LOCAL ECOLOGICAL KNOWLEDGE EXCHANGE OF STEELHEAD

by

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The following individuals read and discussed the thesis submitted by student Mikaela A. Weisenfluh, and they evaluated the student's presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

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DEDICATION

To my family for believing in me and setting me on this path, especially my grandmother and to my friends who supported me along the way despite the distance. To Koda.

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ABSTRACT

Local ecological knowledge (LEK) has been researched in the past to examine how it can aid and support scientific ecological knowledge (SEK). SEK is often seen as the preferred and superior type of knowledge when dealing with environmental changes. However, both of these types of knowledge are not segregated within individuals but are dependent on age, experience with the fishery, experience with a scientific organization, and/or perception of changes in the environment based on lived experiences. Interactions between LEK and SEK users is valuable to the conservation that is needed to protect these fish species and is dependent on how well these groups are sharing their knowledge and communicating with one another. For this study, I have examined the exchange of knowledge on steelhead trout within Idaho between anglers, Idaho Fish & Game, and the Office of Species Conservation. If these three groups are sharing SEK and LEK effectively, despite generational and organizational differences, then the variation between groups should be low. In addition to the exchange of knowledge, I have looked at communication, the meaning behind each group's knowledge, and how age and experience play a factor into their perception of change. Of those that responded to the questionnaire, there were 26 angler respondents, 21 Idaho Fish & Game respondents, and 6 Office of Species Conservation respondents. Statistical tests indicated that there was a significant difference in LEK scores between groups, and there was low communication between the Office of Species Conservation and anglers. There was a significant difference in where these groups reported that most of the mortality for steelhead

occurred, and age and experience did not have an impact on LEK scores. These results indicate that there is variation between groups' LEK which could be due to variations in LEK between groups. How groups define local can cause variation between groups' LEK.

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CHAPTER ONE: INTRODUCTION

Fish are indicators of how healthy their habitat is (Moyle and Leidy 1992). The causes behind fish species decline include habitat alteration, pollution, commercial exploitation, introduction of exotic species, and competition for water between communities (Moyle and Leidy 1992; Cowx, Arlignhaus, and Cooke 2010). The root cause of these impacts are anthropogenic in nature and result in population declines in fish species through the continued use of the resource. A causal factor for these population declines may be individuals' perceptions of the environment, which influence the way that they use or manage it. These perceptions are influenced by the knowledge that individuals have gained through their experience with fishing on these rivers, and they also influence the receptiveness of these individuals to work on conservation efforts (Fazey et al. 2014). Anglers work with fisheries managers in the development of knowledge in order to benefit the continuation of fish species in order for them to adapt to the social-ecological changes (Fernández-Llamazares et al. 2015). Collaborations such as these are increasingly seen as valuable to understand the interaction that occurs between humans and their environment and the knowledge that comes out of it, specifically local and scientific ecological knowledge (Jones et al. 2014; Gaus et al. 2020). Despite this collaboration, there can be mismatch between stakeholder groups' local and scientific knowledge (Fazey et al. 2014; Felt 2008).

This study examines the interaction between small-scale anglers and science-based management organizations. The groups examined are anglers, Idaho Fish & Game

and the Office of Species Conservation that then have an effect on steelhead trout (*Oncorhynchus mykiss*) population within Idaho river systems. Each of these three groups share information between each other which includes information on catch type, research findings, rules and regulations, and policy changes. Although these three groups have a varying relationship with steelhead, they all rely on each other by sharing knowledge in order to maintain steelhead populations in Idaho. Besides the knowledge shared between the three groups, they are also sharing information within their groups that adds to their ecological knowledge of steelhead that is just as valuable to look at to understand the exchange of knowledge and how it is used to define the groups within this environment. The exchange of local and scientific ecological knowledge aids in the protection and management of the fishery in which these groups are a part of (Garcia-Quijano 2007; Gerhardinger, Godoy, and Jones 2009).

Local Ecological Knowledge (LEK)

Local ecological knowledge (LEK) is defined as an individual's knowledge of their natural environment that they develop through observation within their lifetime combining social learning with individual experiences (Aswani, Lemahieu, and Sauer 2018; Reyes-Garcia et al. 2010; Gómez-Baggethun et al. 2012). These observations are done through fishing, hunting, harvesting, transmitted knowledge from previous generations, and information from outside sources like the media, managers, and scientists (Murray, Neis, and Johnsen 2006). Research on LEK has primarily focused on small-scale, indigenous communities and how it can be used to help with natural resource management (Garcia-Quijano 2007). However, some research has speculated that LEK has been eroding in these traditional communities due to modernizing practices like

schooling, technology, and integration into a market economy (Koster, Bruno, and Burns 2016; Gómez-Baggethun et al. 2013; Reyes-Garcia et al. 2010). In others, research has shown that LEK is adapting to these new ecological and socioeconomic conditions that globalization has brought due to its dynamic nature (Gómez-Baggethun et al. 2013; Murray, Neis, and Johnsen 2006). In addition to the effect that globalization has on LEK, other studies have looked at how LEK users have been used to aid scientific knowledge.

Some examples include the use of Cree fishers' monitoring of environmental signals, the Rakiura Maori of New Zealand and their harvest of chicks, marine species assemblages in Puerto Rico, and inclusion of fishers' LEK in Marine Protected Areas in Brazil (Moller et al. 2004; Garcia-Quijano 2007; Gerhardinger, Godoy and Jones 20009). Studies like this look at the relationship between LEK and SEK users and how each type of knowledge user can aid in co-management. The integration of both users aids in the care and strengthening of biodiversity and ecosystems (Tengö et al. 2014). Despite the recognition that LEK can benefit scientific knowledge, there are challenges with how to incorporate LEK with scientific ecological knowledge (Felt 2008). These challenges are fueled by the importance and perception that is placed on LEK and scientific ecological knowledge within western cultures.

Scientific Ecological Knowledge (SEK)

Scientific ecological knowledge (SEK), often described as the knowledge of the west, approaches nature from an objective standpoint in which the development of the knowledge is to be disembeddedness from the study and to find universals (Berkes 2012; Garcia-Quijano 2007). SEK can be categorized as being objective and rigorous through the testing and measurements that SEK users take part in (Mistry and Berardi 2016).

Although SEK is often described as belonging to western scientists, others argue that science is a fundamental characteristic of all human societies (Berkes 2012). The difference between LEK and SEK is not who the creators of the knowledge are but the approach that is taken between the two and the relationship that each group has with nature (Berkes 2012). Oftentimes, SEK has been used by scientists that are working on natural resource management within areas of the world in which scientists are not able to spend extensive amounts of times in their area of study and use LEK as a proxy to their area of study until SEK users are able to collect enough data (Garcia-Quijano 2007; Felt 2008). This then leads natural resource management to rely on traditional LEK users like those found in small-scale communities. Studies like Garcia-Quijano (2007) have used LEK to understand nonlinearity, unpredictability, and complexities within ecosystems in order to support the observations of scientists. However, if these scientists also are interacting with the ecosystem they are studying, then they must have their own form of LEK that is integrated into SEK. As stated above, fisheries scientists play a role in developing LEK through the information that they give to anglers. If this is true, then how are scientists' SEK also influenced by anglers' LEK?

Garcia-Quijano (2007) and Gerhardinger, Godoy, and Jones (2009) have looked at how anglers' LEK has been seen as being collaborative in integrating into SEK research. Fishers are able to gather more sampling hours when compared to scientists that are limited in their time in the field (Garcia-Quijano 2007). Due to this, anglers' LEK can help in management of marine resources and bridge the missing knowledge that scientists would need a more extensive research time to understand (Garcia-quijano 2007; Gerhardinger, Godoy, & Jones 2009). Anglers' LEK can aid through their knowledge

about ecology, behavior and abundance trends of fish and the ecological processes and influences on their local fishing resources (Silvano and Jorgensen 2008). This knowledge can be recorded by fisheries scientists to be used to complement their own research and to help support it (Silvano and Jorgensen 2008). However, there is a trend to have SEK users to become more participatory with their co-creation of research with other stakeholders (Fazey et al. 2014; Mistry and Berardi 2016). The incorporation of both LEK and SEK into studies can increase knowledge and benefit resource management (Menzies 2006). These groups have been researched as two separate entities being able to support each other in managing natural resources. However, these groups are not as separated as we would think and often integrate both LEK and SEK into their ecosystem (Berkes 2012). Despite this, the literature surrounding ecological knowledge often separates LEK and SEK users and puts these knowledges into a minority-majority relation.

Minority-Majority Relations

Some studies on LEK and SEK have an underlying tone of which knowledge is preferred and who has the claim of authority of knowledge (Berkes 2012). This tone lends to a hierarchy of knowledge that then creates a minority-majority relation (Eriksen 2010; Barth 1969; Cohen 1978). In order for there to be a hierarchy within these knowledges, there has to be a resource in which groups are fighting for control over (Cohen 1978; Van den Berghe 1981). When interacting with large numbers of unrelated individuals, humans rely on norms that are enforced within the group in order to enhance cooperation (McElreath, Boyd, and Richerson 2002). In the case of LEK and SEK, these knowledge users are fighting over the power of how to control natural resources through

the knowledge that is being produced. When looking at the group dynamics between Idaho Fish & Game, Office of Species Conservation, and anglers, they have their own minority-majority relationship based off of the power that they hold within Idaho's governmental system. The dynamics between these three groups can be looked at from two different directions: the relationship that LEK and SEK have within the literature and the relationship these three groups have with one another. Scientific knowledge is held at the top due to the belief that it provides the gold standard in which all other knowledge, i.e., LEK, should be judged against (Moller et al. 2004). Although scientists see the benefit in including LEK into research, disagreements on how to fix environmental conditions and when LEK contradicts research evidence creates continued barriers between the two knowledges (Menzies 2006). For example, biologists working with the Kluane First Nation people in Yukon faced these problems when trying to take measures to improve sheep numbers (Menzies 2006). Each group had varying stances on what measures needed to be taken in order to improve sheep numbers but it was the biologists' plan that was used (Menzies 2006). When these barriers are encountered, SEK users hold the power on the type of conservation efforts that will or not be taken, even if they are not efficient enough and tackle the known problems to a population (Menzies 2006). For this reason, SEK is placed within the majority holder position.

