 1994, Meyer and Griffith 1997).

McMahon et al. (1998, 1999) and Selong et al.. (2001) used regression analysis of growth at fixed study temperatures to show age 0 bull trout grew best at a 60-day average temperature of 13.2°C, when fed to satiation. It is well known that food availability affects thermal preference in fish, so more recent work limited rations. McMahon's (2001) recent work showed growth of bull trout was best at a 12°C daily average, as compared to daily average temperatures of temperatures of 8 and 16°C, even when fish were fed at 33% and 66% of satiation (to better simulate limited food availability in real streams). In this most recent work (2001) McMahon also exposed fish to temperatures fluctuating 6°C on a diurnal cycle, to better simulate real world thermal variation. Cyclical temperatures did reduce growth somewhat compared to steady temperatures, though not significantly so at 12°C. More importantly, a daily average temperature of 12°C still produced the best growth. So if we accept 12°C as best, how is that number to be applied in the real world? How does a 60-day average relate to diurnal and seasonal patterns of temperature in a real stream?

As noted above, many would agree that growth translated to size is the best overall indicator of fitness, but how is a laboratory temperature exposure to be translated to a real stream? Figure 1 compares two ways in which a 12°C temperature could be applied. In panel **a,** 12° is used as an upper limit on weekly average temperature (WAT, or MWAT if the warmest week of the year), and in panel **c** as an upper limit on daily maximum temperature (DMT, or MDMT if the warmest day of the year). Panel **b** is intermediate and examines Idaho's 13°C limit on maximum weekly maximum temperature (MWMT, aka 7DADM).

Panel **a** is the most logical application of McMahon's growth findings, but it is still conservative because we are focusing on the warmest week in the year— only in this one week will the fish have a weekly average temperature at this 'optimum' temperature; all other weeks will be colder. Using McMahon's (2001) optimum diurnal range of 9-15°C (12±3°C), 85% of the time the water is within the optimum range during this warmest week with, with 15% sub-optimal time split equally between temperatures warmer and colder. This due to day-to-day weather related variations in temperature found in the field. However, given the day-to-day pattern of variation in this real temperature record, 85% of the week time spent in the optimum temperature range is the best that can occur.

In contrast, application of 12°C as a limit on daily maximum temperature (Figure 1, panel **c**) results in only 40% of the time spent in the optimal range. The remaining 61% is all sub-optimally cold, and this is in the <u>warmest week of the year</u>. The corresponding MWAT is 8.2°C, close to the 8°C McMahon (2001) documented to produce significantly less growth, again during the warmest week of the year. This is does not provide as much time at temperatures best for growth as the panel **a** scenario.

Applying Idaho's bull trout criterion of 13°C maximum weekly maximum (Figure 1, panel **b**) results in a MWAT of 10.3°C and 64% of the warmest week spent in temperatures optimal for growth (9-15°C). While not providing as much time at temperatures found beneficial to growth in controlled experiments as in example panel **a**, this moderately conservative approach could be justified as consideration of possible lower food availability in the field and congruence with field studies showing locally robust populations at streams with temperatures around 13ºC MWMT.

In a study of bull trout distribution in the field Gamett (1999) found that the stream with the highest bull trout density observed (30.3 fish/100m^2) reached a maximum temperature of 15.5°C. While it could be argued that somewhat cooler temperatures might have allowed an even more robust population of bull trout, clearly a high temperature of 15.5°C was not detrimental. The corresponding MWMT in this stream was 14.6°C, and the MWAT was 10.8°C. In five streams with robust bull trout populations (three or more age classes and density > 2.0 fish/100m^2) the average MDMT was 14.5°C, the average MWMT was 13.4°C, and the average MWAT was 10.4°C.

The report by Hillman and Essig (1998) reviews the literature up to that time and takes a critical look at derivation of Environmental Protection Agency's (EPA) bull trout criteria promulgated for Idaho. They describe the difference between temperature metrics (expressions of temperature time series as a single value [e.g. MWMT and MWAT]), and point out that while the various metrics are highly correlated, and can therefore be translated, <u>they are not interchangeable without translation</u>. It is a worth noting that EPA proposed a seasonally adjusted criterion ranging from a 6°C MWAT in March to 12°C MWAT in June, July, and August, and then switched to a flat 10°C MWMT in their final rule. The reasons stated were to gain greater control over thermal maxima by using the MWMT instead of the MWAT, indicating the use of a MWMT was consistent with other temperature criteria or recommendations. At the time, EPA apparently was not aware of the relationships between MWAT and MWMT since they failed to mention that the final criteria was effectively about 4ºC cooler than proposed (62 FR 23004 – 23029 [April 28, 1997], 62 FR 41162-41118 [July 31, 1997]). At the time EPA stated they believed that a 10ºC MWMT was "consistent with other temperature management objectives and criteria" such as a range of 9-15ºC (metric not specified) and a 15ºC MDMT (62 FR 41171). They are not consistent.

Hillman and Essig also compared established methods of deriving a suitable water quality criterion, none of which EPA apparently followed, and reached the conclusion that the EPA promulgated bull trout rearing criterion of 10°C, expressed as a MWMT, was too cold to be best for bull trout. They suggested a MWMT of 12-14°C was better support by the literature.

Given a typical 3°C spread between MWMT and MWAT (Chapman 2002 page 1; and Figure 4 this report), EPA's original proposed criterion for Idaho of 10°C MWAT comports much better with the above information and translates to the 13°C MWMT criterion now adopted in state rule. A 13°C MWMT is what Idaho recommends to be the regional temperature criterion for bull trout rearing.

Idaho is also uncomfortable with the **spawning** and incubation temperatures. While we agree that the optimum for bull trout incubation may be a weekly mean no greater than 6°C, it is unreasonable to expect such optimum temperature to occur at the onset of spawning. Fish evolved with seasonal patterns of temperature and likely key-in on declining fall temperatures (Bjornn and Reiser, 1991). They begin spawning in warmer than optimum conditions in order to assure adequate embryo development before water temperatures become too cold, and to allow sufficient maturation time prior to spring emergence. This is discussed in greater detail in section IV with chinook salmon as an example.

Coupling a 6°C weekly mean with a 7DADM of 7°C is particularly unreasonable if applied early in the fall spawning season. Most streams in Idaho exhibit a diurnal range greater than the approximately 2°C these pair of numbers allow for. Idaho would find an 8°C 7DADM to be more reasonable and fully protective of bull trout egg incubation, <u>if applied after spawning was nearly completed</u>.

II. RTC proposed thresholds for the Cold Water Guild (**Pacific salmon, steelhead, and coastal cutthroat trout**)

Spawning/Incubation

13°C 7DADM
10°C WM

***Juvenile Rearing** (Also covers smoltification except steelhead, adult holding, and bull trout sub-adult/non-spawning adults.)*

16°C 7DADM
15°C WM This threshold would also protect fall chinook and coho salmon smoltification.

***Smoltification** (steelhead)*

14°C 7DADM
12°C WM To be applied through 5/31 or locally specific dates.

This 12°C weekly mean is to apply to tributaries rather than mainstem rivers (e.g. Columbia and Snake), and is intended for the protection of Steelhead. It is to give them a good start on their way through the mainstem to the ocean.

Adult Migration

18°C 7DADM
16°C WM

Adult migration threshold applies to reaches not used for rearing.

Adult Holding

Covered by juvenile rearing threshold plus the additional narrative to protect cold water refugia at various spatial scales.

This threshold is for the protection of summer holding and pre-spawning holding areas. It was recognized by the workgroup that cold-water refugia was an important feature protecting adult holding by providing necessary cold water.

Idaho Response: In this guild, Idaho is dissenting on the juvenile rearing, steelhead smoltification, and adult migration threshold numbers for the reasons presented below.

For **juvenile rearing,** Idaho believes the threshold for the 7DADM should be 18°C. This is based on the literature (review by Chapman 2002) and consideration of translating laboratory studies to temporally variable streams (discussion above under char guild). Most of the literature on effects of water temperature on growth and survival of juvenile fish is based on exposing fish to steady temperatures (e.g., McMahon et al. 1998, Selong et al. 2001). It is difficult to translate results from these lab studies conducted at steady high temperatures for long periods to real streams where water temperature is always varying and does not remain at peak temperatures for long. It is inappropriate to simple use a steady (average) temperature in a lab as a limit on peak temperature in the field.

