Response to Public Comments on Idaho's Steelhead Fishery Management and Evaluation Plan

February 8, 2019

PO Box 25
600 S. Walnut St.
Boise, ID 83707

The Idaho Department of Fish and Game (Department) reviewed the comments received by the National Marine Fisheries Service (NOAA Fisheries) to our Recreational Steelhead Fisheries Management and Evaluation Plan (hereafter FMEP), per the Federal Register Notice (83 FR 55523, November 6, 2018). Our response is provided below.

Cite as: Idaho Department of Fish and Game (IDFG). 2019. Response to Public Comments on Idaho's Steelhead Fishery Management and Evaluation Plan, Boise, ID.

*Comment 1: Some commenters questioned the purpose of the proposed FMEP and suggested that the Page **2** of **27**agency priority should be recovery of wild steelhead.*

Response: The recovery of wild steelhead is a priority and there is a recovery plan that outlines limiting factors and actions needed for recovery (NMFS 2017); however, the focus of the FMEP review and approval process is evaluating fisheries targeting non-listed fish and limiting their impacts to listed fish. This particular FMEP process evaluates the Idaho Department of Fish and Game's (Department) fisheries on non-listed hatchery steelhead so that their effects on wild steelhead are limited.

We also point out that the Department's Statewide Fisheries Management Principles (IDFG 2019a) reflect the importance of these issues:

- Native populations of resident and anadromous fish species will receive priority consideration in management programs.
- Management programs will emphasize maintenance of self-sustaining populations of fish.
- The Department will strive to maintain genetic integrity of native stocks of resident and anadromous fish and naturally-managed fish when using hatchery supplementation.
- Hatchery-reared fish will be stocked as appropriate to preserve, establish, or reestablish depleted fish populations and to provide angling opportunity to the public.

And specific to Anadromous Fisheries Management:

The Department's long-range goal of the anadromous fish program is to rebuild and preserve Idaho's salmon and steelhead runs to healthy and harvestable levels to provide benefits for all users. Key management objectives to achieve the management goal are: (1) maintain genetic and life history diversity of naturally- and hatchery-produced fish; (2) rebuild naturally- reproducing populations of anadromous fish to utilize existing and potential habitat at an optimal level; (3) achieve equitable mitigation benefits for losses of anadromous fish caused by development of the hydroelectric system on the Snake and Columbia rivers; (4) improve overall life cycle survival sufficient for delisting and recovery by addressing key limiting factors identified in all "H's" of hydropower, habitat, harvest, and hatchery effects.

State of Idaho seasons and rules prohibit anglers from targeting wild steelhead; all wild steelhead must be immediately released (Idaho Administrative Code 13.01.01.11.405). Fisheries authorized via the FMEP will occur in areas dominated numerically by hatchery steelhead. Areas where wild steelhead occur without comingling with hatchery steelhead are closed to steelhead fishing.

Comment 2: Some comments referred to the impacts of hatcheries, impacts of hatchery releases on natural spawning populations, locations of hatchery releases and concerns regarding proportions of unmarked hatchery steelhead released (i.e.., hatchery origin steelhead without clipped adipose fins).

Response: Other ESA processes evaluate hatcheries; the purpose of the FMEP process is to describe the fisheries management, monitoring, and evaluation strategies of recreational fisheries that may intercept ESA-listed salmon and steelhead. NOAA Fisheries addresses hatchery management through the review and consultation on Hatchery and Genetic Management Plans (HGMPs) and other agency consultations and analyses, such as the U.S. v. Oregon Columbia River Environmental Impact Statement (NMFS 2018). NOAA Fisheries and other US *v.* Oregon Parties (the States of Oregon, Washington, and Idaho, the Nez Perce Tribe, Shoshone-Bannock Tribes, Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakima Nation, and the U.S. Fish and Wildlife Service) developed the numbers of hatchery steelhead released, including numbers of adipose fin-clipped and unclipped fish (NMFS 2018).

Comment 3: "The 5% average per-encounter mortality rate is too low".

Response: A number of comments stated that the 5% mortality rate used to calculate the potential mortality of wild steelhead encountered in the fishery targeting hatchery steelhead was too low. Some commenters suggested using a 10% or 15% mortality rate. Many aspects of the studies referenced by these commenters—that reported rates higher than 5% --do not reflect fishery conditions in Idaho.

As background, in conjunction with the review and approval of prior permits, NOAA Fisheries and the Department developed the 5% mortality rate through literature review. The Response to Comments on the 4(d) rules governing Take of Threatened Salmon and Steelhead referenced this value: "NMFS agrees that hooking mortality deserves further investigation and we are committed to doing so. However, for now the 5 % rate reported in Hooton (1987) seems to constitute a reasonable average. Other studies do show higher mortality rates for salmonids when stream temperatures are elevated but for most conditions; Hooton's estimates are reasonably accurate." (65 FR 42448, July 10, 2000).

The Department has continued to review scientific literature and conduct relevant research related to catch-and-release (C&R) mortality rates for steelhead, including recent reviews of the studies originally used to inform the 5% rate referenced in the previously approved permits (summarized in Table 1). Our review supports the continued use of 5% as applied to the proposed fisheries. Indeed, our review indicates that the 5% mortality rate likely over-estimates the mortality rate of released steelhead. The median mortality rate reported in available research on C&R mortality rates (Table 1) is 4.2%, and the median rate is 3.9% if the Mongillo study (1984) is excluded. The Mongillo study reported mortality rates of 11% for steelhead collected for broodstock in Washington. However, Hooten (2001) noted the steelhead in Mongillo's study were tethered through the gills before transport to the hatchery, which likely resulted in critical injuries that would not be representative of C&R mortality in Idaho fisheries. In addition, the Mongillo study could not differentiate holding mortality from hooking mortality. Taylor and Barnhart (1997) reported a C&R mortality rate of 8.7% in California's Mad and Trinity Rivers, but higher mortality rates were associated with warmer water temperatures. Mortality rates were greater than 5% at water temperatures above 19°C (66.2 Fahrenheit) and were less than 5% as temperatures declined below 19°C. (We discuss water temperatures of the Idaho Steelhead Fishery under *Comment 9*).

One comment suggested that we should not consider mortality rates for studies of fish brought into a hatchery after C&R because the hatchery fish are not exposed to the same environmental conditions as wild fish (e.g., water temperatures, predation, and migrating and spawning). We note that broodstock studies provide longer time frames to assess hooking mortality, including up to the point of spawning, and they frequently involve additional handling beyond what would be expected from a capture event in a C&R fishery. Additionally these fish are subjected to confinement in hatchery trucks, transportation back to the hatchery facility and containment in high density holding ponds prior to spawning. Recently Whitney et al. (in press) evaluated pre-spawn mortality of steelhead broodstock collected in the South Fork Clearwater River, Idaho via volunteer anglers. Whitney (in press) found that pre-spawning mortality associated with angling, holding on-site in fish tubes, transfer to a fish truck, and transportation to Dworshak National Fish Hatchery (a minimum of one-hour drive time from the fishery) was less than 3% for the 1,148 steelhead included in the study. We cover potential water temperature, sublethal, and reproductive success effects in *Comments 6 and 9*.

Table 1. Reported steelhead C&R mortality rates, including the location of the study, type of study, sample size, and overall mortality rate.

Citation	Location	Type of Study	Sample Size	Mortality Rate
Lough (1980)	Skeena River	C & R for radio-tagging	181	3.9%
Hooten (1987)	Vancouver Island, BC	C & R for broodstock	3,715	3.4%
Hooten (1987)	Keogh River	C&R	336	5.1%
Mongillo (1984)	WA streams	C & R for broodstock	390	11.0%
Thomas (1995)**	Skeena River	C&R	21	4.6%
Nelson et al. 2005	Vedder-Chilliwack River, BC	C&R for radio-tagging	226	3.6%
Twardek (unpublished data)*	Bulkley River, BC	C&R	N/A	3.0%
Taylor and Barnhart (1997)	Trinity River, Mad River, CA	C&R	126	8.7%
Whitney et al. (in press)	South Fork Clearwater River, ID	C & R for broodstock	1148	3.0%
Twardek et al. (2018)	Bulkley River, BC	C&R	129	4.5%

*available at www.psmfc.org/steelhead/2018/Twardek_PSMFC.pdf
**as cited in Hooten (2001)

Many of the commenters cited the Twardek et al. (2018) study as support for a higher C&R mortality rate, with some commenters referencing the study's overwinter mortality rate of 15% (which reflects all sources of mortality). However, the Twardek study's 3-day mortality rate following study handling (4.5%) is more likely to correspond to angling-related (C&R) mortality, as the majority of mortality from angling occurs within 24-48 hours of the catch event (Wood et al. 1983, Mongillo 1984, Muoneke and Childress 1994, Meka et al. 2004). As to the 15% overwinter mortality rate Twardek study, winter generally has the highest rate of natural mortality of any season for salmonids (see review by Brown et al. 2011). Twardek et al. (2018) did not have data on overwinter mortality for fish not subject to a C&R event, so there is no context for determining the component of C&R mortality in the overwinter period. The Twardek study also assumed that no fish lost their tags during this seven-month period, acknowledging that any tag loss would inflate their estimate of overwinter mortality. Additionally, Twardek et al. (unpublished data) reported annual C&R mortality rates of less than 5% for the past 15 years in the Bulkley River. Overwinter mortality is likely controlled by factors not associated with the fishery and is therefore not a reasonable point of reference for C&R mortality.