Anglers' knowledge is able to complement or be added to SEK (Garcia-Quijano 2007; Gerhardinger, Godoy, & Jones 2009). Anglers' knowledge is not thought of as being able to add their own valuable information or thought to stand on their own. SEK users may use LEK as a stand-in until they are able to collect enough data in order to create their own data (Felt 2008). Bruno Latour looked at how frameworks of

understanding at the Salk Institute of Biological Sciences are made to put scientific knowledge as being in the position of the majority (Moore 2019). Latour found that scientific knowledge was a social construct and is no different from any other human activity that individuals take part in (Moore 2019). The creation of scientific knowledge has a specific framework in which we are constantly evolving our evaluations through the practice, presentation of results, discussion, and collective agreement on certain ideas that leads us to believe that science is somehow different or holds more value than other types of knowledge (Moore 2019). Due to the prestige that we attach to scientific knowledge, individuals believe that it has more value and is fueled by the struggles natural resource management has faced when integrating LEK and SEK (Menzies 2006; Ulicsni et al. 2018). This is due to the technological and methodological obstacles that has continued this divide between these types of human knowledge (Menzies 2006; Ulicsni et al. 2018). SEK may have a written down framework, but other types of knowledge still goes through an informal process that is similar to scientific knowledge (Menzies, 2006). Specifically, LEK users use their own personal experiences through trapping, hunting, and fishing that then inform their understanding of species within their environment (Menzies 2006). This line of thought that is within the literature is why SEK is put into the position of the majority. This position of scientific knowledge being the majority holder is because we as a culture have placed an emphasis on SEK.

Power Relations

When looking at the relationship between the three groups within this study, these three groups' relationships are based on the power that each group holds within this system. At the top is the Office of Species Conservation. The Office of Species

Conservation works to plan, coordinate, and implement the state's actions to protect species that are found within Idaho (Title 67, ch. 8, sec. 818). These species are those that are listed on the federal Endangered Species Act as candidate, threatened, or endangered, of which steelhead is a part of the latter list (Office of Species Conservation, Accessed March 12, 2019). This office coordinates with the State's natural resource agencies and input from citizens to develop policy (Office of Species Conservation, Accessed June 24, 2020). The Office of Species Conservation has been tasked with creating a workgroup that is aimed at addressing salmon and steelhead issues in Idaho (Office of Species Conservation, Accessed December 31, 2020). This was created in order to have diverse stakeholders to collaborate in developing policy recommendations to the governor (Office of Species Conservation, Accessed December 31, 2020).

The second group within this hierarchy is Idaho Fish & Game. The Idaho Department of Fish & Game manages and protects Idaho's wildlife resources (Title 36, ch. 1, sec. 104). This is done by issuing fishing and hunting licenses and conducting research on the species that inhabit Idaho (Title 36, ch. 1, sec. 104; Title 36, ch. 4, sec. 401). They use their resources to answer management questions and in developing new technology to assist in their management of Idaho's wildlife (Title 36, ch. 1, sec. 104). Idaho Fish & Game has divided themselves into seven administrative regions and is responsible for the direction of their programs that are implemented by regional staff (Idaho Fish and Game 2015).

At the bottom of this minority-majority relation are the anglers. Anglers hold no governmental power within this system, although they may potentially impact steelhead abundance through their fishing activities. Anglers are the group that have to provide

information and must follow the rules and policies set forth by Office of Species Conservation and Idaho Fish & Game. Due to their low position, anglers within this system may be under-communicating their LEK and over-communicating their gained SEK with increased interaction with natural scientists and managers like Idaho Fish & Game and Office of Species Conservation (Felt 2008). I have created a model that shows the exchange of knowledge that is supposed to be happening within this system (Figure 1).

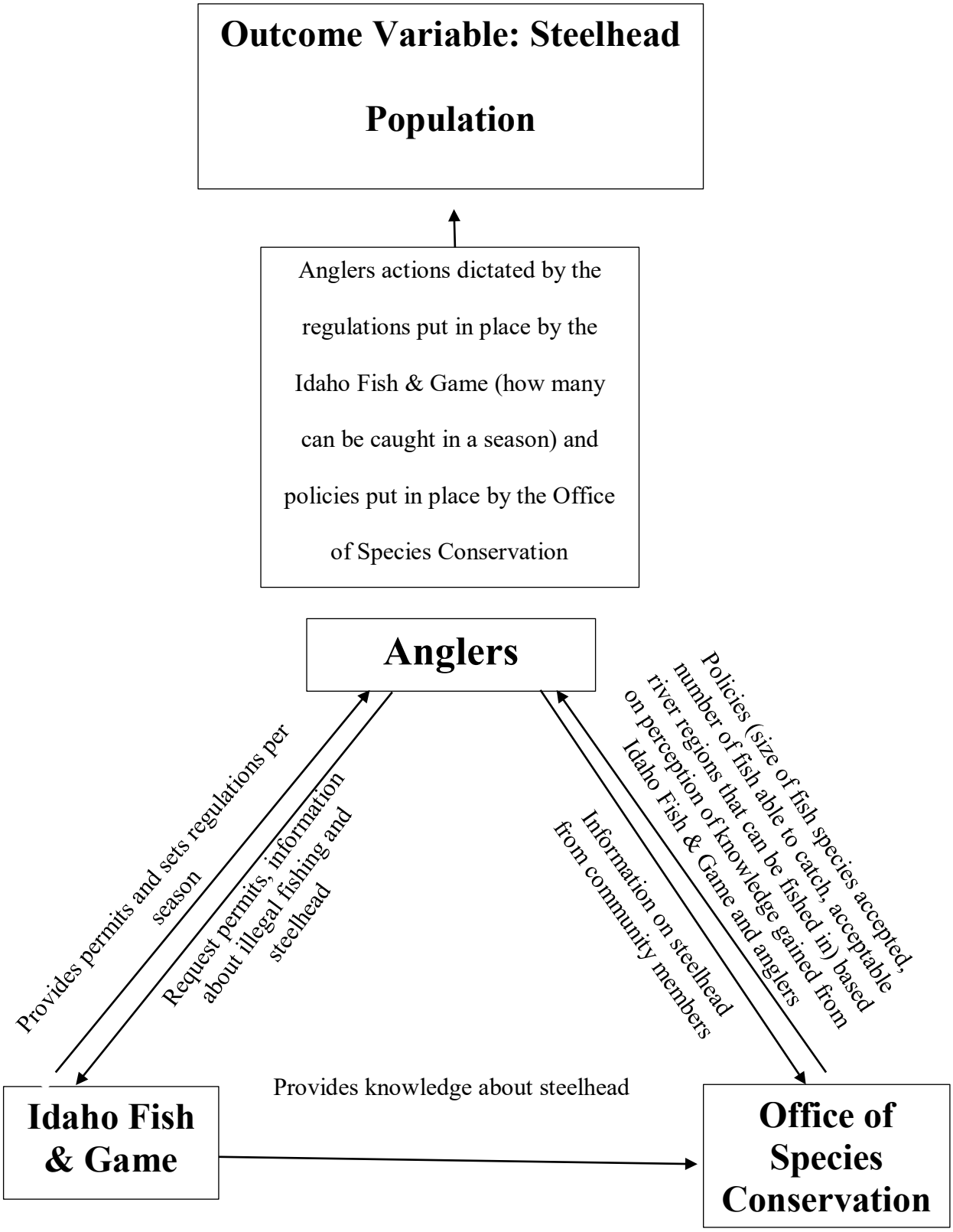


Figure 1 Model of exchange of knowledge between Office of Species Conservation, Idaho Fish & Game, and Anglers

Shifting Baselines and Generational Differences

A key component to LEK is the development of knowledge between generations. When looking at anglers, Idaho Fish & Game, and the Office of Species Conservation, there is a variety of ages, experiences, and backgrounds that have developed within them that lead to a different perception of the environment between these groups. These generational differences can account for how an individual perceives their environment from fifty, thirty or twenty years ago compared to the present. This will also help to better understand how the steelhead population is being perceived within these groups with varying experience. These differences in perception of biodiversity can attribute to shifting baselines.

Shifting baselines occurs when there is a loss of perception on past ecological conditions (Turvey et al. 2010; Hill et al. 2010). This is caused when there is a dissonance between the perceived change and the actual change that has taken place within an ecosystem (Fernández-Llamazares et al. 2015). Those from a younger generation may have less awareness of local species or their abundance from the recent past. This causes them to then interpret a more degraded environment as being normal due to their experience with it (Hill et al. 2010; Turvey et al. 2010). This is because LEK is time-sensitive to when the individual is interacting and learning about the environment they are fishing (Hill et al. 2010). This will considerably impact the perception of biodiversity change in the individuals' studies based on the time in which they are interacting with the environment. This shift in perception of biodiversity change will then severely impact users' knowledge and possible preventative measures that may then be taken by fishery managers within a given area (Fernández-Llamazares et al. 2015).

Individuals that believe that fishing conditions are staying the same or improving may not be as receptive to rule and regulation changes since they do not see a problem with the fishing numbers based on the shifted perception of species within an ecosystem.

Objectives and Hypothesis

If these three groups are sharing SEK and LEK effectively, despite generational and organizational differences, then the variation between groups should be low. The research questions of this study work to test if this hypothesis is true or not by understanding the pathways that were identified in the model above in four parts:

1) Less variation between groups indicates more knowledge transmission between types of stakeholders.

2) I will identify reported pathways of communication between stakeholder groups, both giving and receiving information, to identify how groups perceive types and mechanisms of LEK transmission.

3) I will also examine the distribution of variation between groups' LEK scores

4) I expect older individuals and those with greater experience in the fishery to perceive the same loss of biodiversity as worse than younger individuals and those with less experience.

CHAPTER TWO: METHODS

Study Site

Steelhead (*Oncorhynchus mykiss*) are an anadromous salmonid that spends one to three years in the ocean prior to returning to the Columbia River basin (Rundio et al. 2021; Penney 2011). Steelhead's population has been on the decline since the early 1990s due to habitat alteration, hydropower development, and overharvesting of the species (Scheuerell et al. 2019). Due to these negative effects on steelhead, they have been put on the U.S. Endangered Species List and labeled endangered (Scheuerell et al. 2019). The three groups being studied are the Idaho Fish & Game, the Office of Species Conservation, and anglers within Idaho. As stated above, the Office of Species Conservation uses state and local input to develop policies, Idaho Fish & Game creates regulations for hunting and fishing and also conducts research on species within Idaho, and anglers take part in fishing within Idaho and are subject to following the policies and rules that the above two groups put forth.