It should be obvious that a 7DADM (MWMT) in the lab at steady temperature is not equivalent in thermal units to a 7DADM in the field of the same value. Indeed, because of normal diurnal cycles a 7DADM in a real stream would have to be considerably higher than under a steady lab temperature to provide similar thermal exposure. While some aspects of lab life are less stressful than the real world e.g.

fish are often fed to satiation in lab studies and are without predators, other aspects are more stressful, e.g. constant high temperatures, higher than natural densities and lack of natural cover.

Idaho believes that laboratory studies of optimal temperatures for growth and survival based on steady temperature are only useful in suggesting a weekly mean criterion for the real world, not a maximum criterion such as a 7DADM. The 7DADM criterion should be based on studies that incorporate diurnal temperature cycles and what is known about typical diurnal temperature ranges in the real world to examine how these patterns of variation affect duration of exposure to sub-optimal temperatures at any given weekly mean temperature. We would support coupling a 7DADM with 30-day mean, rather than a weekly mean. A 21-day or 30-day mean is likely more meaningful in terms of measuring and regulating temperatures optimal for growth during rearing and better corresponds to the duration of studies of growth.

It is worth comparing the proposed criteria to the real world, particularly in "reference" streams. If any waters in the Pacific Northwest can be considered reference streams certainly waters draining the large unroaded and wilderness areas of central Idaho qualify. While it can not be said that the Selway and Middle Fork Salmon rivers of Idaho are without human influence, they are certainly the most nearly pristine and least impacted waters, draining the most sparsely populated watersheds, of their size in the lower 48 states. These rivers and several of their tributaries have been nominated several times for recognition as Outstanding Resource Waters (Tier 3 waters under the Clean water Act), and they are designated as national Wild and Scenic Rivers.

Tables 1 and 2 summarize water temperatures collected from the Selway and MF Salmon and their tributaries over the period of September 2000 through September 2001. These data show these rivers are quite warm, exceeding or barely meeting Idaho's current cold water aquatic life criteria of 22°C MDMT and 19°C MDMT. Water temperatures are also summarized as MWMT and MWAT for comparison to the above proposed juvenile rearing criteria. It is assumed in this comparison that waters that are currently designated for cold water aquatic life would likely become designated for juvenile rearing. If the state is allowed deference in future use designations and not required to conduct use attainability analyses for each and every re-designation that may be required under the new criteria guidance, then perhaps the mismatch between the biological criteria real world temperature regimes could be worked out through judicious use designations.

It is interesting to note that the Selway and its tributaries are warmer than the Middle Fork Salmon and its tributaries, showing the overriding influence of lower elevation and warmer air temperatures in producing warm summer water temperatures. The two raw data plots are shown in Figure 3 as examples of the broad seasonal range in water temperature typical in Idaho's climate, showing that while the water does get warm in the heat of the summer, it is generally quite cold. We expect this is also quite naturally different from the thermal regime of Pacific Northwest streams in other climates, such as moderate coastal climates west of the Cascades.

Bjornn and Reiser (1991) note that "salmonids can thrive if the temperature is high for only a short time and then declines well into the optimum range." In an Idaho stream that cooled from 24°C during the day to 8-12°C at night, "juvenile chinook salmon and steelhead maintained high densities and grew normally." While in larger streams that do not cool so dramatically over night, young salmon and trout seasonally moved into cooler headwater and tributary streams.

Finally, the difference or spread between EPA's proposed 7DADM and WM (aka MWMT and MWAT) does not comport with physical reality. Figure 4 is a regression between these two metrics for 185 sites across the Clearwater and Salmon river basins. This regression is highly significant and shows a spread between MWMT and MWAT of about 3°C, at least for most Idaho streams. Thus if 15°C is a reasonable

MW criterion (Chapman 2002), then the corresponding MWMT should be 18°C. If such a spread is not employed then the proposed 16°C MWMT becomes the only effective criterion; all, or almost all, streams will reach a MWMT of 16°C well before reaching a MWAT of only 1°C less.

The data used in the regression shown in Figure 4 does include many less than pristine streams and even a few impaired waters. Some will jump to dismiss this regression because of that. Their reason will be that temperature impaired waters have a higher diurnal range in temperature and that will have inflated the spread in these metrics. Before jumping to that conclusion, one should consider the data set. The sites were randomly selected and then filtered to remove sites that were obviously impaired (e.g. due to flow modification or channel alterations). The vast majority of the remaining 185 sites, while not pristine, are very natural waters, though an exact classification depends on one's criteria. Setting this aside and examining the data reveals that it is not true that warmer waters have a higher diurnal spread, if anything this data shows that the colder (also generally smaller) waters on average have a slightly higher spread (closer to 3.5°C). What is evident is that the average spread is remarkably consistent across the full range of temperature, and is about 3 to 3.5°C.

As further evidence, consider the spread in these metrics in the aforementioned Selway and Middle Fork Salmon data. This is summarized in Chapman's (2002) Table 1 and shows that in these reference streams the mean difference between 7DADM and WM (MWMT and MWAT) is 2.4°C, ranging from a difference of 0.6°C up to 5.6°C. These data show 2.5 to 3.0°C is the mean or typical spread. If this is taken into account in setting a pair of criteria, it would better reflect typical real world diurnal ranges and would result in a nearly equal number of streams that would trip one criterion as opposed to the other. This would make a pair of criteria that is more meaningful. If this spread is not recognized the recommended upper optimal criteria for juvenile rearing should be a WM of 15°C with no 7DADM criterion.

The **steelhead smoltification** thresholds recommended by the technical workgroup appear to be based largely on lab studies of Wally Zaugg (1985, 1987) on ATPase levels in smolting steelhead. Zaugg came to a meeting of the technical workgroup to discuss his work and findings on smoltification at various temperatures (August 7, 2001). In that meeting he was quite cautious about application of his studies to the real world, pointing out his work was conducted to inform improvement in hatchery operations. It should be noted that in the context of hatchery operations the concern was with delayed smoltification, and that by warming hatchery temperatures more complete smoltification would result. The concern with elevated river temperatures is quite the opposite, accelerated or pre-mature smoltification, with reversion (to a condition unprepared for saltwater) prior to reaching the ocean.

In Idaho's view, Zaugg's work adequately supports a 12°C weekly mean as the upper end of optimum for steelhead smoltification. However, Zaugg's work provides little support for any recommendation on a 7DADM. He found no observable change in gill ATPase levels in fish exposed to 16°C for four hours per day for three weeks, not until the fourth week did declines in ATPase levels become evident. Given normal seasonal progression of river temperatures, it would be highly unlikely that limiting the 7DADM to 16°C would result in exposure of smolts headed to the ocean to warm temperatures long enough to cause the effects Zaugg observed. Zaugg also stated he "would expect the effect of temperature in the real world to be less than in the lab, fish seem to be more sensitive to temperature effects in the lab" (Wally Zaugg, personal communication, August 7, 2001). Thus a 16°C 7DADM is likely protective of steelhead smoltification. But given that Zaugg's work is but one set of studies, did not focus on acute exposure, and was geared toward hatchery production, Idaho does not recommend setting an acute exposure limit specific to smoltification of steelhead at this time.

As the **adult migration** thresholds would apply to all waters that other colder criteria do not apply, they would cover most, if not all, of Idaho's larger, warmer rivers, and supplant Idaho's current cold water criteria of 22°C for a daily maximum and 19°C for a daily average. This is problematic as many of these larger systems do not meet the current criteria yet do support healthy fisheries (e.g., Selway and Middle Fork Salmon data in Tables 1 and 2, previously discussed). It is also problematic because these larger streams in Idaho likely can not, and never did, meet Idaho's current criteria (much less colder values) at all times. Thus if not tempered by time of application, the workgroup's upper end of optimal biological thresholds will be disconnected from reality.

There appears to be little evidence that thermal conditions for adult migration have worsened in recent times. In fact the historical data available indicates that the time above supposed critical temperature thresholds for adult migration (i.e., 21°C) has actually decreased in the lower Snake River since the mid-1950s (Chapman 2002, Hillman et al. 2000). Although there is little evidence from the field on how summer migrating salmon were affected by historical warm temperatures, we can only assume the fish are adapted, perhaps behaviorally, to deal with waters that are ostensibly too warm.

Though not well documented, it seems quite obvious to many that the fish must be finding and taking advantage of cooler refugia. We agree protecting these refugia is vital; however, requiring the entire river to be optimal is not the most practical way of doing so. We presume that fish likely tolerate some periods of sub-optimal conditions during this phase of their life cycle in order to reach more suitable conditions upstream or later in the year. The journey may be arduous, but the destination makes it worth while. Setting criteria that recognize some exposure to sub-optimal conditions is reasonable and even necessary if anadromous fish are to get to more optimal temperatures upstream. On the other hand, if the mainstem waters were optimal, more of the headwaters would be sub-optimally cold. Stream networks have a longitudinal gradient in temperature that can not be bent to our will.