Comment 4: A number of commenters referred to wild steelhead as more aggressive and disproportionately susceptible to angling encounters than hatchery steelhead.

Response: We are not aware of any peer-reviewed studies that show that wild salmon or steelhead are disproportionately susceptible to angling relative to hatchery steelhead.

Studies investigating hatchery trout stocking and angling have found that hatchery-origin salmonids have a higher susceptibility to angling than wild fish, but these studies have either focused on juvenile salmon or adult trout (brook trout; Mezzera and Largiader 2001, see review in Weber and Fausch 2003). To our knowledge, there are only two peer-reviewed studies comparing vulnerability to angling for adult hatchery and wild salmon/steelhead. Nelson et al. (2005) evaluated steelhead distribution and vulnerability to angling for steelhead in BC. Nelson et al. (2005) found that hatchery and wild fish had similar spatial distributions, but that hatchery fish were recaptured at twice the rate of wild fish despite being tagged in similar numbers. Holtby et al. (1992) evaluated angling vulnerability for Coho Salmon and Chinook Salmon in an inlet in British Columbia. The authors found that marked Coho and Chinook were overrepresented in the sport catch, indicating that hatchery fish were more vulnerable to the sport fishery than wild fish.

Evidence regarding relative aggressiveness of wild versus hatchery-origin steelhead is inconclusive. We re-reviewed the popular article from Seals and French (2009), which was the basis of many of the comments suggesting wild steelhead were more aggressive. Seals and French described anglers encountering wild steelhead in the Deschutes River in greater proportions than those observed at the Sherars Falls collection facility upstream of the fishery. The authors stated that they do not have a good explanation for the discrepancy but referenced a range of potentially valid explanations for the reported difference: (1) wild fish may be more aggressive, (2) anglers may be over-reporting the number of hooked wild fish, or (3) the proportions of fish enumerated at the collection facility above the fishery reported in the study may not be representative of the population below the collection facility susceptible to angling.

Studies have shown angler bias and misreporting of C&R events (Sullivan 2003, McCormick et al. 2015). There may also be differences in spatial distributions of hatchery and wild fish within a stream system as hatchery fish tend to home back to their release locations (Nelson et al. 2005, Ludwig 1995). Many of the steelhead caught in the Deschutes River fishery are from other drainages and use the lower Deschutes River as a cool water refuge (Hess et al. 2016). So wild/hatchery proportions available to the fishery downstream of Sherars Falls may be higher than those observed/collected at Sherars Falls.

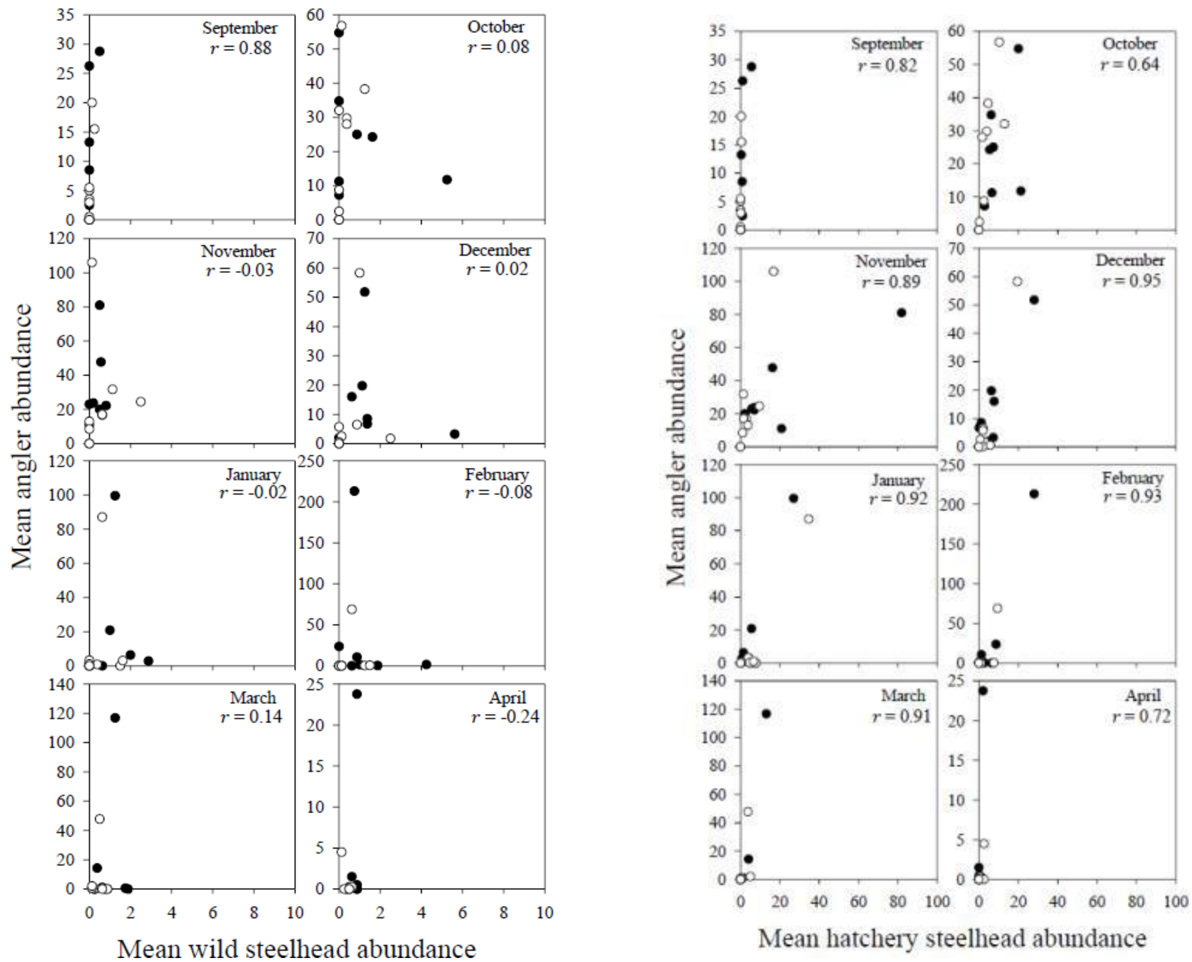
The realized fishery encounter rate also depends on overlap of the fish with anglers in time and space. Within Idaho, Feeken (2018) compared the distribution of steelhead anglers, hatchery steelhead and wild steelhead across reaches of the Clearwater River over an 8-month period in 2017 and 2018. She found a high correlation between the presence of hatchery steelhead and anglers from September through April and very little spatial overlap between anglers and wild fish after September. The harvest season on the main stem Clearwater is closed until October 15, which reduces fishing effort during this time. Anglers targeting hatchery steelhead concentrations would likely result in wild steelhead being encountered at a lower rate than hatchery fish in the Clearwater River.

Current information further suggests that wild encounter rates may be biased high due to the following reasons: (1) substantial portions of the Salmon and Clearwater rivers (e.g., Lochsa, Selway, Middle Fork Salmon, South Fork Salmon) supporting wild steelhead are closed to steelhead fishing, (2) in the spring, many anglers target large concentrations of hatchery fish such as in the upper Salmon and North and South Fork Clearwater rivers (supported by Feeken 2018), (3) anglers may report more wild fish having been caught and released than actually occurred, (4) there is different run-timing of hatchery and wild fish in the Clearwater River. The Department has committed to refining our understanding of steelhead encounter rates and hooking mortality. Subsequently, the Department is planning to work with the University of Idaho to research encounter and hooking mortality rates of wild and hatchery steelhead over the next 5 years.

Figure 1. Excerpted from Feeken 2018. The weekly mean abundance per reach by month of a) wild steelhead and b) hatchery steelhead and anglers across eight sampling reaches during spawn year 2017 (closed circle) and spawn year 2018 (open circle). Pearson correlation coefficients (r) are included.

a) Wild steelhead abundance

b) Hatchery steelhead abundance



Comment 5: Some commenters asserted that wild fish may be caught and released multiple times, which is not accounted for in the C&R mortality rate.

Response: We reviewed the literature and found no evidence that fish caught and released multiple times have higher mortality rates. Peer-reviewed studies, have found no difference in survival of fish captured and released multiple times (Nelson 2005). Bartholomew and Bohnsack (2005) "found no studies of cumulative mortality from multiple C&R events for individual fish", and provided a predictive model of survival rates, (to date unsubstantiated). Richard et al. (2013) did not directly address reproductive success for re-captured adults but did note that two Atlantic Salmon were caught multiple times and successfully spawned and produced many juveniles. Ultimately, catch rates of individual fish may increase with certain traits (citing shyness and domestication as well as aggressiveness; Ruzzante 1994) or may decrease as a result of learning hook avoidance (Askey et al. 2006). There is no evidence to suggest that hooking mortality increases with capture rates. Although some comments cited Cooke et al. (2013) and Twardek et al. (2018) to assert that multiple captures of wild steelhead elevate risk of mortality and deplete energy reserves for successful reproduction, neither of these studies presents data to support those assertions.