Sample Size

Through a contact at Idaho Fish & Game, 25 individuals were sent the questionnaire in which 21 individuals responded. For the Governor's Office of Species Conservation, six individuals were identified through a contact that works on steelhead policy and issues in the state. The questionnaire for the anglers was distributed to four different Facebook pages designated for anglers within Idaho. The groups ranged from being private to public groups and the average membership for each group was

approximately 4,000 members per page. Once permission was given by the administrator of the page, I posted the questionnaire on the page included with the script that was approved by the IRB (041-SB20-260). Despite the high volume of membership on these pages, only twenty-six individuals responded to the questionnaire.

Questionnaire and LEK Score

All three questionnaires had questions related to LEK, LEK communication, and demographics. Questions in the LEK section were then used to create an LEK score to be used to compare means between the three groups. The angler questionnaire contained two additional sections that had to do with the 2020 steelhead season and steelhead fishing rules and regulations.

The LEK section has a total of 11 questions. Questions one and two asked how steelhead fishing has changed in the last 10 years and how abundance of steelhead has changed in the individual's lifetime. These questions were done in order to understand the generational differences between individuals and to be a part of the LEK score. Another question asked respondents to interpret the changing number of steelhead and was done in order to understand individual's different perceptions. Questions five and six dealt with freshwater rearing, migration to the ocean, in the ocean, and migrating upriver as an adult for steelhead in two ways. Question five asked where the most mortality for Idaho's wild steelhead occurs. Question six asked to define the above four stages as having worsened, improved, or had no change throughout the respondent's lifetime. Questions seven, eight, nine, and ten focused on if individuals understood the different stages and type of steelhead that were in Idaho. This included asking about changes to steelhead life cycle, how many years steelhead remain in the ocean, what rivers contain

hatchery or wild steelhead, and when adult steelhead arrived in Idaho. For the question on what rivers hatchery or wild steelhead are in, hatchery steelhead are marked by a clipped adipose fin on the back of steelhead (Idaho Fish and Game 2019). Question eleven asked what river anglers fished in for steelhead the most . This would be used to see how well groups like Idaho Fish & Game and the Office of Species Conservation were gaining knowledge from anglers.

The LEK score used information from the above section. Questions included in the LEK score were the fishing change in the last 10 years, abundance change in individual's lifetimes, where the most mortality of steelhead occur, how many years steelhead remain in the ocean prior to returning to Idaho, and which rivers in Idaho have wild or hatchery steelhead in them (as identified by a clipped adipose fin). From these questions, individuals were given a point for each correct answer given. Although "correctness" is not the best practice when studying LEK, we used this information to evaluate variation in users' knowledge of steelhead among the three groups. From each group, the mean of their score will be taken to conduct an ANOVA test in order to see if there is a difference in the knowledge between these groups.

The second section in the questionnaire was centered on the LEK communication between Idaho Fish & Game, the Office of Species Conservation, and anglers. For each group, these were different based on the type of knowledge that was being transmitted. For the Idaho Fish & Game questionnaire, the sample was asked to think of things they have done personally in their professional capacity at the department of Fish & Game. This included the type of information they have shared with the Office of Species Conservation (i.e., genetic, life history, population size, projected adult return, and smolt

survival). For sharing information with anglers, this included items like fishing opportunities, fishing reports, threats to steelhead populations, regulation changes, and run forecast. In addition to the type of information, they were asked how they shared information. This included in-person conversations, social media, email, blog forums, and public informational meetings. This section also included questions asking what type of information anglers had shared with them, how many hours a day did anglers spend fishing, the average catch and harvest per day of anglers, and if they had any fishing experience and how long they had fished for steelhead outside of work. In addition, they were asked what type of information they developed on steelhead for their job.

For the Office of Species Conservation questionnaire, their LEK communication section shared similar questions to the Idaho Fish & Game but was focused on the type of information they may share. For the type of information they may share to anglers, choices included closed ended answers like steelhead life cycle, fishing opportunities, policy changes, steelhead distribution, steelhead behavior, handling of steelhead when caught, and steelhead angling methods. In addition to asking about catch and harvest average, hours fished, and their own fishing experience, they were also asked what type of information had been used this year to make policy changes.

Anglers had two additional sections that were about the 2020 steelhead season and steelhead fishing rules and regulations. The 2020 steelhead section included questions on how many hours they fished per day, the catch and harvest per day, and the rivers they fished for steelhead. The steelhead fishing rules and regulations section included questions on how the season and limits for steelhead differed between 2016-2017 and 2017-2018, how it affected their fishing, and the type of hook they could use

when fishing for steelhead. The final section for all three questionnaires asked about demographic information. For Idaho Fish & Game and the Office of Species Conservation, this included their age and how long they had worked for their organization. In addition to age, anglers were asked the county they lived in, the county they fished in, if they had a fishing license this year, the first year they got their own fishing license, and how many years they had fished for steelhead.

Statistical Analysis

In order to test these objectives, analysis has been completed in four different ways using IBM SPSS. In order to look at the first objective, an ANOVA test was run to compare the LEK means of the three groups to see if there was variation between them. A second ANOVA test was run with a modified LEK score because one of the LEK questions concerning whether a river contained hatchery or wild steelhead could potentially have seven correct answers within the LEK score. In order to offset it, this question was divided by two and gave each individual a new LEK score that then changed the group's mean LEK score. The second objective was tested by conducting a frequency test on how information is relayed between each group. In addition to examining the frequency of communication, how and what is being communicated was looked at from the responses given from respondents. The third objective was tested by conducting Chi-Square tests on each question between the groups. The questions within the LEK score was used to conduct the test in order to understand the difference in knowledge between anglers, Idaho Fish & Game and Office of Species Conservation. The fourth objective was tested by looking at regression. This looked at how age and experience might be impacting LEK score between the groups.

CHAPTER THREE: RESULTS

Objective 1: LEK ANOVA Test

There was a significant difference in LEK score between all three groups ($p<0.000$) with Idaho Fish & Game having the highest LEK score and anglers having the lowest LEK score. Idaho Fish & Game's LEK score had a mean of 9.24, the Office of Species Conservation's LEK score was 6.33, and anglers' LEK score was 6.13. However, using a Bonferroni post-hoc test (see Table 1) to adjust for multiple comparisons found that there was not a significant difference between the Office of Species Conservation and anglers ($p = 1.000$). Idaho Fish & and Game respondents' LEK scores were significantly higher on average than those from Office of Species Conservation ($p = 0.021$). The LEK scores between Idaho Fish & Game and anglers was significantly different with a p of 0.000 with Idaho Fish & Game scoring higher than anglers. The ANOVA test showed that there is still a significant difference between groups with a p-value of 0.000. The difference in LEK score between Idaho Fish & Game and the Office of Species Conservation has a p-value of 0.067 which is marginally significant. There is a significant relationship between Idaho Fish & Game and anglers with a p-value of 0.000. The relationship between Office of Species Conservation and anglers is still not significant (p-value = 1.000).

Table 1 Bonferroni post-hoc test comparing LEK score means of IDFG, OSC, and anglers

Multiple Comparisons

Dependent Variable: LEK Score

Bonferroni

(I) Group Name	(J) Group Name	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
OSC	IDFG	-2.905*	1.028	.021	-5.46	-.35
	ANG	.203	1.018	1.000	-2.32	2.73
IDFG	OSC	2.905*	1.028	.021	.35	5.46
	ANG	3.108*	.670	.000	1.44	4.77
ANG	OSC	-.203	1.018	1.000	-2.73	2.32
	IDFG	-3.108*	.670	.000	-4.77	-1.44

*. The mean difference is significant at the 0.05 level.

Objective 2: Communication

Frequency tests that were done on the communication between each group showed that communication is happening predominantly more through Idaho Fish & Game and anglers. Of the 26 individuals that responded to the angler questionnaire, nineteen individuals (82.6%) said that they did not share information with the Office of Species Conservation (Table 2). The same number of individuals that said they did not share information with the Office of Species Conservation also said that the Office of Species Conservation did not share information with anglers. When asked about communication with Idaho Fish & Game, thirteen angler respondents reported having shared information with Idaho Fish & Game (56.5%) (Table 3). Fourteen angler respondents (60.9%) said that information was shared to them by Idaho Fish & Game.

Table 2 Frequency of communication from angler respondents on sharing information with Office of Species Conservation

		Frequency	Percent
Valid	No	19	82.6
	Yes	4	17.4
	Total	23	100.0

Table 3 Frequency of communication from angler respondents on sharing information with Idaho Fish & Game

		Frequency	Percent
Valid	No	9	39.1
	Yes	14	60.9
	Total	23	100.0

In addition to the frequency test that was completed, the questionnaire also asked how and what information was shared between these three groups. From the results above, most of the exchange of information shared within these three groups is done by Idaho Fish & Game and anglers. Those within Idaho Fish & Game and the Office of Species Conservation are the two groups that are mainly reaching out to anglers to either gain or share information within this system. Within the questionnaire, both of these organizations were asked the medium that they used in order to share information with anglers. This question allowed individuals to select all forms of communication that applied to their role. Of the twenty-one individuals within Idaho Fish & Game that responded to the questionnaire, eighteen individuals cited in-person conversations as being the medium in which they used to communicate with anglers (Figure 2). The second way in which individuals cited as being the medium to communicate with anglers

is public informational meetings with thirteen of the twenty-one individuals citing it. When asked what they had communicated to Idaho Fish & Game, angler respondents expressed their frustrations with the run size of steelhead, their fishing experience, personal opinions on management topics, perceived abundance of steelhead, and thoughts on what should be done to improve steelhead number.