To recap, Idaho objects to the technical workgroup's decision on adult migration not because we dispute the numbers chosen as upper optimal temperatures but because of the above concerns on their application. In order for optimal thresholds for adult migration to be useful as water quality criteria, Idaho believes it is imperative that application of these thresholds be clarified in terms of the percentage or period of time they need to be met. Alternatively, adult migration temperatures might be reasonably applied broadly across the landscape if based on upper sub-optimal thresholds rather than upper optimal thresholds. In addition, it is our belief that reasonable criteria, or standards, should not require extensive modeling of every large river to confirm that the natural thermal potential is at times sub-optimal.

However, the best approach to protecting adult migration may be to adopt narrative criteria protecting cool water refugia and to limit the duration of exposure to temperatures that are known to slow migration (21-22°C). A suitable time limit on this exposure might be taken from what now occurs in the lower Salmon River (see Figure 5) and what is known to have occurred historically in the lower Snake River prior to the Hells Canyon complex of dams and in the mid-Columbia River prior to Grand Coulee dam (see Chapman 2002, pages 10-19).

III. RTC Proposed thresholds for the Moderately Cold Water Guild *(Interior non-anadromous trouts)*

Spawning/Incubation
13°C 7DADM
10°C WM

Juvenile Rearing
20°C 7DADM

Idaho Response: This guild specifically includes only the Lahontan and redband trout by name. Other interior subspecies of cutthroat trout also fit the description 'interior non-anadromous trout' and the proposed temperature would probably be protective. This assignment of species to guilds implies that the anadromous species listed in the cold water guild have colder temperature requirements than the trout species in this guild, which has not been demonstrated. The final EPA guidance should clarify this.

These are the same spawning temperatures proposed for the cold water guild. Given the more rapid spring warming to maximum summer temperatures found in many streams inhabited by these two species, these criteria will make sense only if applied judiciously to the landscape. Only by careful designation of both spatial and temporal extent will application of these criteria fit the pattern of great temporal range and high summer stream temperatures in semi-desert environments and allow for the sub-optimal to marginal thermal environments fish sometimes inhabit. A great deal more about this conundrum follows in the next section.

IV. <u>RTC proposed</u> <u>Spatial and Temporal Application Directives for Applying [Species Life Stage] SLS Criteria:</u>

The criteria are intended to be applied (and measured for compliance) based on the following assumptions and limitations:

- *Well mixed flows.*
- *Furthermost downstream extent of the use.*
- *The annual average start and ending dates for the life stage (e.g., spawning or smoltification).*
- *Apply in all but the hottest 5 - 10% years (May use a blanket recurrence interval such as 1 in ten years, or link the exception clause to air temperature extremes, etc.).*

Idaho Response: Although Idaho does not object to some of the temperature criteria proposed as upper-optimal biological thresholds, we are quite concerned about the **spatial and temporal application of upper-optimal criteria**.

The above assumptions and limitations were what the technical workgroup used in coming up with the recommended SLS criteria. While these principals did not explicitly make it into the EPA's guidance, they did provide the basis or backdrop for the numbers recommended. Moreover, they merit discussion with regard to the flexibility states and tribes may or may not have in applying SLS criteria during the interim prior to development of thermal potential and its reconciliation with what fish want or prefer.

Basic principals of biogeography tell us not everywhere on the landscape, or waterscape, is or can be optimal for any given species. Rather the landscape is a mosaic of overlapping environmental gradients in which species sort themselves out. In doing so, they find some optimum areas but also push the limits of their range by occupying sub-optimal and even marginal habitat. So it is with water temperature (see Figure 2). Unlike manmade pollutants, temperature has both a lower and upper optimal threshold for a given species, and natural spatial variation can regularly take temperature outside of optimum ranges. As can be readily seen in Figure 2, fish routinely are found in a broad range of temperatures; much broader than what would be considered optimum or preferred.

Targeting upper optimal temperatures as a regulatory upper limit on water temperature does not fully consider the temporal variability of water temperature. Figures 6 and 7 illustrate that a stream the comes close to meeting a MWMT of 13°C spends very little time at or above this threshold temperature even when focusing on the two summer months of July and August. Add in inter-annual variations and application during all but the 5 or 10% extreme years, and allowable peak temperatures of 13°C become even less frequent.

While optimal to upper-optimal thresholds seem to have merit when it comes to protecting endangered species, they make sense only when dealing with human-made pollutants. The concept breaks down some when considering an environmental master variable such as temperature. Water temperatures quite naturally vary throughout the full range of sub optimally cold, through optimal, to sub optimally warm. It is especially problematic in the context of water quality regulation to allow for this variation, or, if not allowing for it, being stuck attempting to control it.

We grant that humans can and have altered the natural thermal regime of many waters in the northwest—some quite substantially. But this impact does not make the application of fixed value criteria, especially those based on species physiological optima for water temperatures, any more reasonable or prudent. Given the great spatial and temporal variability in water temperatures, most of which follow general well-understood natural patterns (e.g., day warmer than night, seasonal progression, headwaters colder than mainstems), the coupling of upper-optimal thresholds with the latter three bullets above makes for excessively conservative criteria.

While the focus on well-mixed flows is advisable in the interest of measurement consistency, the other three principals are not very practical. Consider for a moment just the application of upper optimal temperatures to the furthermost downstream extent of the use. By definition the furthest downstream extent of use is at the margins of a species distribution. At the margin of a species distribution, conditions are expected to be sub-optimal, even barely tolerable, otherwise the distribution would not end there. Assuming temperature to be the controlling variable, expecting optimal temperatures to occur at the limits of a species distribution is self-contradictory and unattainable.

One could also reason that meeting upper optimal conditions at the furthermost downstream (warmest) extent of a use, and at the average start or end date (nearly warmest) time of use, and in all but the one in 10 or 20 warmest years, would result in sub-optimally cold temperatures most of the time throughout most of the drainage network. As an indication, in recent work in Yellowstone National Park, Harig (Harig and Fausch, in press; Harig et. al. 2000) found that where mean July temperatures fall below 10°C cutthroat trout fail to persist. Thus a stream that met a spawning criteria of 10°C maximum weekly mean through the end of June would likely not be warm enough in July for cutthroat to persist. This is neither credible nor desirable.

For another example of the nonsense possible if optimum numbers are applied too broadly, consider the work of Groves and Chandler (1999). They studied the spawning of fall chinook salmon in the Snake River below Hells Canyon Dam, including observation of water temperatures during spawning. Spawning began in late October when <u>weekly average water temperature</u> (WAT) dropped to 16°C and ceased the second week of December when the WAT dropped to 5°C. While no one would suggest WATs of 16°C and 5°C are optimum for spawning, they are clearly suitable for spawning. The fish likely begin spawning at 16°C, even though it is sub-optimally warm, because they key in to declining water temperatures, anticipating cooler water to come, and to be sure their eggs get enough thermal units to fully develop before emergence the following spring. And as the onset of 16°C temperatures varies from year to year, the fish adjust their spawning time.

If we were able to make the Snake River colder, to meet the proposed SLS spawning criteria throughout the reported spawning period, we would expect that the fish would still key in on sub-optimally warm but declining temperatures and begin spawning earlier (an adjustment they make from year to year anyway). This would be fine if we didn't then turn around and say now that they are spawning earlier we need to meet our spawning criteria even earlier – compliance becomes impossible because the fish will not hold themselves to spawning only when or where temperatures are optimum. Same goes for rearing and other life stages as well. We must allow for natural sub-optimal temperatures, without allowing adverse human-caused alteration of water temperature.

The use of optima as water quality criteria in a regulatory manner is questionable, though it may make a fine management goal. Application of upper-optimal temperature criteria fails to recognize natural variations and if applied broadly do not allow for naturally marginal areas of use. If met at the warmest times in the warmest margins of use, the proposed criteria could in fact result in an increase in thermal regimes that are colder than optimal. Therefore, the RTC should clearly state that these upper end of optimal numbers are expected to be met only:

1) in core (optimal) areas that fish do or reasonably should inhabit;
2) during times of prime use, such as the middle 75% of the typical season of use for spawning, and in all but the 10% hottest days of summer for criteria that apply through the summer (June through August); and

3) in a typical or median climate year, which primarily means median conditions of air temperature and river flow, but in order to take into account natural disturbance could also apply to median conditions of canopy cover, sediment load, etc.