Comment 6: Some comments asserted the FMEP fails to consider the effects of catch and release encounters or air exposure that may not be lethal but which involve damage sufficient to have a negative impact on reaching spawning grounds or actual spawning.

Response: Some study authors have hypothesized sublethal detrimental effects in the form of altered behavior, negative physiological response, or increased risk of disease or predation, but studies have not presented clear mechanisms or responses from C&R effects of angling on mortality or reproductive success. There are currently no conclusive data to indicate that sublethal effects have a population-level impact on wild steelhead reproduction. Further, the majority of studies investigating angling and air exposure (see below for more detail) have reported little or no increase in mortality of released fish (Schreer et al. 2005; Gingerich et al. 2007; Thompson et al. 2008; Gagne et al. 2017; Louison et al. 2017).

Few studies have directly assessed the reproductive success of angler-caught fish. The results of these studies suggest that individual fish surviving C&R show no meaningful long-term effects on reproduction. Most recently, Whitney et al. (in press) found that fight duration and air exposure did not reduce survival to the free-swimming stage for progeny of hatchery steelhead. Other studies of gamete viability (i.e., fertilization rates after spawning) have shown no differences between angled and non-angled steelhead (Hooton 1987; Pettit 1977) or Atlantic Salmon (Davidson et al. 1994, Booth et al. 1995). Richard et al. (2013) studied the reproductive success of Atlantic Salmon captured by anglers as they traveled upstream to spawn. They reported that it was unclear whether 5 of the 40 fish did not reach the spawning location because they died or because they were just “dip-ins” that went back to the ocean. With the five fish of unknown fates excluded, Richard et al. (2013) reported that angled Atlantic Salmon had the same probability of reproduction as the uncaught salmon. With these five fish included as presumed mortalities, the study found some relationship between C&R fishing mortality and reproductive success, but only for larger fish. There was overlap in the standard errors around the estimates, indicating that this relationship was weak. Study fish of lengths 65 cm produced ~15 offspring, fish of length 100 cm produced ~12 offspring; the two fish caught multiple times produced 16 and 25 offspring, respectively. Richard et al. (2013) hypothesized that larger fish may be played to exhaustion at a greater rate, but also recognized that other studies investigating fish size and hooking mortalities have inconclusive results. Richard et al. (2013) looked at the interaction of angling, air exposure and water temperature. Richard et al. (2013) found that fish exposed to air when water temperatures were below 17°C had reduced reproductive success, but also found those exposed to air when water temperature was warmer than 17°C had *increased* reproductive success. These counterintuitive findings might be a result of small sample size.

Several studies observing behavioral movements after C&R found no effect on the ability of fish to spawn. In Idaho, Reingold (1975) removed steelhead from a trap, hooked and played them to exhaustion and tagged them and released them downstream along with a control group that was transported and released without simulated angling. Reingold reported no difference in return rates between the two groups. Twardek et al. (2018) evaluated physiological and behavioral responses in steelhead from C&R and reported no difference in fish movement two weeks after capture and no long term behavioral impairments. While there appeared to be an initial stress response from angling, survival to winter was reported as 94%, suggesting adequate recovery subsequent to angling. For Atlantic Salmon, Richard et al. (2014) reported some differences in behavior of C&R fish but stated that “the observed influence of C&R on the migratory behavior of Atlantic Salmon likely has little or no impact on salmon fitness in terms of survival and reproductive success.” Lennox et al. (2015) used radio-telemetry to compare the migration of 27 C&R Atlantic Salmon to a control group captured in bag nets at sea that later entered the River Guala watercourse in central Norway. Lennox et al. (2015) concluded that C&R fish migrated shorter distances than the control fish but noted that this difference may not lead to an effect on reproduction as all the fish were observed in the spawning areas at spawning time. Lennox et al. (2016) used radio-telemetry to evaluate migration and survival of C&R Atlantic Salmon in Norway. While they state that there could be a sublethal effect in the abstract, they provide no support in the body of the paper. They found high survival of the fish released by anglers and that movement appeared to be shortened but they were unsure of the effects on fitness; they speculated that it could cause density-dependent effects by concentrating large numbers of fish into a spawning area. They also speculated that the salmon did not continue migrating because they were at the end of their migration. Thorstad et al. (2007) used radio-tracking to evaluate survival and migration of C&R Atlantic Salmon in Norway. They reported the highest survival rates of any other C&R Atlantic Salmon study. The C&R fish displayed an unusual downstream movement and a delay in upstream migration, but the authors stated that the importance of this finding is uncertain because if the fish arrive on the spawning grounds in time for spawning season, then there should be no effect on reproductive success. They did not further evaluate spawning or reproductive success.

Comment 7: Several commenters called for mandatory requirements to keep fish in the water.

Response: Air exposure, fight time, and associated lethal and non-lethal stress on fish have been the subject of substantial research. Comments suggesting that fish remain in the water during catch and release appear to be tied to a belief that air exposure has detrimental impacts on either survival of released fish or sublethal impacts on fish that may reduce reproductive success. The majority of studies investigating air exposure have reported little or no increase in mortality of C&R fish (brook trout, Schreer et al. 2005; bluegill, Gingerich et al. 2007; largemouth bass, Thompson et al. 2008; golden dorado, Gagne et al. 2017; northern pike, Louison et al. 2017).

Comments advocating keeping fish in the water referenced a study of air exposure conducted by Ferguson and Tufts (1992). However, the authors of this study have themselves cautioned that their results may not be applicable to actual recreational fisheries given the extreme procedures of their experiment (Ferguson and Tufts 1992; Cook et al. 2015). Ferguson and Tufts (1992) exhaustively exercised hatchery Rainbow Trout by chasing them for 10 minutes, to the point that fish could no longer respond to further stimulation. Fish were then exposed to air for 0, 30, and 60 seconds, and experienced mortality rates of 12, 38, and 72%, respectively. However, these fish were the subject of repeated blood sampling during the experiment, through tubes surgically inserted in the fish before exercising (i.e., the fish were cannulated). The mortality rates were elevated as a result of the extreme conditions the fish were subjected to, as evidenced by the 12% mortality rate for fish not even exposed to air.

More recently, Cook et al. (2015) recommended a maximum of 10 seconds of air exposure for C&R fish based on results from the study of Atlantic Salmon by Richard et al. (2013). This study involved angler C&R of Atlantic Salmon as they traveled upstream to spawn. A tissue sample was taken from each fish for genetic analyses, and the angler recorded how long the fish was exposed to air before release. After the spawning season, backpack electrofishing was used to capture age-0 fish that were then genetically assigned back to adult fish to evaluate the relationship between air exposure and production of progeny. The authors reported that Atlantic Salmon exposed to air for more than 10 s had two to three times lower reproductive success than fish not exposed to air. However, this study had a small sample size of only 40 adult fish angled and only 24 exposed to air. Given the high variability in reproductive success found in this study (and salmonids in general, Fleming and Reynolds 2003), and the fact that many salmonids do not produce any offspring in the wild, the small sample size is concerning as a few individuals can bias results. Richard et al. (2013) found longer exposure to air resulted in *increased* reproductive success when the water was warmer (> 17°C), which is contrary to nearly all other studies on the relationship between production of salmonids and water temperature, and the authors do not have a good explanation for the pattern and interaction observed. We believe that this study cannot be used to assess the effects of a C&R event on steelhead reproduction given that it is a different species and due to the study limitations related to sample size and water temperature.

Twardek et al. (2018) studied air exposure in steelhead but did not report mortality rates for air-exposed treatments in the published study. Through recent personal communication, Twardek stated that only one fish died in the 30 s air-exposed group and no fish died in the 0 or 10 s air exposed groups after 3 days. Furthermore, there were more overwinter mortalities in the 10 s air-exposed group (N=4 out of 22) than in groups with shorter or longer air exposures, (mortality in the 0 s air-exposed group (N=1 out of 18) or 30 s air-exposed group (N=1 out of 18) respectively. The short-term stress and behavioral response did not lead to elevated mortality in the 30 s group relative to the 0 s group. We present these results because they do not fit the hypothesis that longer air exposures results in higher stress/mortalities. However, these results may be limited by sample size and Twardek et al. (2018) recommended the 10 s rule without direct evidence for its necessity.

Two other studies have been published that evaluate salmonid reproductive success in relation to air exposure. Raby et al. (2013) observed no reduction in spawning success after simulated capture by anglers and up to 60 s of air exposure for Chum Salmon and Pink Salmon. In the most comprehensive study to date on this subject, Roth et al. (2018a) caught nearly 2,300 adult Cutthroat Trout migrating to their spawning grounds and found no post-release mortality and no reduction in their reproductive fitness for fish angled and exposed to air for up to 60 seconds prior to release.

