

TABLE III-1.—SUMMARY OF TEMPERATURE CONSIDERATIONS FOR SALMON AND TROUT LIFE STAGES—Continued

Life stage	Temperature consideration	Temperature and unit	Reference
	* Reduced Viability of Gametes in Holding Adults.	> 13 °C (constant) .....	Issue Paper 5; pp 16 and 75.
Juvenile Rearing .....	* Lethal Temp. (1 Week Exposure) .....	23–26 °C (constant) .....	Issue Paper 5; pp 12, 14 (Table 4), 17, and 83–84.
	* Optimal Growth. —unlimited food .....	13–20 °C (constant) .....	Issue Paper 5; pp 3–6 (Table 1), and 38–56.
	—limited food .....	10–16 °C (constant).	
	* Rearing Preference Temp. in Lab and Field Studies.	10–17 °C (constant) .....	Issue Paper 1; p 4 (Table 2). Welsh et al. 2001.
	* Impairment to Smoltification .....	<18 °C (7DADM) .....	Issue Paper 5; pp 7 and 57–65.
		12–15 °C (constant) .....	Issue Paper 5; pp 7 and 57–65.
	* Impairment to Steelhead Smoltification	>12 °C (constant).	
	* Disease Risk (lab studies) .....	.....	Issue Paper 4, pp 12–23.
	—High .....	>18–20 °C (constant).	
Adult Migration .....	—Elevated .....	14–17 °C (constant).	
	—Minimized .....	12–13 °C (constant).	
	* Lethal Temp. (1 Week Exposure) .....	21–22 °C (constant) .....	Issue Paper 5; pp 17, 83–87.
	* Migration Blockage and Migration Delay	21–22 °C (average) .....	Issue Paper 5; pp 9, 10, 72–74. Issue Paper 1; pp 15–16.
	* Disease Risk (lab studies).		
	—High .....	>18–20 °C (constant) .....	Issue Paper 4; pp 12–23.
	—Elevated .....	14–17 °C (constant).	
	—Minimized .....	12–13 °C (constant).	
	* Adult Swimming Performance.		
	—Reduced .....	>20 °C (constant) .....	Issue Paper 5; pp 8, 9, 13, 65–71.
	—Optimal .....	15–19 °C (constant).	
	* Overall Reduction in Migration Fitness due to Cumulative Stresses.	>17–18 °C (prolonged exposures).	Issue Paper 5; p 74.

TABLE III-2.—SUMMARY OF TEMPERATURE CONSIDERATIONS FOR BULL TROUT LIFE STAGES

Life stage	Temperature consideration	Temperature and unit	Reference
Spawning and Egg Incubation.	* Spawning Initiation .....	<9 °C (constant) .....	Issue Paper 5; pp 88–91.
	* Temp. at which Peak Spawning Occurs	<7 °C (constant) .....	Issue Paper 5; pp 88–91.
	* Optimal Temp. for Egg Incubation .....	2–6 °C (constant) .....	Issue Paper 5; pp 18, 88–91.
	* Substantially Reduced Egg Survival and Size.	6–8 °C (constant) .....	Issue Paper 5; pp 18, 88–91.
Juvenile Rearing .....	* Lethal Temp. (1 week exposure) .....	22–23 °C (constant) .....	Issue Paper 5; p 18.
	* Optimal Growth. —unlimited food .....	12–16 °C (constant) .....	Issue Paper 5; p 90. Selong et al 2001. Bull trout peer review, 2002.
	—limited food .....	8–12 °C (constant).	
	* Highest Probability to occur in the field	12–13 °C (daily maximum) .....	Issue Paper 5; p 90. Issue Paper 1; p 4 (Table 2). Dunham et al., 2001. Bull trout peer review, 2002.
	* Competition Disadvantage .....	>12 °C (constant) .....	Issue Paper 1; pp 21–23. Bull trout peer review, 2002.

#### D. IGDO Criterion for Salmonid Spawning

##### 1. Background

The early life stages of fish are recognized as being the most sensitive and requiring relatively high DO concentrations. The oxygen demand by embryos depends on temperature and on the stage of development with the greatest DO required just prior to hatching. When water temperature is near 15°C/58°F, maximum critical levels of DO (where ambient levels meet

metabolic needs) for steelhead embryos were estimated at 10.2 mg/L (Rombough, 1986). Rombough (1986) and other researchers have shown that critical oxygen concentration increases with temperature and with the stage of development of the fish. In experiments to determine critical DO levels in steelhead embryos, Rombough (1988) found that critical DO levels rose from less than 1.0 mg/L shortly after fertilization to 9.7 mg/L prior to hatching (implies an IGDO of at least 6.7

mg/L), depending on the temperature. The crucial timing of IGDO, stream temperature, and flow rate varies with each salmonid. Evolutionarily Significant Unit's specific characteristics. Sowden and Power (1985) observed that survival in field studies is negligible when IGDO falls below 5 mg/L. This is consistent with other studies. Phillips and Campbell (1962) and Maret *et al.* (1993) observed no or negligible survival in field studies where IGDO fell below 8.0 mg/L.