Alternatively, if the proposed criteria are not tempered by the above limits on application, they should be reconsidered in terms of a more limiting upper end of thermal tolerance that can be more reasonably met most everywhere most of the time, i.e. numbers that more closely describe the thermal limits of species distributions. Such “high” numbers can still be protective considering normal longitudinal gradients in water temperatures in a stream network (i.e. cold headwaters, progressively warmer water downstream), particularly where upstream heat loads are cumulatively evident in large mainstem waters. But the best solution may be a set of criteria numbers that varies geographically in some simple algorithm that takes into account the effects of latitude, elevation, and perhaps distance (time of travel) from headwaters source. Although this would be viewed as straying from a strict biological basis for criteria, it would very much embody a ecological basis. Given the nature of water temperature it would be wholly appropriate.

V. *<u>Proposed</u> <u>Interim Temperature Management Plan</u>*

This proposal was not part of the recommendations of technical workgroup but was proposed in the October 2001 Public Review Draft “EPA Region 10 Guidance for State and Tribal Temperature Water Quality Standards”. The proposed requirements include:

NPDES [National Pollution Discharge Elimination System] permits must require the implementation of the temperature management plan and that requirement must be enforceable.

Idaho response: The guidance should be clarified so that only NPDES permitted sources that result in temperature increases that have a reasonable potential to violate temperature standards need temperature management plans.

Under no circumstances shall a source’s discharge contribute to incipient lethal temperatures (25ºC) in a water body (including within a mixing zone).

Idaho response: Because of the broad and absolute wording, this provision is fairly extreme and no analysis of it could be located in the workgroup’s technical issue papers. “Incipient lethal thresholds” are not time-independent. For example, Brungs and Jones (1977) show that for young chinook acclimated to 20 ºC, the incipient lethal levels ranged from 29ºC at 10 minutes to 25ºC at 1000 minutes. The duration of exposure that a juvenile fish swimming downstream in a river is likely to experience in passing through a thermal plume is quite low. For example, Mebane (2000) analyzed travel times for organisms passing through a variety of acute mixing zone configurations in a large river and small and medium sized streams. No drift time exceeded one minute. When diffusers are used, thorough mixing usually occurred within 1-2 meters of the outfalls. Juvenile salmonids are not seston: if they encountered a small plume of unsuitably warm water they could easily avoid it with an exposure duration of seconds.

Idaho recommendation: The best approach would be a requirement for dischargers to demonstrate that the configuration and temperatures of their discharges is unlikely to cause any mortality to fish drifting or swimming through their thermal plumes. Alternatively, but still somewhat arbitrary, the guidance should replace the 25ºC limit with one more reflective of exposure durations in flowing waters (28-29ºC), and retain the 25ºC for discharges to reservoirs and lakes with low currents and the potential for greater exposure durations.

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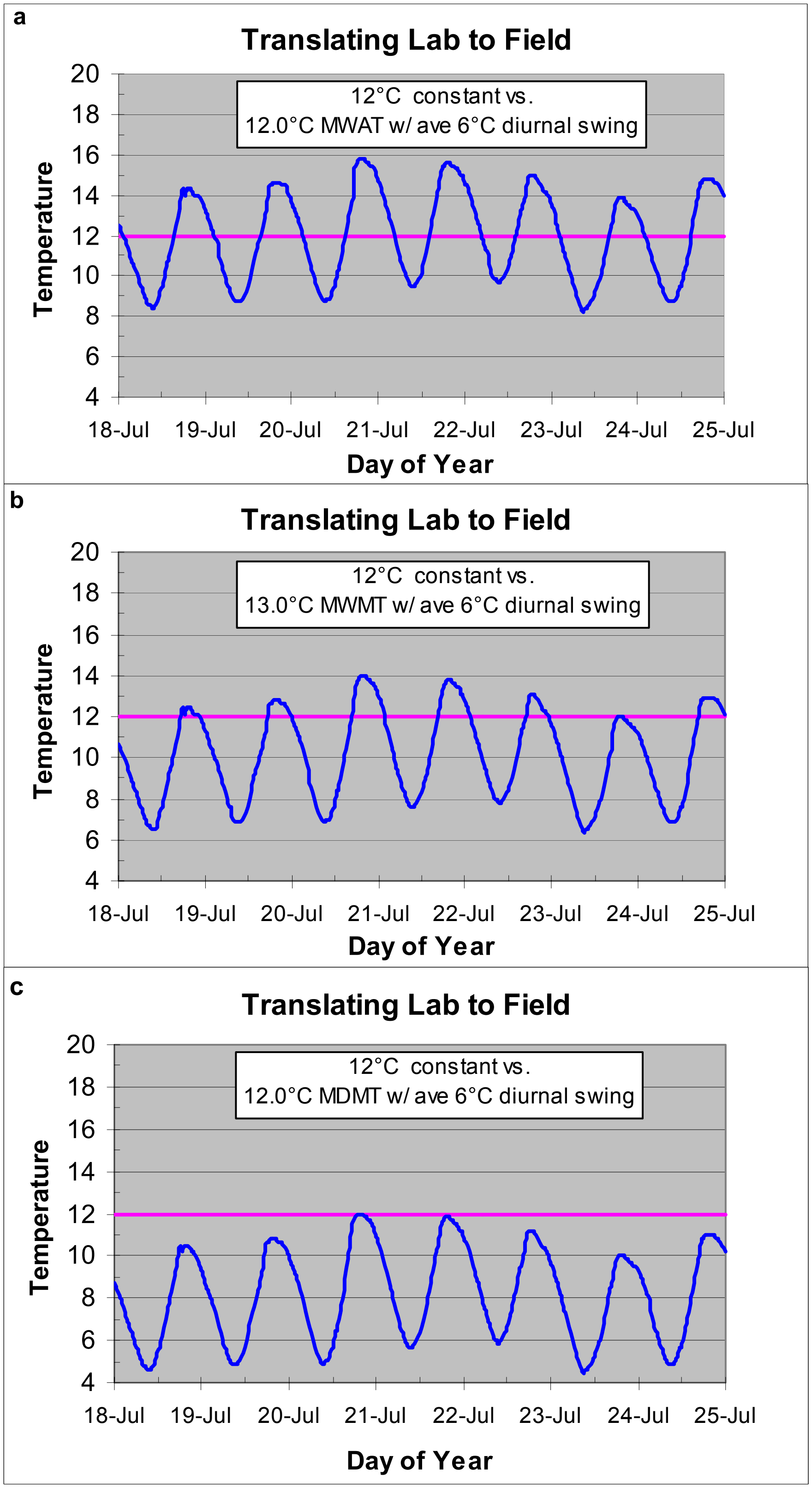


Applying McMahon et al. growth optimum as a MWAT

MWAT = 12.0°C

MDAT = 13.3°C
MWMT = 14.7°C
MDMT = 15.8°C

Time in optimum range: 85%
Optimum = 12±3°C

Hours > 12°C = 85 (51% of week)
Hours > 13°C = 64 (38% of week)

Applying Idaho's BT criterion

MWAT = 10.3°C, sub-optimal for growth

MDAT = 11.6°C
MWMT = 13.0°C
MDMT = 14.1°C

Time in optimum range: 64%

Hours > 12°C = 36 (22% of week)
Hours > 13°C = 15 (9% of week)