One of the most important aspects of the air exposure debate is knowledge of fight times and how long anglers actually expose fish to air during a C&R event. To our knowledge, the Department is the first to conduct such research with robust sample sizes. Lamansky and Meyer (2016) found that for Idaho trout anglers (N = 280), fight time averaged 53 seconds and total air exposure averaged 29 seconds, with 95% of anglers holding trout out of water for <60 seconds before releasing them. A subsequent study in Idaho confirmed similar fight times (mean = 40 seconds) and air exposure times (mean = 19 seconds) by anglers in other trout fisheries (Roth et al. 2018b). Steelhead anglers in Idaho exposed angled steelhead to a similar amount of air before release (mean = 28 seconds); anglers in Idaho took slightly longer to fight and land a steelhead (mean = 130 seconds) compared to trout (Chiaramonte et al. 2018). Air exposure of steelhead was equivalent between fly tackle anglers and conventional tackle anglers, but fight time was more than 50% longer for fly tackle anglers compared to conventional tackle anglers. While Chiaramonte et al. (2018) did not estimate mortality rates of C&R steelhead, they concluded that the conditions that fish were exposed to suggest minimal population-level effects based on previous literature. These studies reveal that the majority of anglers fight and expose fish to air for shorter times than what has been typically tested in the air exposure C&R literature (albeit for different species). Whitney et al. (in press) found that neither the survival of adults to spawning, nor the subsequent hatchery ponding success of their progeny, was negatively influenced by fight and air exposure times for adult hatchery steelhead caught by recreational anglers. Air exposure times in the Whitney study were similar to the general angling public.

Cook et al. (2015) stated that various factors can collectively interact and contribute to a stress response, and recognized the difficulty in differentiating air exposure from other factors such as water temperature, laboratory or field setting, exercise duration, and condition of the individual fish. The Department has taken the initiative to perform studies in Idaho to help inform the science and management of recreational fisheries and C&R impacts. At this point, there is not compelling evidence as to negative impacts from air exposure in C&R occurring during Idaho steelhead or trout fisheries to warrant prohibiting the removal of steelhead or trout from the water for release.

As a matter of angler ethics and respect for fishery resources, the Department provides general guidance for Releasing Fish under the General Information section of the Seasons and Rules pamphlet as well as guidelines for properly photographing and releasing fish (IDFG 2019b). The Department likewise publishes guidelines for Releasing Wild Salmon and Steelhead in the Idaho Fishing 2019-2021 Seasons and Rules pamphlet which state (IDFG 2019b):

> Please help ensure the survival of released wild salmon and steelhead by:
>
> - Using proper sized gear and keep fight time to a minimum,
> - Not pulling fish onto rock, sand or dirt banks and instead, use a net or “tail” the fish,

- Minimizing time out of water,
- Not handling fish by the gills,
- Reviving the fish by gently holding it in the water if necessary,

Comment 8: Comments requested the FMEP prohibit the following while steelhead fishing in Idaho: barbed hooks, fishing with bait and fishing with treble hooks.

Response: The FMEP reflects that Idaho rules already require barbless hooks while fishing for steelhead and salmon in the Salmon and Clearwater drainages and the Snake River below Hells Canyon Dam. Barbed hooks are only allowed when hatchery fish are released into non-anadromous terminal fisheries in the Boise River and the Snake River between Hells Canyon Dam and Oxbow Dam, where no wild salmon or steelhead are present.

The level of C&R hooking mortality is determined by an interaction of factors: angler experience, fishing technique, fish size, fight time, hook type, hook size, hooking location, water temperature and, subsequent injuries, all of which is variable by species. The anatomical hooking location (and associated bleeding) was cited as the most important factor influencing C&R morality (Meka et al. 2004). Deep hooking is strongly associated with mortality for non-anadromous salmonids when using bait (Wydoski 1977, Pauley and Thomas 1993, Schill 1996). Because deep hooking is strongly associated with mortality, if bait fishing for steelhead does not elevate deep hooking, it also should not elevate mortality of caught-and-released steelhead. A recent Department study found that steelhead caught with bait were no more likely to be deep hooked than steelhead caught without bait; overall deep hooking rate in the study was 0.6% (Chiaramonte et al. 2018). Idaho does not prohibit bait fishing in steelhead fisheries, but we note that steelhead do not feed actively once they have entered freshwater which may minimize deep hooking rates.

The majority of hooking-mortality studies for salmonids have investigated resident trout and not anadromous salmon or steelhead (e.g., Hunsaker et al. 1970; High and Meyer 2014, Wydoski 1977, Muoneke and Childress 1994). These studies found higher rates of deep hooking and mortality when using bait, but that active fishing with an immediate hook set reduced the time for baited hooks to be ingested and that cutting the line rather than trying to remove the hook led to higher levels of survival To date, the salmon and steelhead studies present mixed or inconclusive results regarding whether the use of bait leads to higher mortalities (Cowx et al. 2017). Hooton (1987, 2001) found slightly higher rates of hooking mortality with bait (5.6%) relative to lures (3.8%) for steelhead, but the average was within the 5% rate. Twardek et al. (2018) reported the total rate of deep hooking mortality for steelhead as 3%. Twardek et al. (2018) cites that immediate hooking mortality for bait-angled steelhead ranged from 0.31 to 11% for other studies, with a mean of 4.0%. Bendock and Alexandersdottir (1992) found no difference in mortality for Chinook Salmon caught with bait and without bait. Lindsay et al. (2004) found survival was better for Chinook Salmon caught with bait than Chinook Salmon caught on lures. There is no evidence to suggest that there are greater impacts to steelhead from bait fishing.

Besides the issue of bait, there is often concern among anglers that the use of treble hooks causes more C&R mortality than single hooks. Similar to above, there is not conclusive evidence for steelhead to indicate that treble hooks lead to higher mortality rates. Wydoski (1977) noted that most studies up to that point in time had demonstrated an opposite effect: single hooks generally resulted in higher mortality rates than treble hooks. He argued that perhaps single hooks are easier to swallow than treble hooks, or perhaps they look more natural as part of the total lure than a treble hook does and that results in higher rates of deep hooking, and thus, hooking-related mortality. Bartholomew and Bohnsack (2005) stated that there were not enough studies to look at mortalities related to treble hooks. They hypothesized that treble hooks may cause less mortality because they are difficult to swallow or conversely, may cause more tissue damage at the hooking locations, and ultimately the degree of mortality is uncertain. Taylor and Barnhardt (1997) found no statistically significant difference in mortalities between steelhead caught with single and treble hooks.

Comment 8: Several commenters suggest specific reach closures where wild fish may be encountered and vulnerable to fishing stating, "there are no active measures to protect wild steelhead in low-run years."

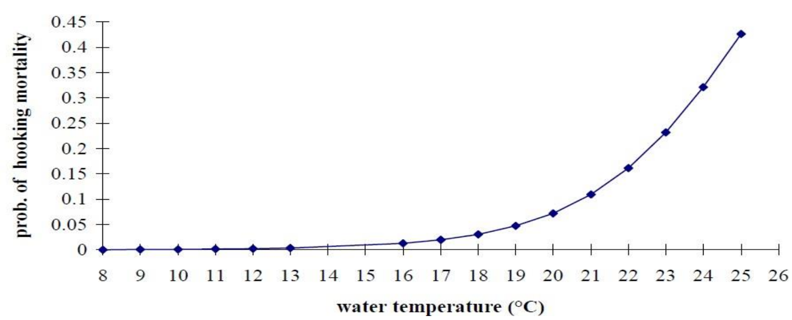
Response: Commenters suggested closures for various reaches of river with assertions they would protect specific wild steelhead populations. The FMEP reflects closure to steelhead fishing in 85% of Idaho's steelhead habitat. The closure encompasses over 2,741 river and stream miles in the Salmon River basin and 1,780 river and stream miles in the Clearwater River basin. More specifically, the following rivers (and their tributary streams) are closed to fishing for steelhead to protect wild steelhead: Rapid River, the Middle Fork Salmon, the South Fork Salmon, Secesh, North Fork Salmon, Lemhi, Pahsimeroi, East Fork Salmon, Yankee Fork Salmon, Valley Creek, Chamberlain Creek, Potlatch, Lochsa, and Lolo Creek. All tributaries to the Salmon River (except the Little Salmon River) are closed to steelhead fishing, as are all Idaho tributary streams to the Snake River and tributaries to the Clearwater River (except the South Fork Clearwater). Additionally the Salmon River from Long Tom Creek (upstream of the Middle Fork of the Salmon River) downstream to Lake Creek Bridge (below the South Fork of the Salmon) closes to steelhead fishing on March 31, earlier than all other river sections. The closures significantly restrict fishing areas and fishing opportunities where wild steelhead dominate and substantially reduce the possibility of wild fish encounters by focusing angler effort on areas where hatchery-origin fish dominate.

Comment 9: Several commenters expressed concerns regarding the impacts of fishing during elevated water temperatures, overall thermal exposure of steelhead due to climate warming, suggestions to close steelhead fishing in the summer when water temperatures are excessive, or to establish a water temperature threshold before opening fisheries.