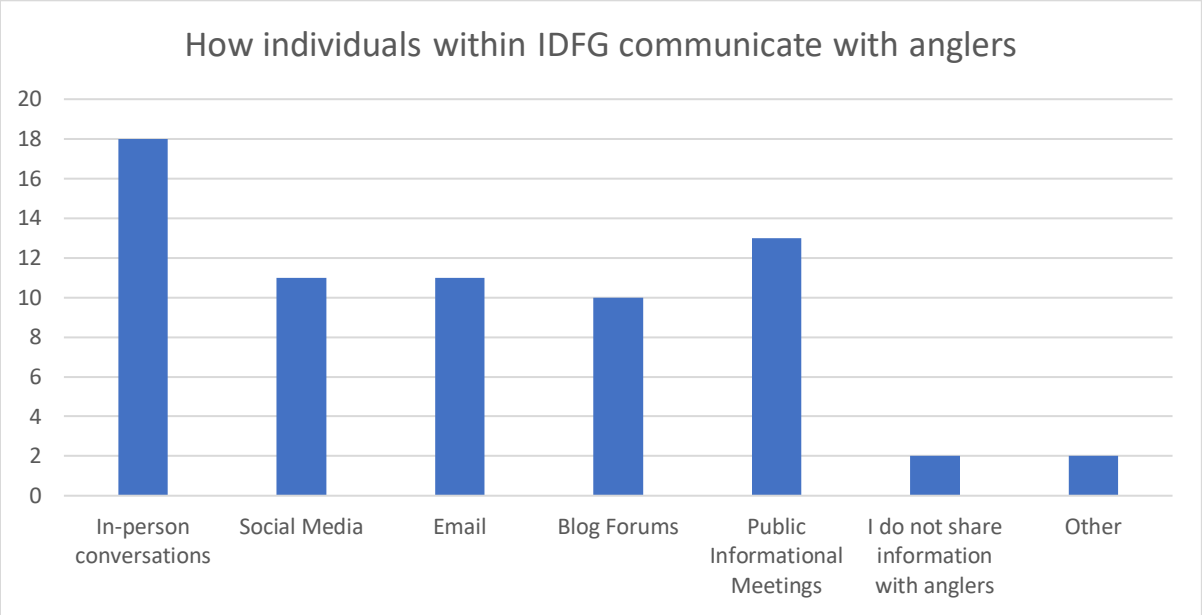


Figure 2 **Frequency distribution of the medium Idaho Fish & Game used to communicate with anglers**

In regards to the communication between the Office of Species Conservation and anglers, as shown above there is far less communication than what is seen between Idaho Fish & Game and anglers. From those that do communicate, the Office of Species Conservation say that they share information mostly about steelhead life cycle, fishing opportunities, steelhead distribution, and steelhead behavior (see Figure 3). The type of information that anglers said was shared with them included the Governor's Salmon Workgroup, population information, tags, and the efforts the Office of Species

Conservation are trying to improve on, and continued frustration with river management. When looking at the type of information that anglers share with the Office of Species Conservation, respondents said that they shared suggestions for seasons and bag limits, tags, population estimates, and "sixty years of mistakes with the Columbia River operations". Although there is some communication happening, as shown above, the communication between the Office of Species Conservation and anglers is lacking.

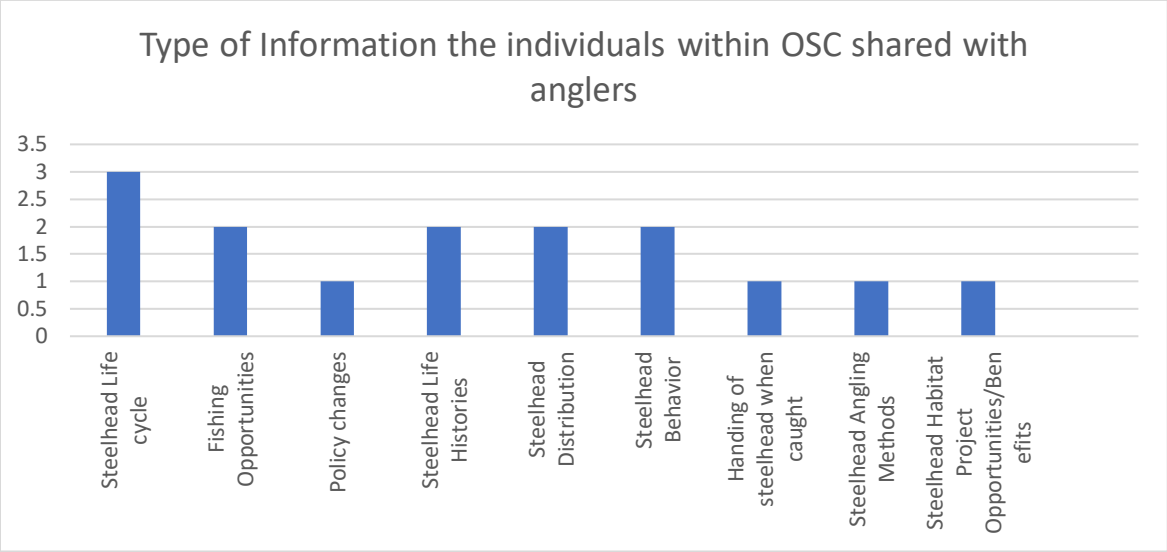


Figure 3 Bar chart showing the type of information the Office of Species Conservation shared with anglers (y-axis is the number of individuals that shared the type of information that is found on the x-axis)

Objective 3: Chi-Square Test on LEK Score Questions

The Chi-Square test and Fisher's Exact test looked at comparing the answers from the LEK questions that created the LEK score between the three groups. The Fisher's Exact test was run since my sample size of each group is small (less than 100 individuals). Each group was done in comparison to one other group in order to be able to run the Fisher's Exact test. When looking at the fishing change in the last ten years, none

of the groups' LEK score were significantly different from each other (p>0.11) For abundance change in lifetime, all groups agreed that abundance has decreased and there was not a significant difference between groups. When asked where the most mortality for steelhead occur in Idaho, there was a significant difference between the Office of Species Conservation and anglers (p-value = 0.030) and Idaho Fish & Game and anglers (p-value = 0.013) (see Table 4 and 5). For the years steelhead remain in the ocean, there was not a significant difference between any of the groups. The majority of respondents within each group answered correctly for this question.

Table 4 Chi-Square Test between the Office of Species Conservation and anglers

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.244[a]	1	.002		
Continuity Correction[b]	4.431	1	.035		
Likelihood Ratio	7.324	1	.007		
Fisher's Exact Test				.030	.030
N of Valid Cases	32				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .38.

b. Computed only for a 2x2 table

Table 5 Chi-Square Test between Idaho Fish & Game and Anglers

Chi-Square Tests

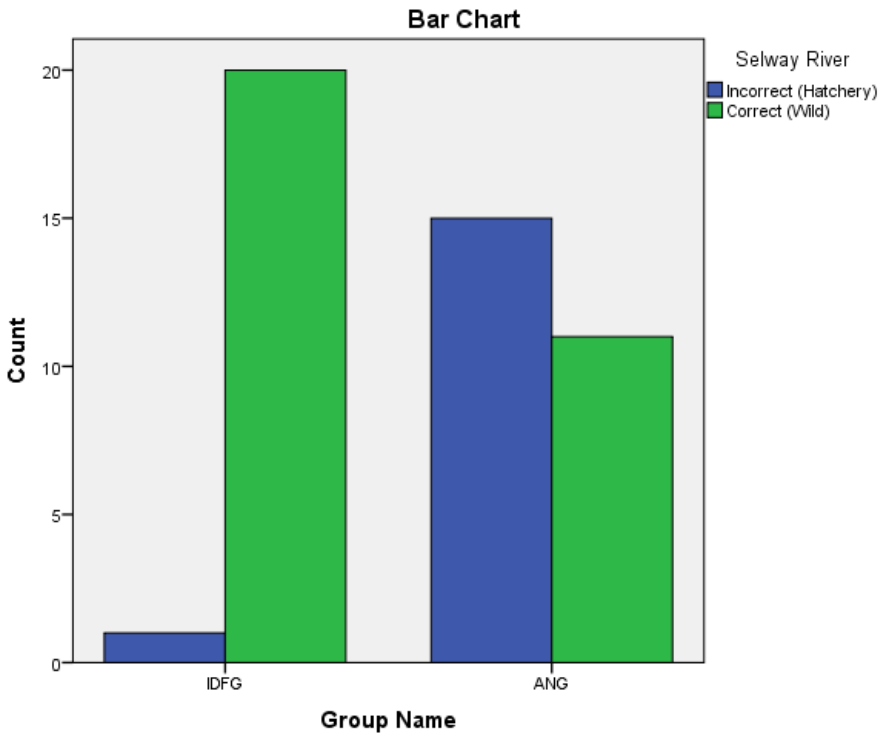
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.927[a]	1	.008		
Continuity Correction[b]	4.649	1	.031		
Likelihood Ratio	8.803	1	.003		
Fisher's Exact Test				.013	.013
N of Valid Cases	47				

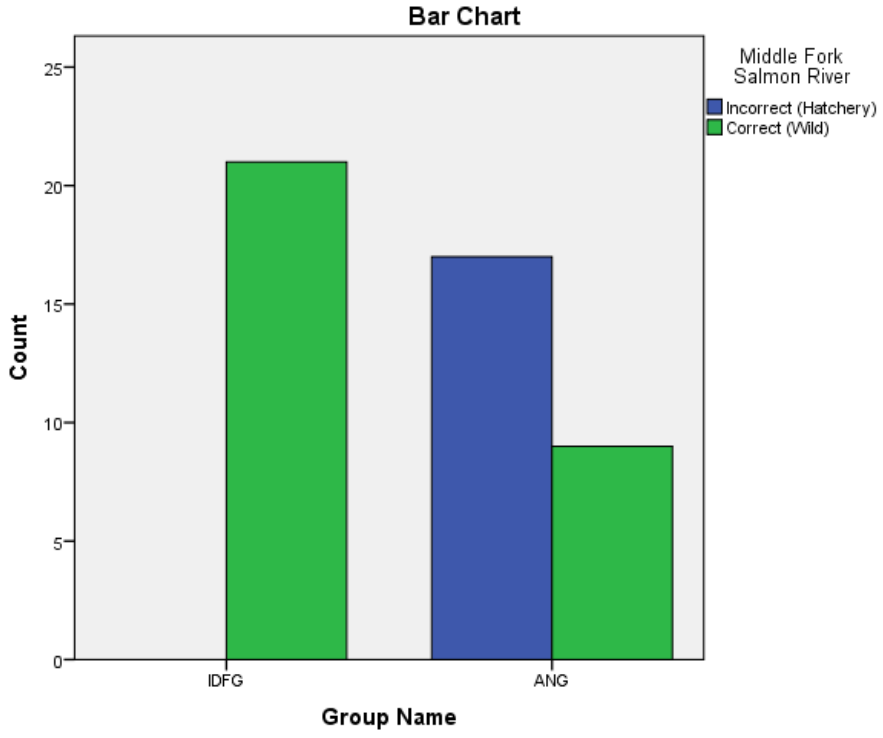
a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.23.