Applying McMahon’s growth optimum T as a MDMT

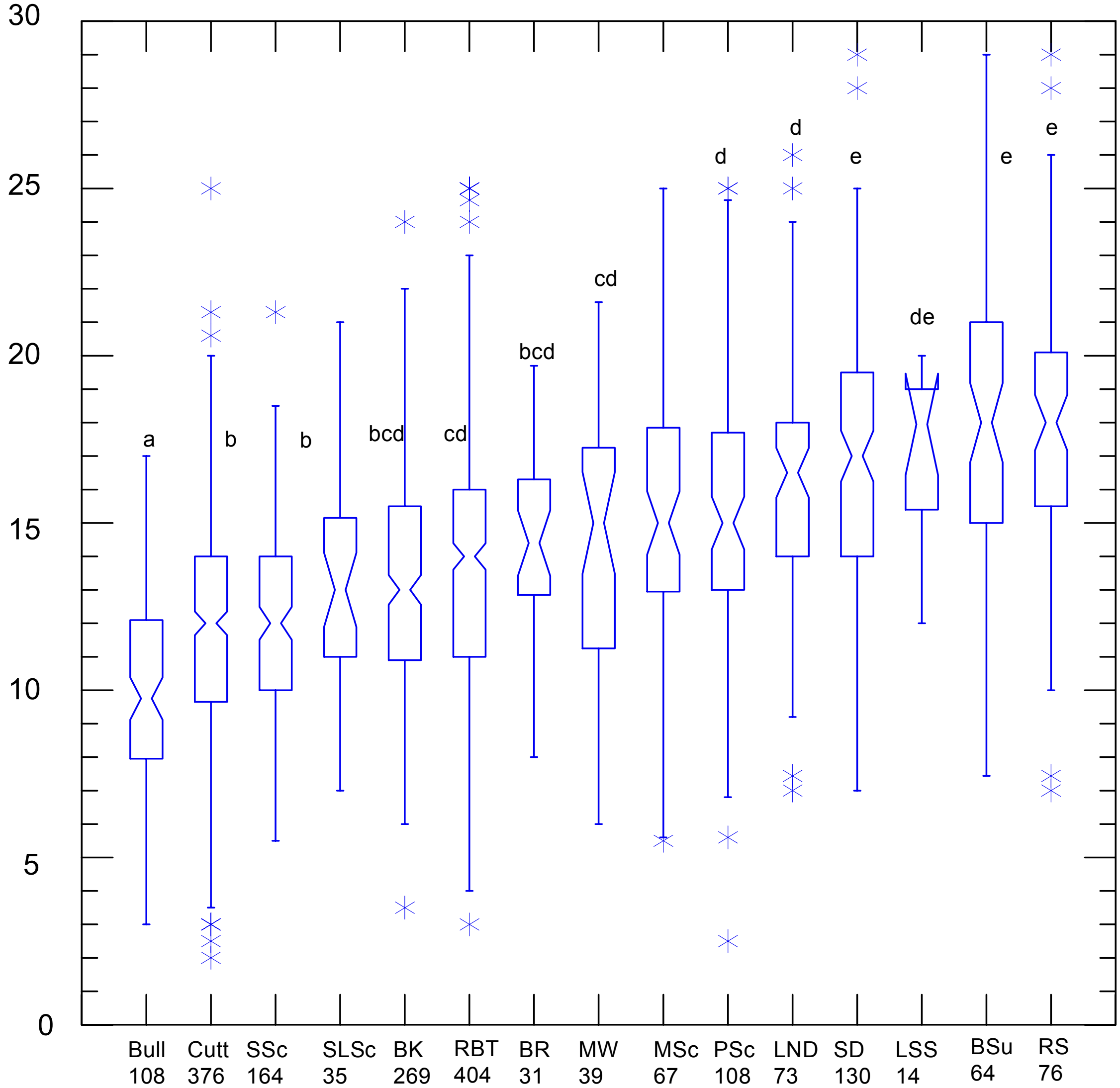
MWAT = 8.2°C, stream spends most of the time at T sub-optimal for BT growth

MDAT = 9.4°C
MWMT = 10.9°C
MDMT = 12.0°C

Time in optimum range: 40%

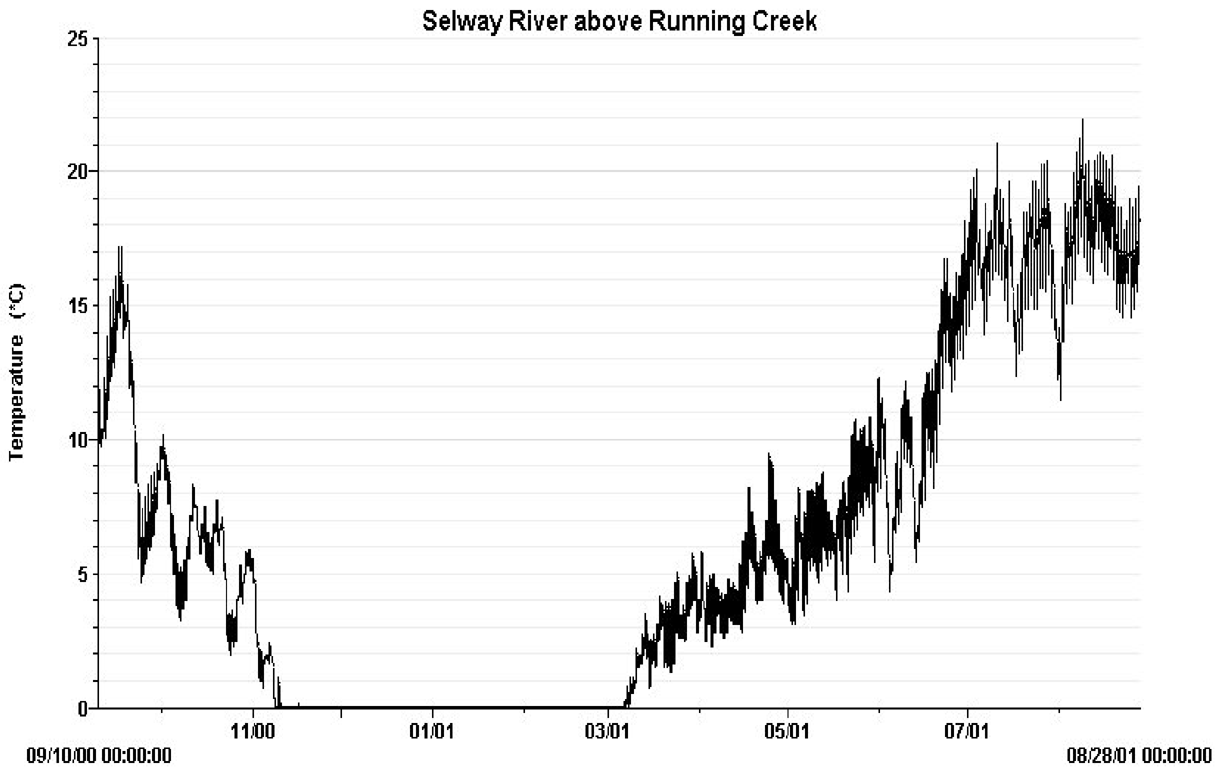
Hours > 12°C = 0 (0% of time)
Hours > 13°C = 0 (0% of time)

Figure 1. Examples of translation of laboratory physiological thresholds to the field. Based on measured temperature in Silver Creek Idaho, chosen because the actual record for the warmest week of the year exhibited the same diurnal range as targeted in McMahon et al. (2001) lab study of fluctuating temperatures. Actual data recorded was shifted downward in temperature so that temperature record would just meet the bolded temperature metric. McMahon et al. reported maximum growth in a temperature regime of 12±3°C.



Code	Common Name	Scientific Name	Code	Common Name	Scientific Name
Bull	Bull trout	*Salvelinus confluentus*	MW	Mountain whitefish	*Prosopium williamsoni*
SSc	Shorthead sculpin	*Cottus confusus*	MSC	Mottled sculpin	*Cottus bairdi*
Cutt	Cutthroat trout	*Oncorhynchus clarki*	PSC	Paiute sculpin	*Cottus beldingi*
SLSC	Slimy sculpin	*Cottus cognatus*	LND	Longnose dace	*Rhinichthys cataractae*
BK	Brook trout	*Salvelinus fontinalis*	SD	Speckled dace	*Rhinichthys osculus*
RBT	Rainbow trout	*Oncorhynchus mykiss*	LSS	Largescale sucker	*Catostomus macrocheilus*
BR	Brown trout	*Salmo trutta*	BSU	Bridgelip sucker	*Catostomus columbianus*
			RS	Redside shiner	*Richardsonius balteatus*

Figure 2. Ranges of temperatures at which selected fish species were captured in Idaho, 1995-1999. The boxes indicate the median and upper and lower quartiles (the central 50% of the values), the whiskers extend up to 1.5X the interquartile value, and asterisks show outlying values. Notches in the boxes indicate 95% confidence intervals of the median. Plots marked with the same letter indicates that their means are not significantly different at $P < 0.05$ using Tukey's multiple comparison procedure. Data from the Idaho Department of Environmental Quality's Beneficial Use Reconnaissance Program and Idaho Department of Fish and Game's Resident Fisheries Research program.