Response: In order to evaluate the effects of water temperature on C& R mortality, we summarized minimum, maximum, and average water temperatures by river section, by month and by week (within the month) for 2014 to 2018 (where available) in Appendix A for the Idaho steelhead fishery. We noted where maximum temperatures exceeded 19 °C and found it to be in limited temporal and geographical extent (Table 2). We chose a 19 °C threshold based upon the findings of Taylor and Barnhart (1997). Taylor and Barnhart (1997) indicated that rates of hooking mortality of steelhead exceeded 5% when water temperatures exceed 19 °C (N = 126; Figure 2). Most of the available angling literature related to water temperature for salmonids has focused on Atlantic Salmon and Sockeye Salmon (Gale et al. 2013), which have different thermal tolerances than steelhead (Beitinger et al. 2000) and are not appropriate to assess mortalities related to steelhead.

Figure 2. Excerpt from Taylor and Barnhart (1997):

Figure 5. Probability of hooking mortality of adult summer steelhead versus water temperature based on 126 summer steelhead angled from the Mad and North Fork Trinity rivers, California, 1995 and 1996.



Maximum temperatures in the Clearwater River downstream of Orofino did not exceed 19 °C (Table 2). Maximum temperatures in the main stem Clearwater upstream of Orofino exceeded 19 °C from July through the second week in September. The temperature differential in the reaches above and below the North Fork Clearwater River reflects the influence of cold water released from Dworshak Reservoir, located on the North Fork of the Clearwater River near Orofino. The Salmon River downstream of Whitebird Creek exceeded 19 °C in August and the first two weeks in September. Upstream in the Salmon River near Shoup, temperatures exceeded 19 °C in August and the first two weeks of September.

In the Snake River downstream of the Salmon River, temperatures exceeded 19 °C in August. Exceedance of 19 °C in the first two weeks of September was consistent across years but was variable in the final two weeks. Exceedance during the first week of October occurred once between 2014 and 2018. In the Snake River upstream of the Salmon River, exceedance of 19 °C occurred through August and the first two weeks in September. Exceedances in the last two weeks of September and the first week of October were observed in 2015 and 2016 but not in 2017 and 2018.

Table 2. Days exceeding a maximum temperature of 19 Celsius (C) by river section by year by month when steelhead fishing is open for catch and release fishing or harvest.

		Number of Days in Month with Max Temp > 19C									
River Section	**Year**	**January**	**February**	**March**	**April**	**July**	**August**	**September**	**October**	**November**	**December**
	2014	0	0	0	0	0	0	0	0	0	0
	2015	0	0	0	0	0	0	0	0	0	0
Clearwater River Below Orofino	2016	0	0	0	0	0	0	0	0	0	0
	2017	0	0	0	0	0	0	0	0	0	0
	2018	0	0	0	0	0	0	0	0	0	0
	2014	0	0	0	0					0	0
	2015	0	0	0	0					0	0
Clearwater River Above Orofino	2016	0	0	0	0			no data		0	0
	2017	0	0	0	0	31	31	21	0	0	0
	2018	0	0	0	0	31	31	14	0	0	0
	2014	0	0	0	0	-	31	30	7	0	0
	2015	0	0	0	0	-	31	30	7	0	0
Snake River downstream of the Salmon R.	2016	0	0	0	0	-	31	30	7	0	0
	2017	0	0	0	0	-	31	21	0	0	0
	2018	0	0	0	0	-	31	28	0	0	0
	2014	0	0	0	0	-	31	30	0	0	0
	2015	0	0	0	0	-	31	28	0	0	0
Snake River upstream of the Salmon River	2016	0	0	0	0	-	31	30	7	0	0
	2017	0	0	0	0	-	31	21	0	0	0
	2018	0	0	0	0	-	31	28	0	0	0
Lower Salmon River	2017	0	0	0	0	-	31	14	0	0	0
	2018	0	0	0	0	-	28	14	0	0	0
	2016	0	0	0	0	-	31	7	0	0	0
Upper Salmon River @ Shoup	2017	0	0	0	0	-	31	14	0	0	0
	2018	0	0	0	0	-	21	14	0	0	0

Steelhead fisheries in Idaho begin in the summer and last through the following spring. Although some river sections may be open to C&R when water temperatures exceed 19 °C, there are few steelhead in Idaho during those months. It is estimated that, on average, 2.2% of the total adult steelhead return has crossed Lower Granite Dam by August 1 and 11% percent have crossed LGD by September 1 (C. Camacho, Department, unpublished data). Steelhead harvest is allowed in most river sections from September 1 to April 30 in the Snake and Salmon rivers while steelhead harvest seasons in the mainstem Clearwater downstream from Orofino Bridge open October 15. While some wild fish may be encountered during these warmer periods, catch-and-release regulations for hatchery fish limit angler effort and lessen encounter rates during the month of August.

To evaluate potential overlap of wild steelhead with temperature exceeding 19 °C, we evaluated harvest rates of hatchery steelhead as a surrogate to estimate encounter rates for wild steelhead. Based on the temperature data (Appendix A) and harvest of steelhead from spawn year 2018, the proportion of fish harvested in river sections with water temperatures exceeding 19 °C water totaled 165 fish. By applying the catch data from the creel survey to this estimate, ~241 hatchery steelhead were caught and released, which equate to a 2% encounter rate. If the encounter rate of wild steelhead is the same as the encounter rate of hatchery steelhead, then wild fish are similarly encountered during warm temperatures at a rate of 2%. However, we believe that this encounter rate is an over-estimate. This analysis assumes that the water temperatures remained at greater than 19 °C for the entire month of September which we show in Table 2 and Appendix A is variable across years and minimum temperatures frequently drop below 19 °C. Also, this assumes a uniform thermal environment and that steelhead are not actively seeking out cool water refuges in pools or tributaries.

Mortality of steelhead from C& R fishing may be mediated in warmer water in several ways: (1) steelhead may seek out cooler areas to reside and (2) catch rates may decline as water temperatures increase. First, steelhead exit main stem locations and reside in tributaries/cooler refugia during times when there are higher water temperatures (Keefer et al. 2004, Keefer et al. 2008, Keefer et al. 2009, High et al. 2006, Hess et al. 2016). Congregating in cooler water areas not only reduces steelhead exposure to warm water but to potential angling encounters in warm water. Water releases from Dworshak Reservoir are used to cool the Snake River downstream of Lower Granite Dam (targeting 20 °C or lower) in the Snake River during summer (Bonneville Power Administration et al. 2019). The cool water in the Clearwater River downstream of Dworshak Dam attracts steelhead into the lower Clearwater River where they avoid warmer water in the Snake River during August and September. Second, steelhead catch rates decrease with increasing temperatures, and possibly as a result of fish that may not be present (i.e., having migrated to cooler areas) or due to reduced activity (Hook et al. 2004). We also note that the fishery in the Snake River downstream from the Salmon River is largely confined to the cold water plume near the mouth of the Clearwater River until the temperatures in the main stem Snake River begin declining in October and anglers move upstream to follow the steelhead.

Comment 10: Some commenters suggested mandatory retention of all hatchery fish caught.

Response: Commenters suggested mandatory retention of hatchery steelhead to reduce wild fish encounters or to prevent hatchery steelhead spawning in-river with wild steelhead. Idaho rules require steelhead anglers who reach their daily bag limit, possession limit, or seasonal limit for steelhead to cease fishing for steelhead, including on a catch and release basis (IDFG 2019b). Harvest rates of legally caught hatchery steelhead in Idaho is very high without being mandatory, with a range of 70% to over 80% of legally caught steelhead ultimately harvested. In most years, steelhead daily bag limits are two or three adipose fin clipped steelhead. The Department lowers bag limits to reduce fishing effort and encounter rates as appropriate for smaller run sizes. A mandatory harvest regulation would eliminate the C&R only season, as well as the option of C&R of hatchery fish before reaching bag limits. The current C&R season provides a valued angling experience important to social support for steelhead conservation.

Some commenters proposed mandatory hatchery retention as a way to reduce the risk of hatchery steelhead interbreeding with wild steelhead. The risk of hatchery steelhead in the Salmon and Clearwater Major Population Groups (MPGs) is minimized by consolidating hatchery release locations in the Salmon River to locations with weirs and maintaining half or more of the wild steelhead populations in the MPGs free from hatchery releases. As noted above in Response to *Comment 2*, direct impacts of hatchery fish on wild fish are evaluated through the separate regulatory process for approval of Hatchery Genetic Management Plans.

Comment 11: Some comments stated a desire for wild steelhead management for genetic diversity and/or life history diversity.

Response: The FMEP process is for evaluating the incidental encounter of wild steelhead during fisheries targeting hatchery steelhead. The very low mortality rates for wild fish incidentally encountered in the FMEP fisheries, should not specifically reduce genetic diversity or life history diversity of wild steelhead. Other administrative processes, such as the Recovery Plans (NMFS 2017) and Idaho's Statewide Fishery Management Plan (IDFG 2019a) focus more directly on wild steelhead management objectives.