b. Computed only for a 2x2 table

The next seven tests were concerned with whether a river contained hatchery or wild steelhead. The Clearwater River (Hatchery) responses did not have significant difference between any of the groups. The Selway River (Wild) responses did have a significant difference between the Office of Species Conservation and Idaho Fish & Game (p-value = 0.025) and Idaho Fish & Game and anglers (p-value = 0.000). Between the Office of Species Conservation and Idaho Fish & Game, only 50% of the Office of Species Conservation answered that it contains wild steelhead while 95.2% of Idaho Fish & Game respondents answered contains wild steelhead. For the relationship between Idaho Fish & Game and anglers, 57.7% of angler respondents answered incorrectly. The South Fork Clearwater River (Hatchery) responses did not have a significant difference between any of the groups. The Lower Snake River (Hatchery) had a significant difference between Idaho Fish & Game and anglers (p-value = 0.030). 95.2% of Idaho Fish & Game respondents answered that it is hatchery and 69.2% of anglers answered it

was hatchery as well. The Upper Salmon River (Hatchery) responses did have a significant difference between the Office of Species Conservation and Idaho Fish & Game (p-value = 0.056) and Idaho Fish and Game and anglers (p-value = 0.004). 50% of the Office of Species Conservation and anglers answered that it was wild whereas 90.5% of Idaho Fish & Game answered it was hatchery. The Middle Fork Salmon River (Wild) responses did have a significant difference between the Office of Species Conservation and Idaho Fish & Game (p-value = 0.043) and Idaho Fish & Game and anglers (p-value = 0.000). 67.7% of the Office of Species Conservation and 34.6% of anglers answered it was wild for this question. 100% of Idaho Fish & Game respondents answered it was wild. The South Fork Salmon River (Wild) responses did have a marginal significance between the Office of Species Conservation and Idaho Fish & Game (p-value = 0.060) and Idaho Fish & Game and anglers (p-value = 0.080). 41.7% of theOffice of Species Conservation respondents and 61.5% of angler respondents answered it was wild. 66.7% of Idaho Fish & Game answered it was wild. From these results, rivers that contain wild steelhead were answered incorrectly predominantly by anglers (Figure 4 and 5).


Bar Chart
Selway River
Incorrect (Hatchery)
Correct (Wild)
Count
20
15
10
5
0
IDFG
ANG
Group Name


Bar Chart
Middle Fork
Salmon River
Incorrect (Hatchery)
Correct (Wild)
Count
25
20
15
10
5
0
IDFG
ANG
Group Name

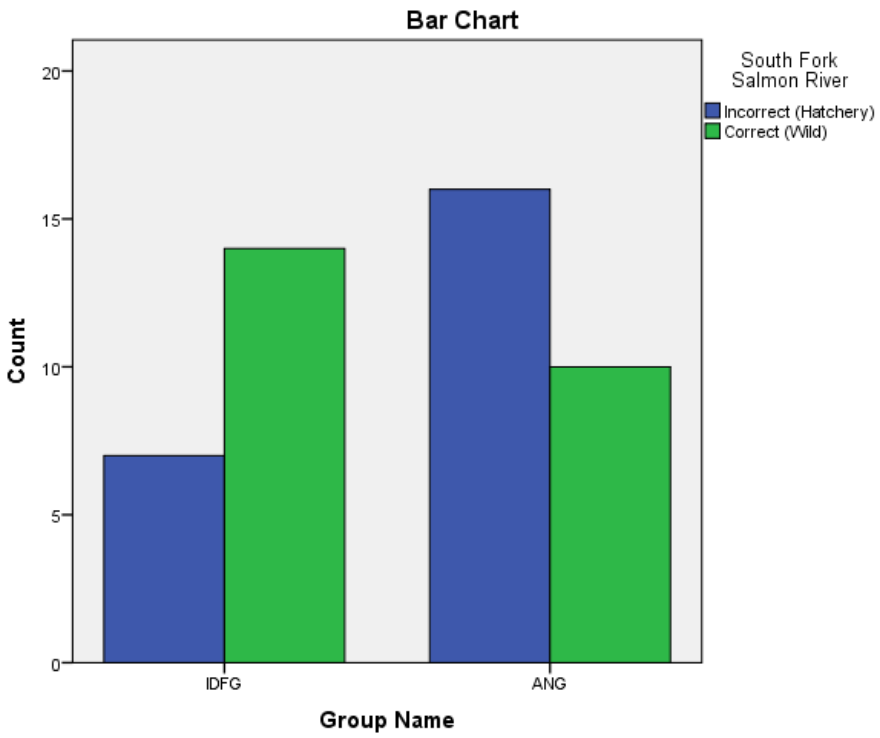
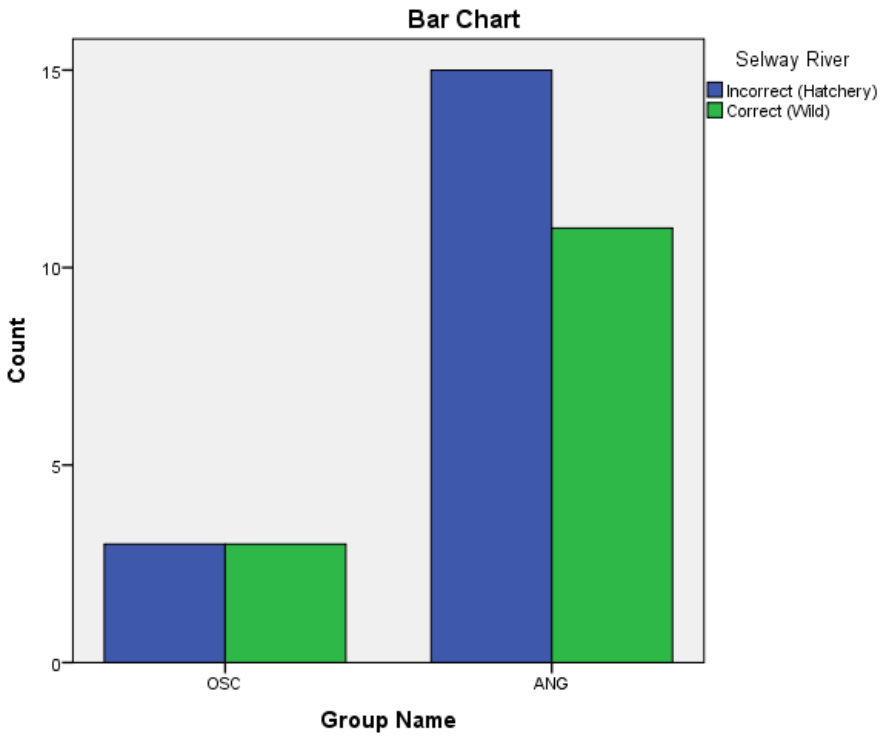
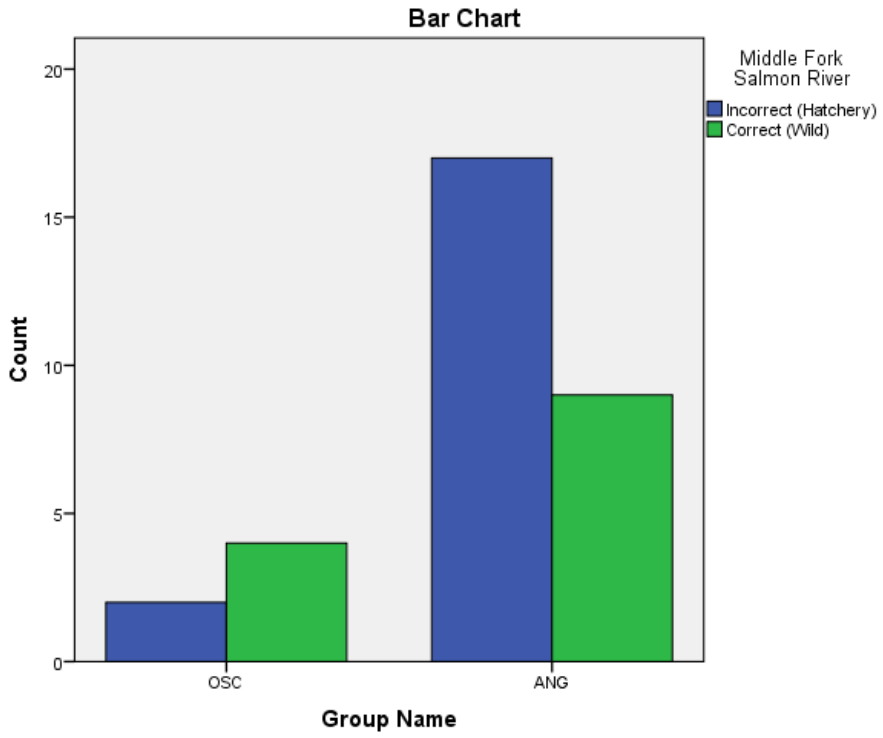


Figure 4 Bar chart of rivers containing wild steelhead and the responses from IDFG and anglers. The green bars indicates the number of individual's answering correctly within the group. The blue bar indicates the number of individual's answering incorrectly within the group.