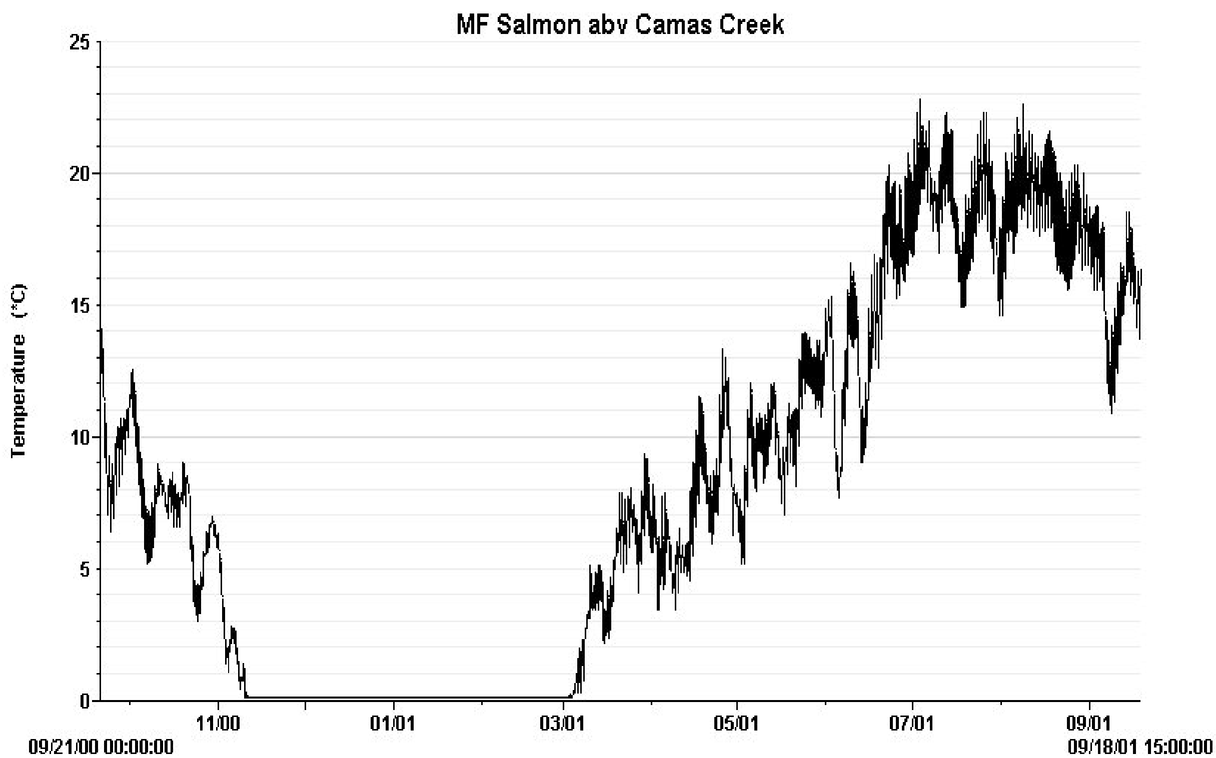
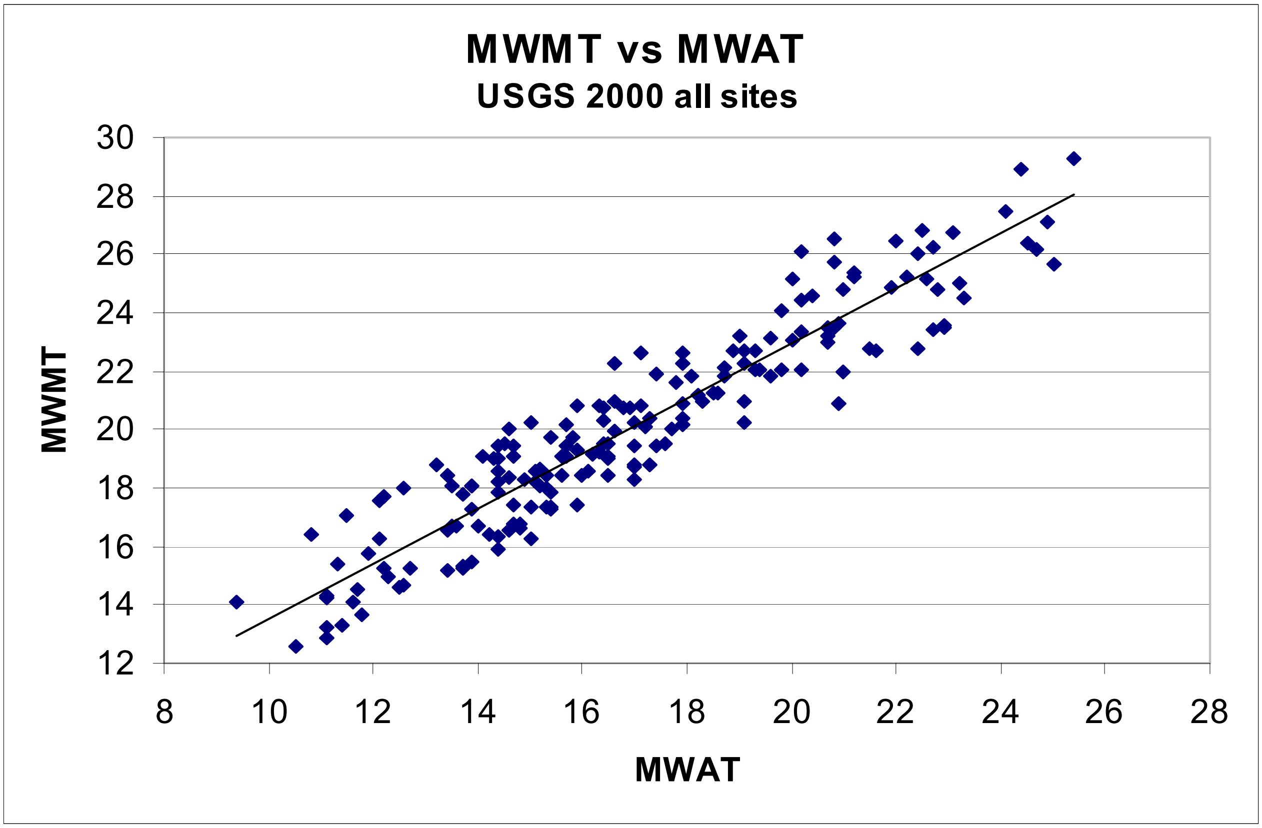


Figure 3. Raw data plots of half-hourly water temperature at two reference sites. Note that the date range differs somewhat in the two plots.



SUMMARY OUTPUT

MWMT=0.945*MWAT+4.073

Regression Statistics	
Multiple R	0.9357673
R Square	0.8756604
Adjusted R Square	0.874981
Standard Error	1.288438
Observations	185

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2139.46202	2139.46	1288.776	9.02345E-85
Residual	183	303.7932798	1.66007		
Total	184	2443.255299			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	4.0732504	0.456643853	8.91997	4.77E-16	3.172286405	4.974214313
MWAT	0.9449575	0.026322282	35.8995	9.02E-85	0.89302335	0.996891724

given MWAT	predict MWMT
8	11.63
9	12.58
10	13.52
11	14.47
12	15.41
13	16.36
14	17.30
16	19.19
18	21.08
19	22.03
20	22.97

Figure 4. Regression of maximum weekly maximum temperature (MWMT) on maximum weekly average temperature (MWAT) based on 185 sites throughout the Clearwater and Salmon basins in Idaho.