Comment 12: Some commenters suggest managing fisheries based on escapement objectives measured at the level of the stream, the individual population, B-run steelhead run size, basin run size or overall wild steelhead run size at Lower Granite Dam, instead of the number of hatchery fish.

Response: Commenters suggest a variety of Escapement Based management scenarios. The 4(d) rules allow an FMEP to specify escapement objectives and/or maximum exploitation rates. Under the proposed impact (exploitation) rates as outlined in the submitted FMEP, greater than 90% of the wild population is destined to escape the recreational fisheries targeting hatchery steelhead.

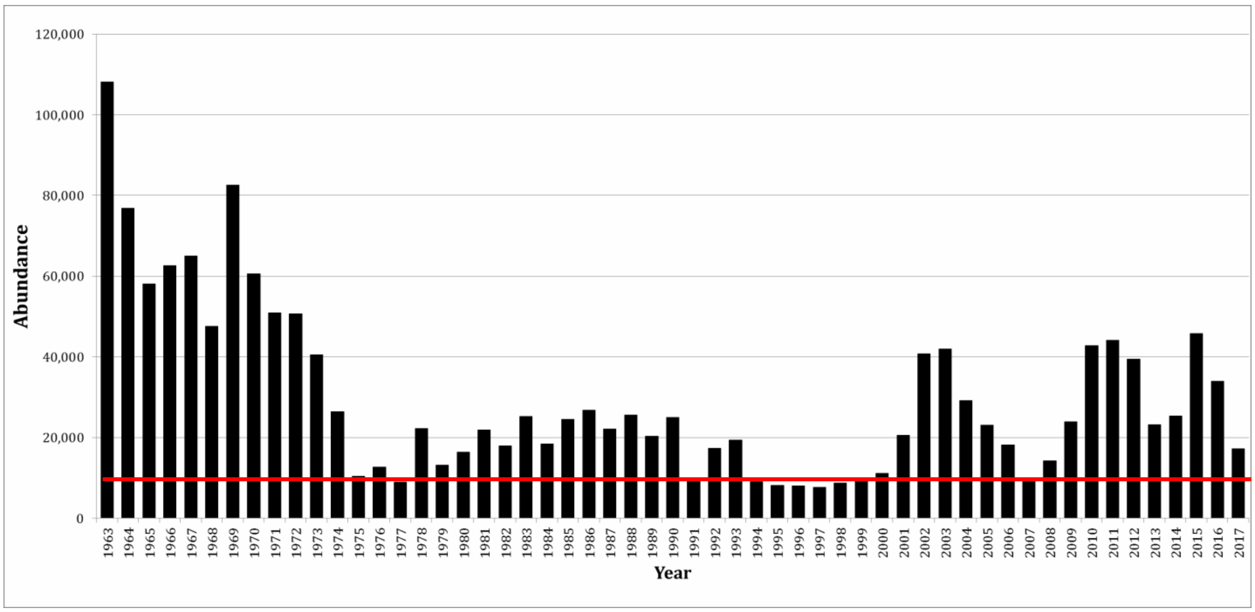
As described in the US v OR EIS (NOAA Fisheries 2018), "Escapement based management scenarios are sometimes coupled with a *de minimis* level of harvest opportunity to meet minimal fishery needs for tribal fisheries and limited access to other harvestable stocks." The Department is not proposing directed harvest on wild steelhead; the C&R mortality represents the *de minimis* rate for conducting a fishery targeting hatchery steelhead.

NOAA Fisheries, Idaho, Washington and other fishery managers manage Snake River steelhead fisheries and assess impacts assessment at the Distinct Population Segment (DPS) level. The Department and other fishery managers will continue to refine monitoring efforts (e.g. genetic and PIT-tag technologies) to understand fishery impacts at finer scales such as the MPG level. Only since 2011 have abundance levels been available at a finer scale than the DPS level for wild steelhead in the Snake River. Current estimates of abundance are provided using a combination of Genetic Stock Identification and Parental Based Tagging genetic methods (Campbell et al. 2012; Camacho et al. 2018a,b). By sampling fish passing over Lower Granite Dam genetic analysis allows identification of fish back to major basins corresponding to population aggregates (e.g., the Lochsa and Selway rivers cluster into an Upper Clearwater unit) and allows the estimates to exclude unmarked (adipose intact) hatchery origin adults. Further delineations into finer units are not available with the current genetic techniques. This technology has provided resolution and information not previously available for Idaho populations and is directly relevant to the scale of management.

Comment 13: Some commenters described wild steelhead as depressed or nearing extinction, and stated concern that the mortality rates and proposed impacts rates under the proposed fishing regimes would push steelhead to extinction.

Response: Some comments refer to downward decline in abundance in recent years, and stated concern with Clearwater and Snake River basins meeting viability standards for recovery, with some commenters asserting that the recovery of these populations has been subordinated to harvest concerns. The Department recognizes that returns in 2017 and 2018 are far below the Fish and Game Commission objectives (IDFG 2019a) and recovery levels (NMFS 2017). We also note that in 7 of the previous 20 years Snake River wild steelhead were above delisting thresholds at the DPS level (Figure 3). Salmon and steelhead adult return rates fluctuate annually and over the course of the last decades, there are cycles of good returns and poor returns, with periods of low years followed by high return years and so forth (Camacho et al. 2018b). Unfortunately, the FMEP review coincides with low steelhead returns due to poor freshwater migration conditions and ocean survival, with fewer steelhead entering the Columbia River as a result. As Figure 3 shows, Snake River Steelhead have rebounded following years of low returns. Steelhead have complicated life history strategies that help to buffer the impact of annual events. Variable age of smolt outmigration results in the annual smolt production being from 5 different age classes representing 5 spawn years (Camacho et al. 2018b). Adult returns are similarly variable with annual returns represented by potentially 21 different freshwater/saltwater age combinations (see Appendices C3 through C10 in Camacho et al 2018a). The diversity in steelhead life history allows steelhead populations to produce strong year classes well above the annual replacement rate when survival conditions are favorable. The impact rates in the FMEP do not jeopardize the ability of the species to recover or the continued existence (reproduction, numbers, diversity and distribution) of steelhead.

Figure 3. Wild Steelhead abundance estimated at the uppermost Snake River Dam from 1963 through 2018. The red line represents the Minimum Abundance Threshold (21,000) steelhead as adopted in the Snake River Steelhead Recovery Plan (NMFS 2017).



Comment 14: Some commenters suggest banning bait in resident trout fisheries where juvenile steelhead may be encountered.

Response: There are no data to suggest that bait fishing has high impacts on juvenile steelhead. The effects of Idaho's resident trout fisheries on ESA-listed steelhead are the subject of a different FMEP - the Fisheries Management and Evaluation Plan for IDFG General Fishing Rules (IDFG 2011), which NOAA Fisheries approved in 2011. In the Biological Opinion and Environmental Assessment for the prior permit (#1481) issued in 2005, an analysis was conducted for incidental take of juvenile steelhead for recreational trout fisheries conducted by the Department (NMFS 2005a,b). In these documents, NOAA Fisheries expected encounter rates of juvenile steelhead by trout anglers to be less than 10%, and expected the mortality rates to be very low, with an overall population impact of no more than 0.5 % (NMFS 2005a). During the authorization of the General Fishing FMEP in 2011, NOAA Fisheries concluded that the impacts would be entirely within the scope and purpose of the EA and FONSI for the 2005 permit. NOAA Fisheries determined that additional NEPA analysis was not needed for approval of the 2011 FMEP, as the affected environment and environmental resources had not changed in a substantial way to warrant a new analysis. Instead, NOAA Fisheries referred to this original analysis for the scope of the impacts. In the Biological Opinion for the 2011 FMEP, NOAA Fisheries states:

> Take of juvenile steelhead will be small because larger smolts would have emigrated from the basin when resident trout fisheries open and smaller juvenile steelhead would not likely be recruited to the fishery because of their size…NMFS expects the actual catch rate is small (NMFS 2011). Based on average adult returns discussed above, the number of juveniles that would need to die from catch-and-release mortality to result in 5% impact to average adult returns would be over 100,000 juveniles…Because Idaho implements small daily bag limits and minimum size restrictions that would exclude steelhead, reaching this level of impact is highly improbable.

Comment 15: There appears to be an error in Table 3 in abundance of wild and hatchery steelhead for run year 1997-1998 and 2000-2001.

Response: We have revised this table in the FMEP.

Comment 16: The FMEP should be reviewed annually not every 5 years.

Response: We are confident the 5-year review period is sufficient to address issues that may arise with respect to the fishery or impacts identified through monitoring efforts. The Department submits an annual report to NOAA Fisheries describing the performance metrics, including estimates of incidental encounter and mortality of wild steelhead associated with the steelhead fishery. Department staff maintain in-season communications with NOAA Fisheries staff and are ready to address any issues that may arise. NOAA fisheries has discretion to re-initiate consultation should unforeseen circumstances arise.