Bar Chart
Selway River
Incorrect (Hatchery)
Correct (Wild)
Count
15
10
5
0
OSC
ANG
Group Name


Bar Chart
Middle Fork
Salmon River
Incorrect (Hatchery)
Correct (Wild)
Count
20
15
10
5
0
OSC
ANG
Group Name

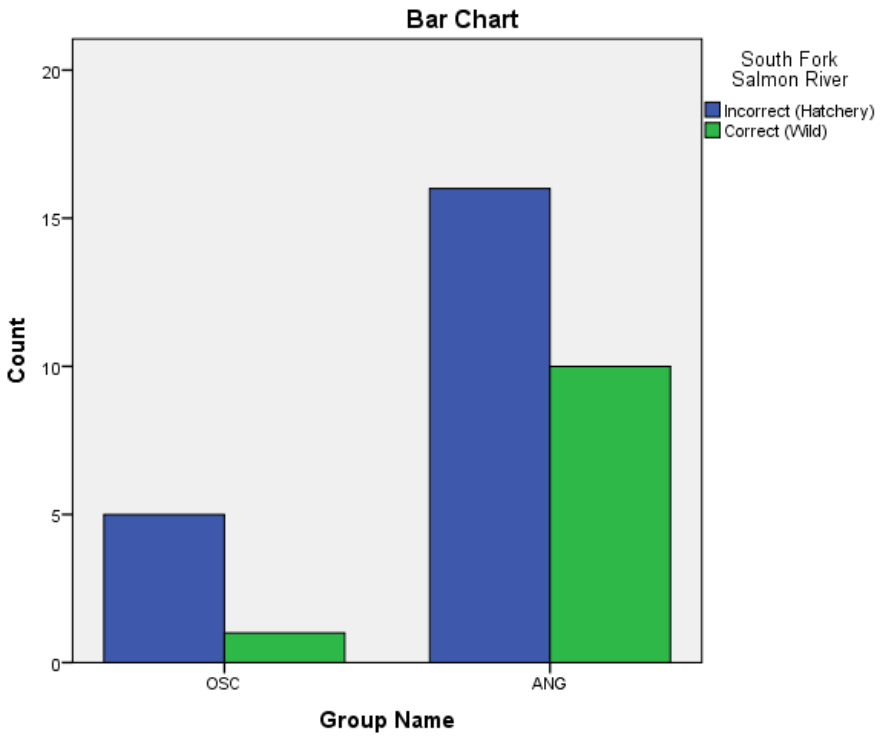


Figure 5 Bar chart of rivers containing wild steelhead and the responses from OSC and anglers. The green bars indicates the number of individual's answering correctly within the group. The blue bar indicates the number of individual's answering incorrectly within the group

The final question looked at when steelhead first arrive in Idaho each year and there was no significant difference between any of the groups. However, it is noteworthy that for the Office of Species Conservation and anglers, each individual answered the question incorrectly (see Figure 6). Months that anglers did answer for this question were October (9 respondents), November (6 respondents), February (5 respondents), December (2 respondents), January (2 respondents), and September (2 respondents).

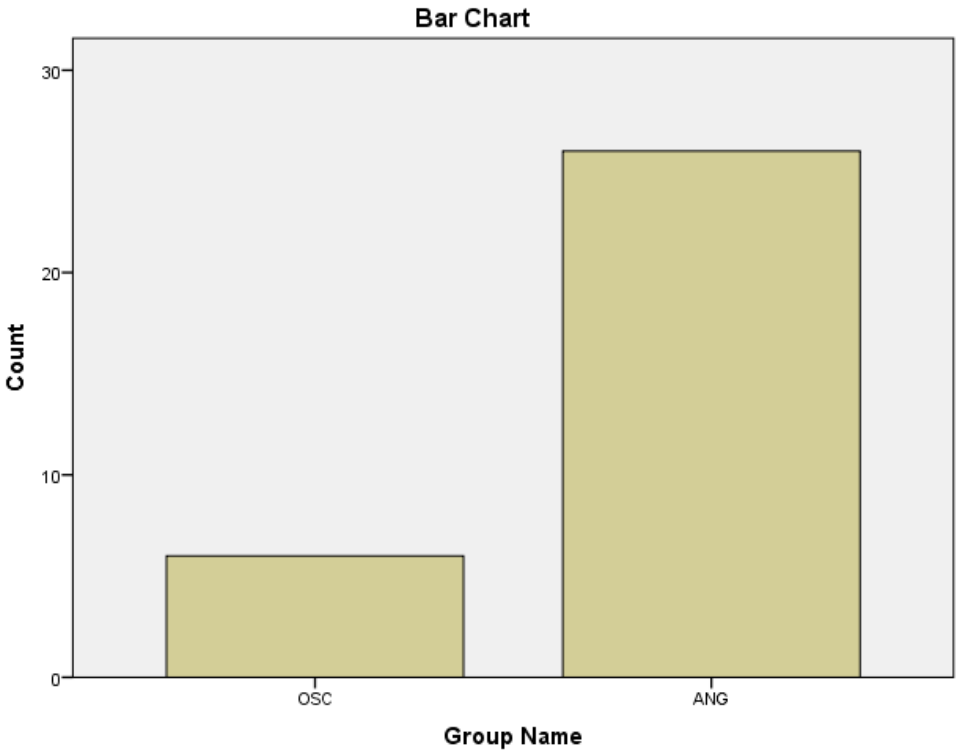


Figure 6: Bar chart of the Office of Species Conservation and angler where all respondents answered incorrectly about when steelhead come into Idaho (correct answer is July)

Objective 4: Age and Experience Regression

When looking at the impact that age and experience could have on LEK scores, a regression test was run in order to see the relationship. Neither age nor experience fishing/working in their current organization showed a significant relationship with LEK score. This is shown in both the ANOVA and Coefficients table (Table 6 and 7). The ANOVA table shows that age and experience do not correlate with LEK scores with a p-value of 0.768. The coefficients table shows that age and experience is not correlated to LEK score.

Table 6 ANOVA table in regression showing the impact age and experience fishing/working at organization has on LEK score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.772	2	1.886	.265	.768[b]
	Residual	348.920	49	7.121		
	Total	352.692	51			

a. Dependent Variable: LEK Score

b. Predictors: (Constant), Experience at Fishing/Organization, Age of Individual

Table 7 Coefficients table in regression showing that age and experience fishing/working at organization are not correlated with LEK score

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	6.307	1.648		3.827	.000	2.995	9.618		
	Age of Individual	.026	.044	.098	.606	.548	-.061	.114	.768	1.302
	Experience at Fishing/Organization	.002	.029	.010	.062	.951	-.057	.060	.768	1.302

a. Dependent Variable: LEK Score

Hours Fishing, Catch, and Harvest

An ANOVA test showed that only Sunday and Saturday were significant between groups and reporting how long anglers fish for those two days (Table 8). This looked at comparing what anglers said they fished on a given day and what Idaho Fish & Game and the Office of Species Conservation believed the length of time that anglers fished on a

given day. When looking at the mean plots for both Sunday and Saturday, anglers are reporting fishing for less hours than what Idaho Fish & Game and the Office of Species Conservation say that they are (Figure 7 and 8). For Sunday, the mean for anglers was 4.25 hours, Idaho Fish & Game's mean was 5.18 hours, the Office of Species Conservation's mean was 6.5 hours. For Saturday, the mean for anglers was 4.33 hours, Idaho Fish & Game's mean was 5.47 hours, and the Office of Species Conservation's mean was 6.5 hours.

Table 8 ANOVA test comparing hours reported per day between groups

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Hours Fished on Sunday	Between Groups	16.279	2	8.140	3.063	.062
	Within Groups	79.721	30	2.657		
	Total	96.000	32			
Hours Fished on Monday	Between Groups	18.968	2	9.484	2.206	.130
	Within Groups	111.791	26	4.300		
	Total	130.759	28			
Hours Fished on Tuesday	Between Groups	13.382	2	6.691	1.820	.181
	Within Groups	99.284	27	3.677		
	Total	112.667	29			
Hours Fished on Wednesday	Between Groups	20.197	2	10.098	2.085	.142
	Within Groups	145.318	30	4.844		
	Total	165.515	32			
Hours Fished on Thursday	Between Groups	24.169	2	12.085	2.718	.082
	Within Groups	137.831	31	4.446		
	Total	162.000	33			
Hours Fished on Friday	Between Groups	8.090	2	4.045	1.075	.355
	Within Groups	105.330	28	3.762		
	Total	113.419	30			
Hours Fished on Saturday	Between Groups	18.987	2	9.493	3.537	.041
	Within Groups	88.569	33	2.684		
	Total	107.556	35			

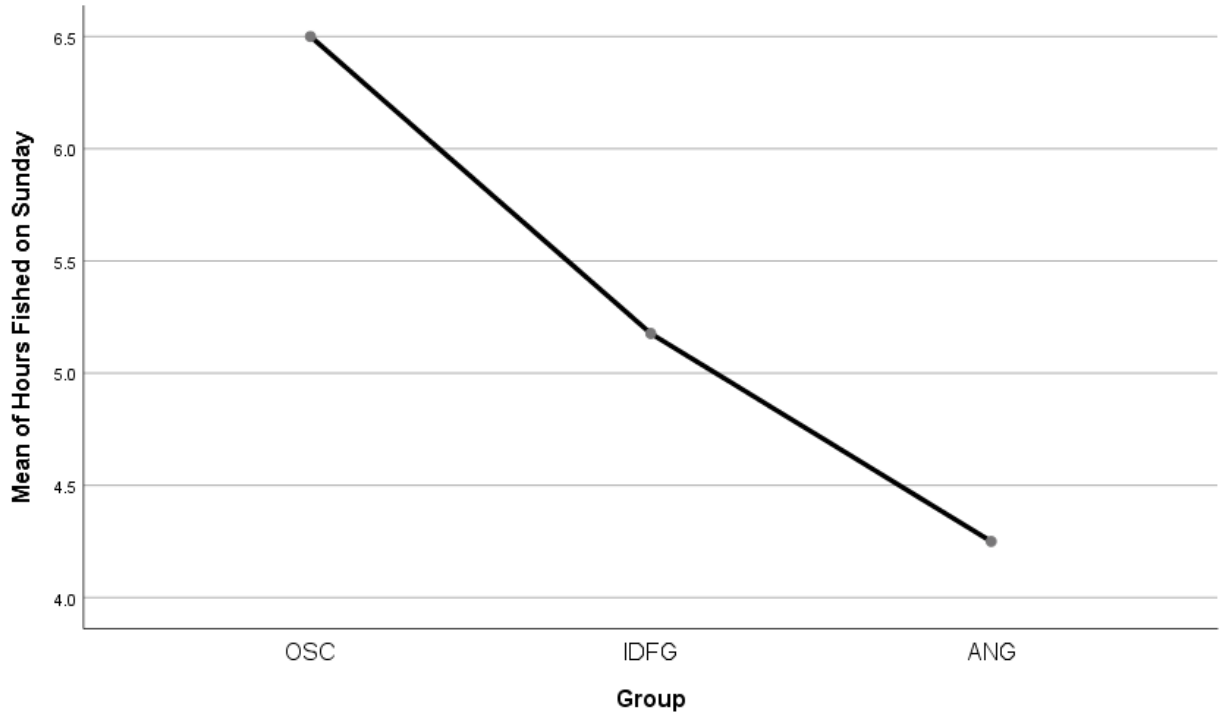


Figure 7 **Mean plot comparing mean hours fished for Sunday between IDFG, OSC, and anglers**