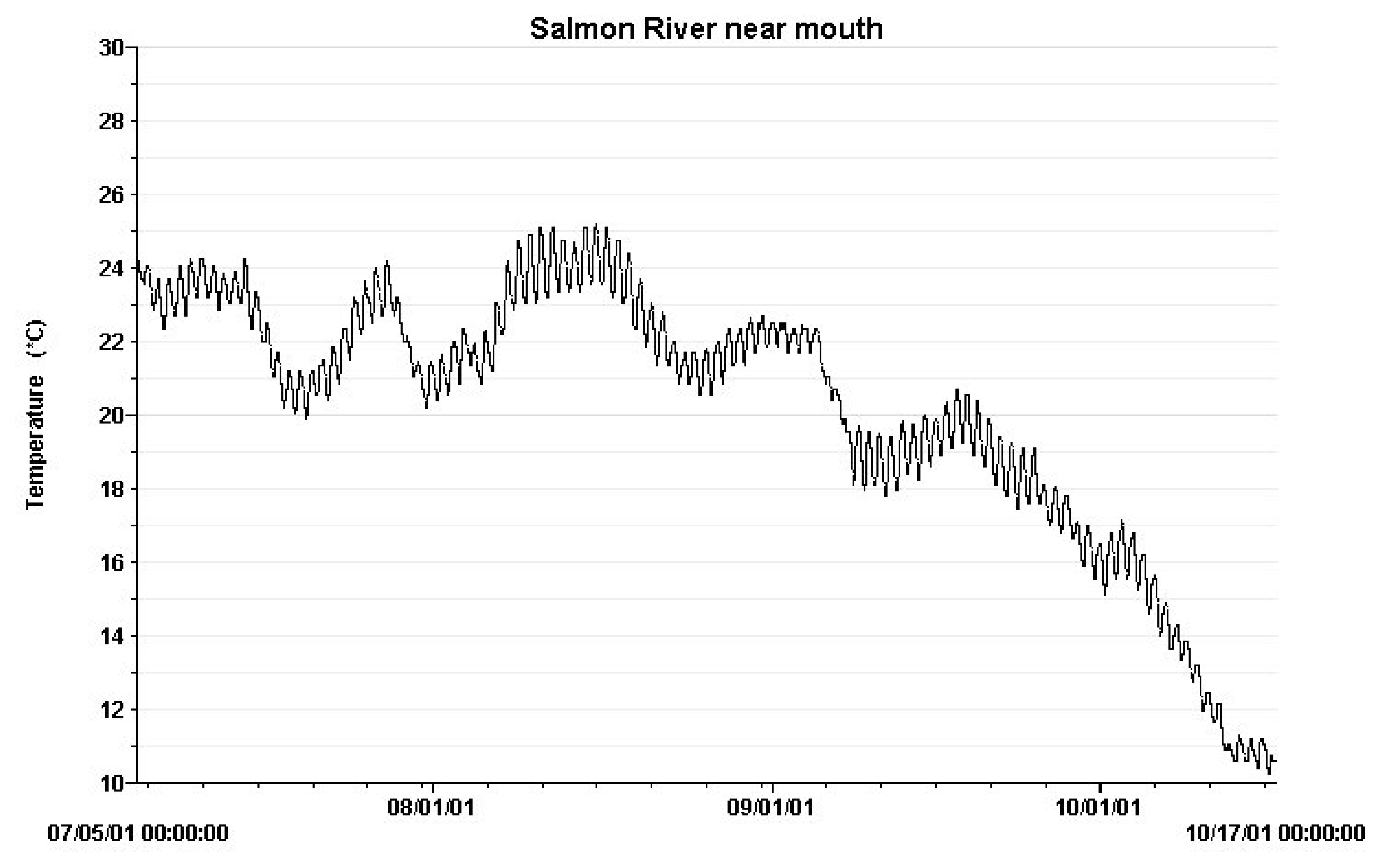
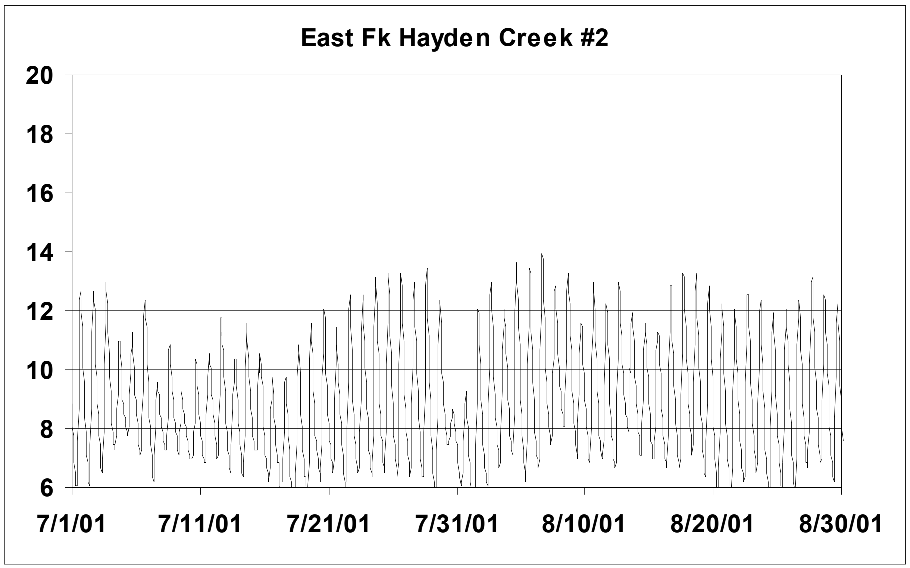


Figure 5. Water temperatures measured in the Salmon River in summer 2001 ¼ mile above its confluence with the Snake River.

East Fk Hayden Creek, #2 Ser# 299564

	Sub optimal cold T < 9°C	Sub optimal warm T > 15°C	Optimal T 9-15°C	Total hrs
Hours	869	0	619	1488
% of time	58.4%	0.0%	41.6%	
MDMT	13.9	6-Aug		
MWMT	13.2	8-Aug		
MDAT	10.3	8-Aug		
MWAT	9.7	10-Aug		
July/Aug Ave	8.87			
	Week of MWMT	July/Aug Total		
Hours >13°C	8	20		
% of time	4.8%	1.3%		



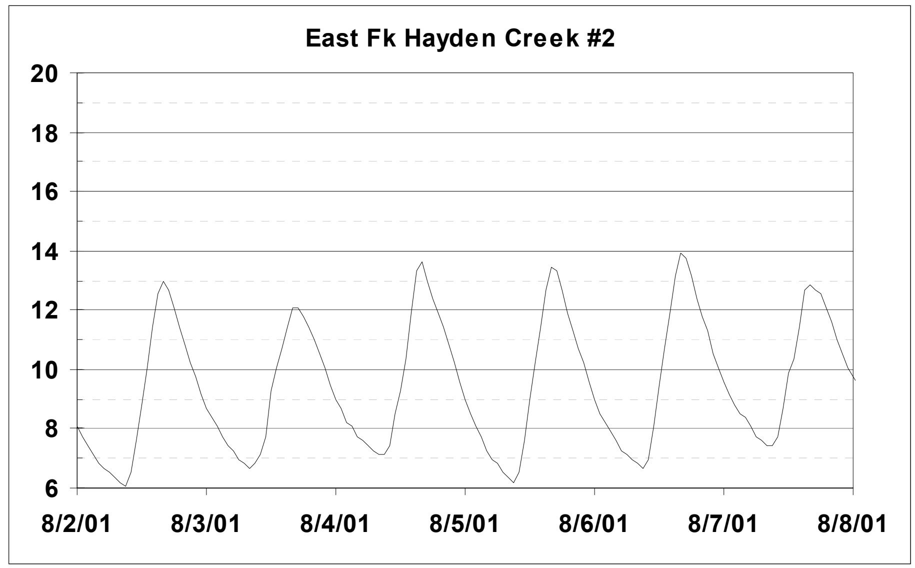
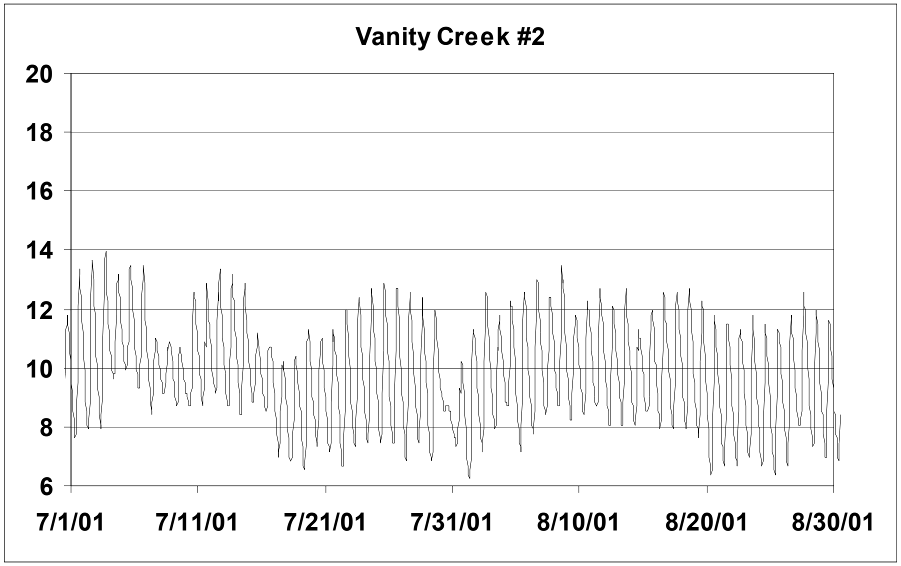


Figure 6. This temperature time series illustrates that due to fluctuating temperatures a real stream that comes close to meeting a MWMT of 13°C spends very little time at or above 13°C. In this case a total of 20 hours (1.3% of the time) through the two summer months of July and August .