Comment 17: One commenter noted that some citations in the FMEP were unavailable.

Response: We have provided copies of all citations to NOAA Fisheries.

Literature Cited

Askey, P.J., S. A. Richards, J.R. Post, and E. A. Parkinson. 2006. Linking angling catch rates and fish learning under catch-and-release regulations. North American Journal of Fisheries Management 26: 1020–1029.

Bartholomew A., and J. A. Bohnsack. 2005. A review of catch-and-release angling mortality with implications for no-take reserves. Reviews in Fish Biology and Fisheries 15:129–154.

Beitinger, T. L, W. A. Bennett and R. W. McCauley. 2000. Temperature tolerances of North American freshwater fishes exposed to dynamic changes in temperature. Environmental Biology of Fishes 58: 237-275.

Booth, R. K., J.D. Kieffer, B.L. Tufts, K. Davidson, K, and A.T. Bielak. 1995. Effects of late- season catch-and-release angling on anaerobic metabolism, acid-base status, survival, and gamete viability in wild Atlantic Salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 52: 283-290.

Bonneville Power Administration, US Bureu of Reclamation, US Army Corps of Engineers. 2019. Draft 2019 Water Management Plan. Available at http://pweb.crohms.org/tmt/documents/wmp/2019/Nov_14_Draft/20181116_WMP_Draft.pdf

Bendock, T. and M. Alexandersdottir. 1993. Hooking mortality of Chinook Salmon released in the Kenai River, Alaska. North American Journal of Fisheries Management 13: 540-549.

Brown, R. S., W. A. Hubert, and S. F. Daly. 2011. A primer on winter, ice and fish: what fisheries biologists should know about winter processes and stream-dwelling fish. Fisheries 36: 8-26.

Camacho, C. A., J. Powell, M. Davison, M. E. Dobos, W. C. Schrader, T. Copeland, and M. R. Campbell. 2018a. Wild adult steelhead and chinook salmon abundance and composition at lower granite dam, spawn year 2017. Idaho Department of Fish and Game Technical Report 18-06. Boise, Idaho.

Camacho, C. A., K. K. Wright, J. Powell, W. C. Schrader, T. Copeland, M. W. Ackerman, M. E. Dobos, M. Davison, M. P. Corsi, and M. R. Campbell. 2018b. Wild juvenile steelhead and Chinook Salmon abundance and composition at Lower Granite Dam, migratory years 2010 and 2017. Idaho Department of Fish and Game Report 18-05. Boise, Idaho.

Campbell, M.R., C.C. Kozfkay, T. Copeland, W. C. Schrader, M. W. Ackerman, and S. R. Narum. 2012. Estimating abundance and life history characteristics of threatened wild Snake River steelhead stocks by using genetic stock identification. Transactions of the American Fisheries Society 141: 1310-1327.

Chiaramonte, L. V., K. A. Meyer, D. W. Whitney, and J. L. McCormick. 2018. Air exposure, fight times, and deep-hooking rates of steelhead caught in Idaho fisheries. North American Journal of Fisheries Management 38: 1114-1121.

Cooke, S. J., G. D. Raby, M.R. Donaldson, S. G. Hinch, C. M. O'Connor, R. Arlinghaus, A. J. Danylchuk, K. C. Hanson, T. D. Clark, and D. A. Patterson. 2013. The physiological consequences of catch-and-release angling: perspectives on experimental design, interpretation, extrapolation and relevance to stakeholders. Fisheries Management and Ecology 20: 268-287.

Cook, K.V., Lennox, R.J., Hinch, S.G., Cooke, S.J. 2015. Fish out of water: how much air is too much? Fisheries 40: 452–461.

Cowx, I.G., N. Angelopoulos, J. D. Dodd and A. D. Nunn. 2017. Impact of catch and release angling practices on survival of salmon. Environment Agency Report. Bristol, UK.

Davidson, K., J. Hayward, M. Hambrook, A. T. Bielak, and J. Sheasgreen. 1994. The effects of late-season angling on gamete viability and early fry survival in Atlantic Salmon. Canadian Technical Report of Fisheries and Aquatic Sciences 1982: 1–12.

Feeken, S. J. 2018. Distribution and Movement of Wild and Hatchery Steelhead: Interactions Among Populations and Overlap with Angling Effort. Masters thesis, University of Idaho, Moscow, ID.

Ferguson, R. A., and B. L. Tufts. 1992. Physiological effects of brief air exposure in exhaustively exercised Rainbow Trout (Oncorhynchus mykiss): implications for “catch and release” fisheries. Canadian Journal of Fisheries and Aquatic Sciences 49:1157–1162.

Fleming, I. and J. D. Reynolds. 2003. Salmonid breeding systems. I*n* Evolution Illuminated: Salmon and their relatives, pg 264.

Gagne, T. O, K. L. Ovitz, L. P. Griffin, J. W. Brownscombe, S. J. Cooke and A. J. Danylchuk. 2017. Evaluating the consequences of catch-and-release recreational angling on golden dorado (*Salminus brasiliensis*) in Salta, Argentina. Fisheries Research 1: 625-633.

Gale, M. K., S. G. Hinch, and M. R. Donaldson. 2013. The role of temperature in the capture and release of fish. Fish and Fisheries 14:1-33.

Gingerich, A.J., S. J. Cooke, K. C. Hanson, M. R. Donaldson, C. T. Hasler, C. D. Suski, and R. Arlinghaus. 2007. Evaluation of the interactive effects of air exposure duration and water temperature on the condition and survival of angled and released fish. Fisheries Research 86: 169-178.

Hess, M. A., J. E. Hess, A. P. Matala, R. A. French. C.A. Steele, J. C. Lovtang and S. R. Narum. 2016. Migrating adult steelhead utilize a thermal refuge during summer periods with high water temperatures. ICES Journal of Marine Science 73: 2616-2624.

High, B., Peery, C.A., and Bennett, D.H. 2006. Temporary staging of Columbia River summer steelhead in coolwater areas and its effect on migration. Transactions of the American Fisheries Society: 135: 519–528.

High, B., and K. A. Meyer. 2014. Hooking mortality and landing success using baited circle hooks compared to conventional hook types for stream-dwelling trout. Northwest Science 88:11-22.

Holtby, L. B., R. K. Kadowaki, and K. S. Simpson. 1992. Factors affecting the vulnerability of juvenile coho (Oncorhynchus kisutch) and Chinook Salmon (*O. tshawytscha*) in a saltwater sport fishery. Canadian Journal of Fisheries and Aquatic Sciences 49: 2164-2178.

Höök, T. O., Rutherford, E. S., Brines, S. J., Schwab, D. J., & McCormick, M. J. (2004). Relationship between surface water temperature and steelhead distributions in Lake Michigan. North American Journal of Fisheries Management 24:211-221.

Hooton, R. S. 1987. Catch and release as a management strategy for steelhead in British Columbia. In R. Barnhart and T. Roelofs, editors, Proceedings of: Catch and Release Fishing – A Decade of Experience. Sept 30 – Oct 1, 1987. Humboldt State University, Arcata, California.

Hooton, R. S. 2001. Facts and issues associated with restricting terminal gear types in the management of sustainable steelhead sport fisheries in British Columbia. Ministry of Environment, Lands, and Parks. Nanaimo, BC.

Hunsaker, D., II, L. F. Marnell, and F. P. Sharpe. 1970. Hooking mortality of Yellowstone Cutthroat Trout. Progressive Fish-Culturist 32:231–235.

Idaho Department of Fish and Game (IDFG). 2019a. Fisheries Management Plan 2019-2024. A comprehensive guide to managing Idaho's fisheries resources. Boise. 402 p.

Idaho Department of Fish and Game (IDFG). 2019b. Idaho Fishing 2019-2021 Season & Rules. Boise, 62 p.

Idaho Department of Fish and Game (IDFG). 2011. Fisheries Management and Evaluation Plan Submitted under ESA Section 4(d). IDFG General Fishing Rules. Boise, 23 p.

Keefer, M.L., Peery, C.A., Bjornn, T.C., Jepson, M.A., and Stuehrenberg, L.C. 2004. Hydrosystem, dam, and reservoir passage rates of adult chinook salmon and steelhead in the Columbia and Snake rivers. Transactions of the American. Fisheries Society 133: 1413–1439.

Keefer, M. L., C. T. Boggs, C. A. Peery, and C. C. Caudill. 2008. Overwinter distribution, behavior, and survival of adult summer steelhead: variability among Columbia River populations. North American Journal of Fisheries Management 28: 81-96.

Keefer, M.L., C. A., Peery and B. High. 2009. Behavioral thermoregulation and associated mortality trade-offs in migrating adult steelhead (*Oncorhynchus mykiss*): variability among sympatric populations. Canadian Journal of Fisheries and Aquatic Sciences 66: 1734-1747.

Lennox, R. J., I. Uglem, S. J. Cooke, T. F. Anesje, F. G. Whorisky, T. B. Havn, E. M. Ulvan, O. Solem, and E. B. Thorstad. 2015. Does catch-and-release gngling alter the behavior and fate of adult Atlantic Salmon furing upriver migration?. Transactions of the American Fisheries Society 2015 144: 400-409.