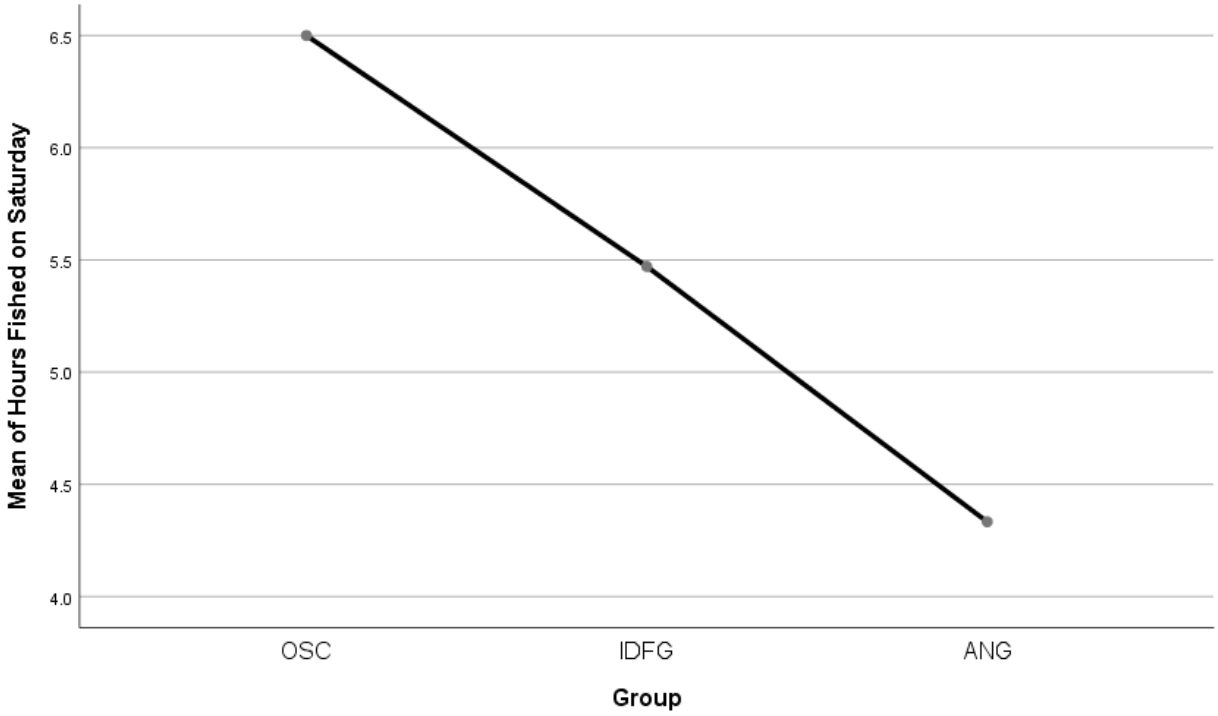


Figure 8 Mean plot comparing mean of hours fished on Saturday between IDFG, OSC, and anglers

When looking at catch average per week, the ANOVA test showed that there was no significant difference between groups with $p>0.05$ (Table 9). When looking at harvest average per week, the ANOVA test showed that there was a significant difference between groups with $p = 0.001$ (Table 10). When looking at the mean plot for harvest average per week, this shows that anglers are reporting a higher harvest average than what Idaho Fish & Game and the Office of Species Conservation believe they are (Figure 9).

Table 9 ANOVA test comparing reporting of catch average per week between groups

ANOVA

Catch Average for One Week

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.129	2	.064	.124	.884
Within Groups	25.002	48	.521		
Total	25.131	50			

Table 10 ANOVA test comparing reporting of harvest average per week between groups

ANOVA

Harvest Average for One Week

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.220	2	.610	8.904	.001
Within Groups	3.289	48	.069		
Total	4.510	50			

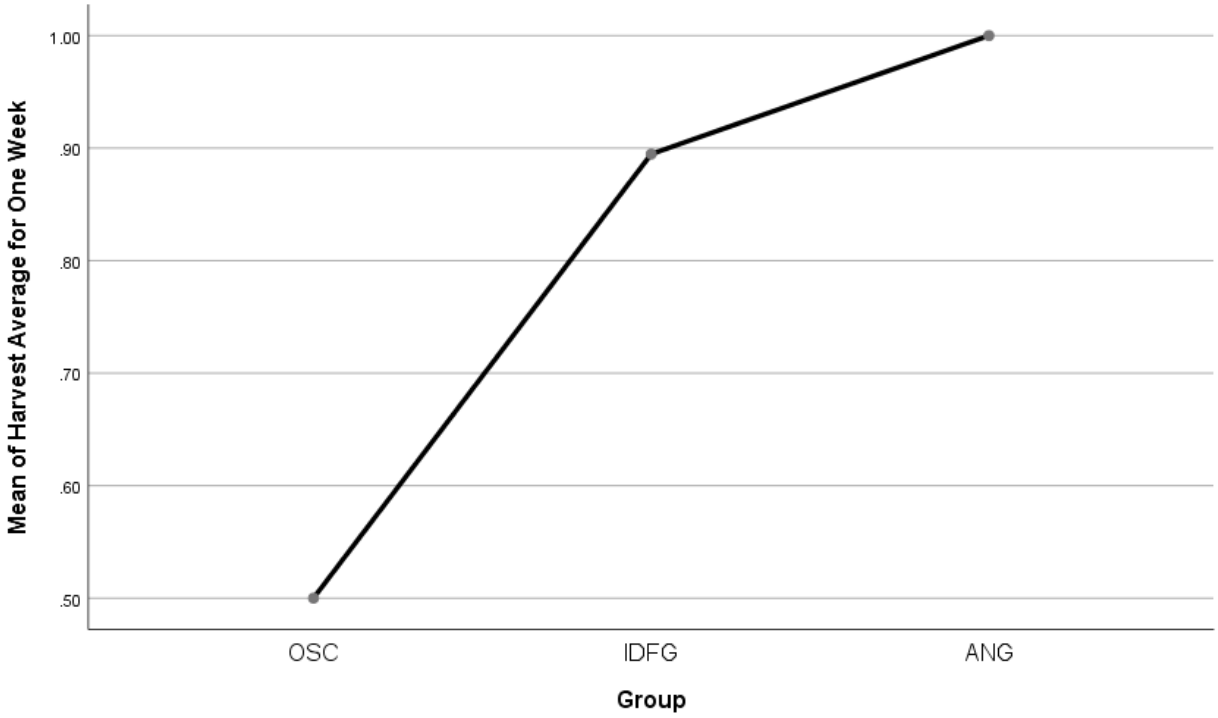


Figure 9 **Mean plot looking at mean of harvest average for one week across IDFG, OSC, and anglers**

CHAPTER 4: DISCUSSION

How well are these three groups exchanging knowledge?

As shown above, there is a significant difference in LEK score ($p<0.000$), especially from the Office of Species Conservation and anglers. Idaho Fish & Game appears to hold the most knowledge on steelhead in comparison to the other two. A reasoning behind this may be that the questionnaire was made in collaboration with Idaho Fish & Game and may be more suited to their domain of knowledge. This indicates that there is a discord between the knowledge that these three groups are sharing. If there is discord between groups, then there can be variation of understanding on how steelhead are being impacted. This variation impacts the group's perception and then impacts the willingness to take part in management efforts. When looking at the individual questions within the LEK score, the question surrounding where the most mortality occurs for steelhead is the one that individuals answered incorrectly. Those that answered this question incorrectly were the anglers which is shown within the Chi-Square test that was conducted above. This is significant in itself because angler respondents from my questionnaire stated that they are concerned about run size and stock. This could be due to the fact that there are steelhead hatcheries that would supplement any loss that would occur with the wild steelhead population.

Another fact may be that anglers might not have understood the question or see that their perception of where the most mortality occurs is different from those within Idaho Fish & Game and the Office of Species Conservation. However, as discussed

above, LEK is developed through an individual's lifetime in which individuals gather information from other anglers and from outside sources like scientists (Aswani, Lemahieu, and Sauer 2018; Reyes-Garcia et al. 2010; Gómez-Baggethun et al. 2012; Murray, Neis, and Johnsen 2006). Anglers within this system are supposed to be gaining knowledge from SEK users like Idaho Fish & Game and use that to build on their own LEK. However, the defining difference between LEK and SEK users is how they define "local". For stakeholders like Idaho Fish & Game and the Office of Species Conservation, local means the entire state of Idaho as shown in each of their responsibilities outlined by the Idaho government (Title 67, ch. 8, sec. 818; Title 36, ch. 1, sec. 104). For anglers, this might be delineated by the rivers in which they fish. This difference in known locality can affect the difference in LEK scores between the groups. When looking at other case studies, the collaborations between LEK and SEK users face methodological and technological issues that may maintain variation in knowledge (Menzies 2006; Ulicsni et al. 2018). Studies like those done by Moller et al. (2004), examined the monitoring techniques done by both SEK and LEK users. They found that these two groups are more aligned in their findings despite technique differences and that LEK users can aid in extending spatial and temporal scales (Moller et al. 2004). For this study, LEK scores varied between the three groups. This may be due to co-design of the questionnaire questions with SEK users at the department of Idaho Fish & Game and information individuals working for this stakeholder feel to be important. The inclusion of what anglers consider to be important can provide additional information in aiding the management of steelhead and may bridge the gap between the differences of LEK score within these groups.

How and what are these groups communicating?

Communication is a key component to the development of LEK and an integral part of the success of resource management. Since information is not flowing easily between the groups observed here, this can impact the stakeholders' perception of the environment beyond their local niche. The perceived lack of communication between Office of Species Conservation and anglers may lead to LEK/SEK mismatch and may increase reluctance towards future communication and alignment of attitudes towards resource use. When looking at the words that anglers used when talking about the Office of Species Conservation and Idaho Fish & Game, anglers assigned words like frustration into their responses. In contrast, there is a reported high volume of information being shared between anglers and Idaho Fish & Game. When asked the type of information they shared with Idaho Fish & Game, one angler praised Idaho Fish & Game for the work that has been implemented. As discussed above, LEK is developed through personal observations and is also learned through interactions with scientists and natural resource managers (Aswani, Lemahieu, and Sauer 2018; Reyes-Garcia et al. 2010; Gómez-Baggethun et al. 2012; Murray, Neis, and Johnsen 2006). If stakeholders do not trust one another, they may deplete natural resources even when it is in the best interest of all groups to maintain them. As shown by Menzies (2006), collaboration between biologists, outfitters, and Kluane First Nation people began when looking at improving sheep populations within the Yukon. The biologists and outfitters believed that the decline in sheep population could not be attributed to hunting by humans. The Kluane First Nation people believed that hunting by humans had a significant impact on sheep population. This fact became an issue of contention between the groups and highlighted the power

dynamics in play since the Yukon Department of Renewable Resources sided with the outfitters who opposed any resource management that would ban hunting. In the simplest form, these groups were unwilling to listen or communicate effectively in order to create a management plan that would benefit all those involved and create a space in which they could be heard. Idaho Fish & Game and the Office of Species Conservation do take steps in order to involve anglers with their processes. However, the level in which they feel shared or heard varies between groups. The Office of Species Conservation does have a workgroup aimed at combing stakeholder knowledge on salmon and steelhead. However, other methods of communication may be necessary for anglers to feel heard.