Vanity Creek #2 Ser# 376441

	Sub optimal cold T < 9°C	Sub optimal warm T > 15°C	Optimal T 9-15°C	Total hrs
Hours	514	0	974	1488
% of time	34.5%	0.0%	65.5%	
MDMT	14.0	3-Jul		
MWMT	13.3	6-Jul		
MDAT	11.4	5-Jul		
MWAT	10.7	2-Jul		
July/Aug Ave	9.74			

	Week of MWMT	July/Aug Total
Hours >13°C	18	27
% of time	10.7%	1.8%



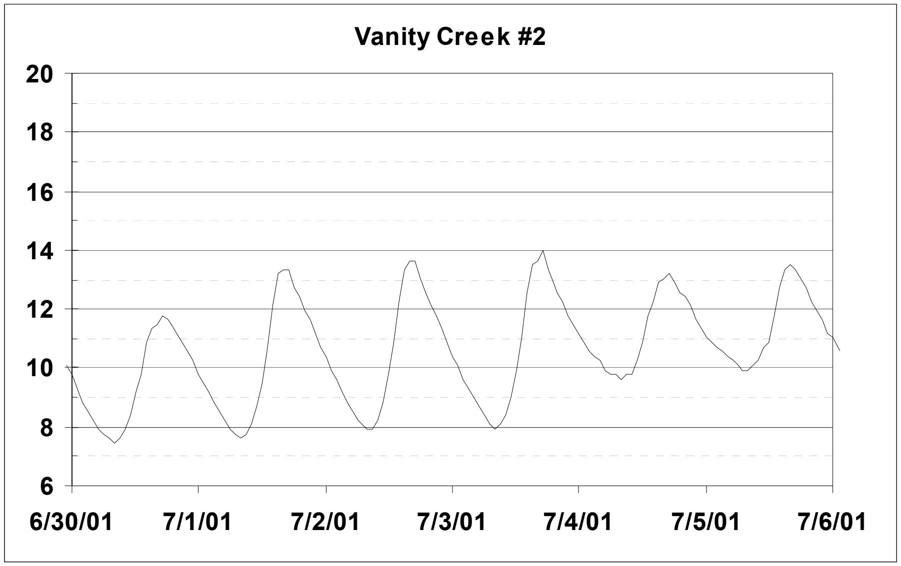


Figure 7. This temperature time series illustrates that due to fluctuating temperatures a real stream that comes close to meeting a MWMT of 13°C spends very little time at or above 13°C. In this case a total of 27 hours (1.8% of the time) through the two summer months of July and August .

Table 1. Selway 2000-2001 Water T Summary

Site	MDMT 22°C	MWMT 16°C	MDAT 19°C	MWAT 15°C	Date of ocurrence			
Running Cr.	**22.2**	**21.1**	18.6	**17.7**	A8	A12	A8	A13
Selway abv Running	22.0	**20.7**	**19.9**	**18.9**	A8	A12	A8	A13
Selway abv Bear	**23.7**	**22.8**	**21.0**	**20.1**	A7	A12	A8	A13
Bear Creek	**23.0**	**22.2**	**20.1**	**19.3**	A7	A12	A8	A13
Moose Creek	**25.0**	**24.2**	**21.2**	**20.4**	A7	A12	A8	A13
Selway abv Moose	22.0	**21.3**	**21.2**	**20.4**	A8	A13	A8	A13
Pinchot	**23.3**	**22.2**	19.0	**18.1**	A10	A14	A9	A14
Selway abv Pinchot	**22.2**	**21.7**	**21.3**	**20.7**	A15	A18	A8	A14
Max	25.0		21.3					
Min	22.0		18.6					
Moose Cr RAWS, Air T	61 days > 32.2°C, May 22nd/Sep 16th				A17	A17	A13	A16
Selway GS Air T	23 days > 32.2°C, June 21st/Aug 30th				A12	A17	A13	A17

Bolded values exceed respective criterion. Pink shaded cells are highest value among sites tabulated, turquoise shaded cells are lows. In date of ocurrence, A=August and J=July, with columns corresponding to temperature metrics to the left. With Air temperature (bottom two rows) the dates to the left indicate the first and last date of occurrence of daily maximum air temperature above 32.2°C (90°F).

Two sites barely meet Idaho's MDMT criterion of 22°C, but both of those fail to meet the MDAT of 19°C. Two other sites meet the MDAT, but fail the MDMT, thus no site meets cold water aquatic life criteria.

None of these sites comes close to meeting EPA's proposed criteria.

Temperature metric definitions:

MDMT – Maximum Daily Maximum Temperature, the highest daily maximum temperature recorded during the survey period at a site. This is the metric for Idaho's cold water biota criterion of 22°C, and salmonid spawning criterion of 13°C. In the case of the salmonid criterion, the applicable time period is when spawning is known to occur, not necessarily the entire survey period.

MWMT – Maximum Weekly Maximum Temperature, the highest weekly maximum temperature, that is, the peak in a series of seven-day running means of daily maximum temperatures during the survey period. This is the metric for Idaho's bull trout criterion of 13°C, and EPA's bull trout criterion of 10°C, both for juvenile rearing. Idaho's criterion applies June through August; EPA's June through September. This is also the metric for EPA's proposed juvenile rearing criterion of 16°C.

MDAT – Maximum Daily Average Temperature, the highest daily average temperature recorded during the survey period. This is the metric for Idaho's cold water biota criterion of 19°C and salmonid spawning criterion of 9°C.

MWAT – Maximum Weekly Average Temperature, highest weekly mean temperature, that is, the peak in a series of seven-day running means of daily average temperature during the survey period. This is the metric for EPA's proposed juvenile rearing criterion of 15°C.

Table 2. MF Salmon 2000-2001 Water T Summary

Site	**MDMT** 22°C	**MWMT** 16°C	**MDAT** 19°C	**MWAT** 15°C	**Date of ocurrence**			
MF Salmon @ Bndry Cr.	19.7	**18.8**	17.7	**16.7**	J4	J7	J4	J7
Indian Creek	**23.6**	**22.1**	17.3	**16.5**	A8	A11	A8	A11
MF blw Indian Cr	**22.8**	**21.6**	17.3	**16.9**	A8	A11	A8	A12
MF abv Sunflower Hot Spr	21.3	**20.3**	19.0	**18.3**	J12	J7	J4	J7
Little Loon	18.9	**17.8**	15.1	14.4	J2	J27	J12	A12
Loon Creek	21.6	**20.3**	18.4	**18.0**	A8	A12	A8	A12
MF abv Loon Cr	**23.3**	**22.2**	**20.6**	**19.9**	A8	J6	J4	J7
MF abv Camas Cr	**22.8**	**21.8**	**20.7**	**20.1**	J3	J7	J5	J7
Camas Creek	20.3	**19.1**	17.7	**17.1**	A8	A11	A8	A13
Wilson Creek	17.6	**16.8**	15.4	15.0	A8	A11	A8	A12
Big Creek	21.3	**20.4**	**19.2**	**18.8**	J3	A11	A9	A12
Papoose Creek	18.2	**17.3**	16.0	**15.6**	A8	A12	A8	A13
Ship Island Creek	16.0	15.5	15.0	14.5	J3	J7	J5	J9
MF @ Cliffside	21.8	**21.1**	**20.9**	**20.5**	J4	A12	A8	A12
Max	23.6		20.9					
Min	16.0		15.0					
Indian Creek GS Air T	14 days > 32.2°C, June 21st / Aug 27th				A6	A12	J4	J7
Bernard GS Air T	23 days > 32.2°C, May 22nd / Sep 4th				A6	J5	J3	J7

Bolded values exceed respective criterion. Pink shaded cells are highest value among sites tabulated, turquoise shaded cells are lows. In date of ocurrence, A=August and J=July, with columns corresponding to temperature metrics to the left. With Air temperature (bottom two rows) the dates to the left indicate the first and last date of occurrence of daily maximum air temperature above 32.2°C (90°F).

Four of 14 sites fail to meet Idaho's MDMT criterion of 22°C, and four sites fail to meet the MDAT of 19°C. Taken together, six of the 14 sites fail one or the other criterion thus fail to meet cold water aquatic life.

One of the 14 sites would meet EPA's proposed MWMT of 16°C, three of the 14 would meet EPA's proposed MWAT criterion. Only Ship Island Creek would meet all four criteria.