Lamansky, J. A., and K. A. Meyer. 2016. Air exposure time of trout released by anglers during catch and release. North American Journal of Fisheries Management 36:1018–1023.

Lennox, R.J., S. J. Cooke, O. H. Diserud, T. B Havn, M. R. Johansen, E. B. Thorstad, F. G. Whoriskey, and I Uglem. 2016. Use of simulation approaches to evaluate the consequences of catch-and-release angling on the migration behaviour of adult Atlantic salmon (*Salmo salar*). Ecological modelling, 333: 43-50.

Lindsay, R. B., R. K. Schroeder, K. R. Kenaston, R. N. Toman and M. A. Buckman. 2004 Hooking mortality by anatomical location and its use in estimating mortality of spring Chinook Salmon caught and released in a river sport fishery. North American Journal of Fisheries Management 24:367-378.

Lough, M.J. 1980. Radio-telemetry studies of summer run steelhead trout in the Skeena River, 1978, with particular reference to equipment and capture methods. Skeena Fisheries Report. 78-10,18 pp.

Louison, M.J., C.T. Hasler, M. M. Fenske, C.D. Suski and J. A. Stein. 2016. Physiological effects of ice angling capture and handling on northern pike, *Esox Lucius*. Fisheries Mangement and Ecology 24: 10-18.

Ludwig, B. 1995. British Columbia's trout hatchery program and the stocking policies that guide it. Pages 139–143 *in* H. L. Schramm, Jr., and R. G. Piper, editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society, Symposium15, Bethesda, Maryland.

McCormick, J. L., D. Whitney, D. J. Schill, and M. C. Quist. 2015. Evaluation of angler reporting accuracy in an off-site survey to estimate statewide steelhead harvest. Fisheries Management and Ecology 134-142.

Meka, J. M. 2004. The influence of hook type, angler experience, and fish size on injury rates and the duration of capture in an Alaskan catch-and-release rainbow trout fishery. North American Journal of Fisheries Management 24: 1309-1321.

Mezzera, M. and C. R. Largiader. 2001. Evidence for selective angling on introduced trout and their hybrids in a stocked brown trout population. Journal of Fish Biology 59: 287-301.

Mongillo, P. E. 1984. A summary of salmonid hooking mortality. Washington Department of Fish and Wildlife, Fish Management Division Report, Olympia

Muoneke, M. I., and W. M. Childress. 1994. Hooking mortality: a review for recreational fisheries. Reviews in Fisheries Science 2:123-156.

Nelson, T.C., Rosenau, M.L. and Johnston, N.T. 2005. Behavior and survival of wild and hatchery-origin winter steelhead spawners caught and released in a recreational fishery. North American Journal of Fisheries Management 25, 931–943.

NMFS. 2005a. National Marine Fisheries Service Endangered Species Act 7 Biological Opinion on the issuance of 10(a)(1)(B) incidental take permit 1481 for recreational fisheries conducted by Idaho Department of Fish and Game.

NMFS 2005b. Environmental Assessment of the National Marine Fisheries Service action to issue incidental take permit 1481 to the Idaho Department of Fish and Game under section 10(a)(1)(B) of the Endangered Species Act.

NMFS 2011. National Marine Fisheries Service Endangered Species Act (ESA) Section 7 Consultation Biological OpinionAnd Magnuson-Stevens Act Essential Fish Habitat Consultation. 2011/00192. Portland, Oregon.

NMFS 2017. ESA recovery plan for Snake River Spring/Summer Chinook Salmon (*Oncorhynchus tshawytscha*) & Snake River Basin Steelhead (*Oncorhynchus mykiss*). Portland, Oregon.

NMFS 2018. Final Environmental Impact Statement to Analyze Impacts of NOAA's National Marine Fisheries Service joining as a signatory to a new U.S. v. Oregon Management Agreement for the Years 2018-2027. Seattle, WA. Available at

https://www.westcoast.fisheries.noaa.gov/publications/nepa/salmon_steelhead/final_environmental_impact_statement_and_record_of_decision_for_us_v._oregon.pdf

Pauley, G. B., and G. L. Thomas. 1993. Mortality of anadromous coastal cutthroat trout caught with artificial lures and natural bait. North American Journal of Fisheries Management 13:337–345.

Pettit, S. 1977. Comparative reproductive success of caught and released and unplayed hatchery female steelhead (Salmo gairdneri) from the Clearwater River, Idaho. Transactions of the American Fisheries Society 106: 431-435.

Raby, G. D., S. J. Cooke, K. V. Cooke, S. H. McConnachie, M. R. Donaldson, S. G. Hinch, C. K. Whitney, S. M. Dreener, D. A. Patterson, T. D. Clark, and A. P. Farrell. 2013. Resilience of Pink Salmon and Chum Salmon to simulated fisheries capture stress incurred upon arrival at spawning grounds. Transactions of the American Fisheries Society 142:524–539.

Reingold, M. 1975. Effects of displacing, hooking, and releasing on migrating adult steelhead trout. Transactions of the American Fisheries Society 104: 458-460.

Richard, A. M. Dionne, J. Wang, and L. Bernatchez. 2013. Does catch and release affect the mating system and individual reproductive success of wild Atlantic Salmon (*Salmo salar* L.)? Molecular Ecology 22:187–200.

Richard, A.M., L. Bernatchez, E. Valiquette, and M. Bionne. 2014. Telemetry reveals how catch and release affects prespawning migration in Atlantic Salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 71: 1730-1739.

Roth, C. J., D. J. Schill, and M. C. Quist. 2018a. Fight and air exposure times of caught and released salmonids from the South Fork Snake River. Fisheries Research 201:38–43.

Roth, C. J., D. J. Schill, M. C. Quist, and B. High. 2018b. Effects of air exposure in summer on the survival of caught-and-released salmonids. North American Journal of Fisheries Management 38:886–895.

Ruzzante, D. E. 1994. Domestication effects on aggressive and schooling behavior in fish. Aquaculture 120: 1-24.

Seals, J.T., and R.A. French. 2009. Deschutes River juggling act: Mange native wild summer steelhead and out-of-basin strays. Osprey, Issue 64.

Schill, D. J. 1996. Hooking mortality of bait-caught Rainbow Trout in an Idaho trout stream and a hatchery: implications for special-regulation management. North American Journal of Fisheries Management 16:348–356.

Schreer, J. F., D. M. Resch, M. L. Gately, and S. J. Cooke. 2005. Swimming performance of brook trout after simulated catch-and-release angling: looking for air exposure thresholds. North American Journal of Fisheries Management 25: 1513-1517.

Sullivan, M. G. 2003. Exaggeration of walleye catches by Alberta anglers. North American Journal of Fisheries Management 23: 673-580.

Taylor, G., and R. A. Barnhart. 1997. Mortality of angler caught and released summer steelhead. Final Report. Contract FG 5018 IF, Department of Fish and Game Steelhead Trout Catch Report -Restoration Card. Arcata, CA: California Cooperative Fishery Research Unit and Humboldt State University Foundation.

Thomas, J.O., 1995. 1995 Skeena River Sport Fish Coho and Steelhead Catch and Release Study. Unpublished report, J.O. Thomas and Associates Ltd. Contract No. FP 95-5049-170H-0315. Department of Fisheries and Oceans, Prince Rupert, B.C.

Thompson, L.A., S. J. Cooke, M. R. Donaldson, M. R., K. C. Hanson and A. Gingerich *et al.* 2008. Physiology, behavior, and survival of angled and air-exposed largemouth bass. North American Journal of Fisheries Management 28: 1059-1068.

Thorstad, E. B., T. F. Næsje, and I. Leinan. 2007. Long-term effects of catch-and-release angling on ascending Atlantic salmon during different stages of spawning migration. Fisheries Research 85: 316-320.

Twardek,W.M., T. O. Gagne, L, K. Elmer, S. J. Cooke, M. C. Beere and A. J. Danylchuk. 2018. Consequences of catch-and-release angling on the physiology, behavior, and survival of wild steelhead Oncorhynchus mykiss in the Bulkey River, British Columbia. Fisheries Research 206: 235-246.

Weber, E.D. and K. D. Fausch. 2003. Interactions between hatchery and wild salmonids in streams: differences in biology and evidence for competition. Canadian Journal of Fisheries and Aquatic Sciences 60: 1018-1036.

Whitney, D.W., K.A. Meyer, J.L. McCormick, and B.J. Bowersox. in press. Effects of fishery related fight time and air exposure on pre-spawn survival and reproductive success of adult hatchery steelhead. North American Journal of Fisheries Management.

Wood, C.M., J. D. Turner, and M. S. Graham. 1983. Why do fish die after sever exercise? Journal of Fish Biology 22: 189-201.

Wydoski, R. S. 1977. Relation of hooking mortality and sublethal hooking stress to quality fishery management. Pages 43-87 *in* R. A. Barnhart and T. D. Roelofs, editors. Catch-and-release fishing as a management tool. Humboldt State University, Arcata.