What is the perception of change for steelhead within Idaho?

As far as resource management, the Chi-Square test showed that there was not a significant difference between the three groups when asked about fishing change in the last ten years and abundance change within the individual's lifetime. By looking at respondents' ages, it can aid in explaining why these two results were not significant. Ages of anglers ranged from 21 to 57, Idaho Fish & Games ages ranged from 31 to 56, and the Office of Species Conservation ages ranged from 37 to 45. These age ranges are small, especially those found within the Office of Species Conservation. The largest gaps between individuals can be found within anglers where there is a 36-year age gap between the oldest and youngest respondents. This attributes to the fact that most respondents from all three groups answered either less fish or less abundant to the respective questions that they were asked. This shows that groups see the change for steelhead in the same way.

The regression test showed that neither age of respondent nor experience fishing/working in their current organization showed a significant relationship with LEK score. Since there is no correlation between LEK and age and experience, this indicates that there is no shifting baseline between the groups. Other studies like Turvey et al. (2010), did find that there was a shifting baseline between generations on the Yangtze River. The differences between Turvey et al.'s study and this one may be the age range. The age range for this study is 21 to 57 between all of the groups. Turvey et al.'s (2010), had an age range of 22 to 99. The age range found within Turvey et al.'s study may attribute to being able to identify a shifting baseline.

Hatchery vs. Wild Rivers within Idaho

The results of the Chi-Square test showed that there were no significant differences between any of the groups when asked whether a river contained hatchery or wild steelhead. However, the rivers that have wild steelhead within them is of particular interest since they were answered incorrectly predominantly by anglers. This indicates that this knowledge is not being shared with anglers or is not a concerning factor to anglers when fishing for steelhead. Although these rivers are throughout the whole of Idaho and not specific to a region, the questionnaire did also ask anglers where they fished for steelhead. The rivers that contained wild steelhead, which include the Selway, Middle Fork Salmon, and South Fork Salmon River, had a small proportion of respondents that did fish on these rivers. A total of five individuals said that they fish for steelhead on the Middle Fork Salmon River and one individual said they fished for steelhead on the South Fork Salmon River. No individuals reported having fished for steelhead on the Selway River. Because of the low numbers of individuals that fish for

steelhead on these specific rivers, anglers may not have known whether the steelhead within these rivers are hatchery or wild steelhead. However, as part of the rules and regulations that anglers must follow, anglers can only harvest steelhead that are from hatcheries. As already discussed above, anglers define local differently and know about their specific fishing spot. Any river outside of their locality does not affect their fishing and does not require them to know whether there are hatchery or wild steelhead.

Hours Fished, Catch, and Harvest

The ANOVA test showed there was a significant difference between groups on hours fished on Sunday and Saturday and harvest average. There was no significant difference between groups on catch average but there was a significance between groups on harvest average per week. When looking at catch and harvest average, the amount in which anglers are allowed to harvest per day is put in place by Idaho Fish & Game. The number of steelhead anglers are allowed to harvest is set to the specific run size of hatchery fish that are available for all anglers to enjoy. A reason for this significance may be the way the three groups answered the question within the questionnaire. For Idaho Fish & Game and the Office of Species Conservation, they were asked to provide the average catch/harvest per week of anglers. However, anglers were asked to list how many steelhead they caught/harvested per day. When running the analysis, I added up the total for the week and then divided the sum by seven in order to get the average. If just the total average of the week was asked, the average between the three groups on catch and harvest may not be as significant. However, these two questions are important to look at in terms of how much anglers are taking home each week in order to maintain the fishery for all. Run size, as already stated, is a concern for anglers. In addition, what steelhead

they catch, harvest, and how long they spend in the fishery is vital in the creation of angler's LEK. Other case studies have looked at incorporating LEK with SEK when SEK users are unable to spend extensive amounts of time in a field (Garcia-Quiano 2007; Felt 2008). The time in which anglers are able to spend within one given location creates this depth of knowledge and experience that scientists do not have due to funding or distance from a laboratory (Garcia-Quiano 2007). Understanding how long and when anglers fish can help scientists pinpoint valuable LEK users that have an extensive knowledge range on a given locality (Garcia-Quiano 2007). These users can provide valuable information that can then be used to aid in resource management.

Limitations of the Study

The main limitation of this study is the small sample size, especially the size of the Office of Species Conservation sampled. This study is examining a small group of stakeholders and does not represent all of the stakeholders that can have an effect on steelhead biodiversity. In regard to both the Office of Species Conservation and Idaho Fish & Game, contacts at both organizations were asked to email the questionnaire to only individuals that are involved with steelhead information. This factor contributes to the fact that there is such a small sample size for both of these organizations. For the angler questionnaire, the distribution of the questionnaire was done online in order to limit any possible exposure and spreading of COVID-19. If I was completing this study when COVID-19 was not occurring, I would have shared the questionnaire online, within bait and tackle shops around Boise, Idaho, and interviewed anglers on local rivers. This would have allowed me to have a larger sample size and possibly get more information by conducting informal interviews. A larger sample size would have allowed for

increased generational differences to be found and would have aided in understanding the varying perceptions of the steelhead fisheries. Informal interviews would have allowed anglers to speak even further on the subject rather than the only 350 characters that were allotted by the long answer responses or clicking of a box that is allowed within an online questionnaire.

Future Directions

Future research should expand the knowledge questions asked in the questionnaire and include other types of stakeholders and expand on generational differences in knowledge. This would include asking from whom individuals learned to fish for steelhead, how younger and older generations interact with one another (i.e., do they share fishing stories with those of similar ages or those that are younger than them), and expand on how individuals are impacting this ecosystem and steelhead. Future research should also focus on the relationship between SEK and LEK. This would include asking about individuals' perception of LEK, for how long they have fished for steelhead, and if it is used within their research or recommendations. As was mentioned above, this study does not include all of the possible actors that are present within this system. Other actors include indigenous populations, federal level government agencies like NOAA, local conservation groups and other states like Washington and Oregon of which steelhead travel through. The scale that was chosen for this project was small in comparison to the other actors that are present and have an impact on steelhead. By including other actors, it expands the knowledge that is being exchanged between all of the possible actors within the system.

Conclusion

I have shown that there is mismatch between the groups' LEK most likely due to differences in the conception of what is local, and that age and experience does not impact LEK scores within these groups. The mismatch between groups' LEK may indicate that steelhead are being negatively impacted. This mismatch can be attributed to the lack of communication between certain groups and the length of experience fishing or working within groups has on that knowledge. Another factor could be that anglers may be under-communicating their LEK, which could impact how the fishery steelhead is managed.

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APPENDIX A

Angler Questionnaire

Angler Questionnaire

INFORMED CONSENT

Issues surrounding salmon and steelhead can be complex and easily misunderstood. As such, we are conducting a study to evaluate how well information is communicated between scientists and anglers. In this particular case, we will be evaluating angler's knowledge about Idaho's steelhead fisheries. Our hopes are that by filling out this questionnaire we will gain a better understanding of where Idaho Fish & Game and Office of Species Conservation can improve in how they communicate with anglers. You are being asked to participate because you are an angler that subscribes to an email service and/or blog from the Idaho Fish & Game.

If you agree to be in this study, you will participate in a brief (~15 minute) questionnaire. Besides questions about steelhead, you will be asked your age and your fishing experience. There are no perceived risks to participation, and you may stop at any time. We hope that this survey will provide insight into how knowledge about steelhead is acquired and remembered by different groups of stakeholders.

Clicking the next button below you are over 18 years of age and consent to participate in this questionnaire.

If you have questions about your rights as a research participant, you may contact the Boise State University Institutional Review Board (IRB),

which is concerned with the protection of volunteers in research projects. You may reach the board office between 8:00 AM and 5:00 PM, Monday through Friday, by calling (208) 426-5401 or by writing: Institutional Review Board, Office of Research Compliance, Boise State University, 1910 University Dr., Boise, ID 83725-1138.

Research Project Information

Study Title: Local Ecological Knowledge Exchange of Steelhead

Principal Investigator: Dr. Kathryn Demps (kathryndemps@boisestate.edu)

Co-Investigator: Mikaela Weisenfluh (mikaelaweisenflu@u.boisestate.edu) Sponsor: This research is for Ms. Weisenfluh's Master's Thesis and is not sponsored by any agency

2020 Steelhead Season

1. On your last steelhead fishing trip, how many hours did you fish on the following days? Choose the closest time that you have fished. For example: if you fished for an hour and 45 minutes, then chose 2 hrs.

Mark only one oval per row.

0 hrs 1 hr 2 hrs 3 hrs 4 hrs 5 hrs 6 hrs 7 hrs 8+ hrs Sunday

Sunday

Monday

Tuesday

Wednesday

Thursday

Friday

Saturday

2. On your last steelhead fishing trip, how many steelhead did you catch per day? *Mark only one oval per row.*

0 1 2 3 4 5 6 7+ I did not fish this day

Sunday

Monday

Tuesday

Wednesday

Thursday

Friday

Saturday

3. On your last steelhead fishing trip, how many steelhead did you harvest per day? *Mark only one oval per row.*

0 1 2 3 4 5 6 7+ I did not fish this day

Sunday

Monday

Tuesday

Wednesday

Thursday

Friday

Saturday

4. In what river(s) have you ever fished for steelhead in Idaho? Check all that apply .*Check all that apply.*

North Fork Clearwater River

Clearwater River

Selway River

South Fork Clearwater River

Upper Salmon River

Little Salmon River

Lower Salmon River

Middle Fork Salmon River

South Fork Salmon River

Boise River

Lower Snake River (Hells Canyon)

Other:

Steelhead Fishing Rules and Regulations

5. How did the season and limits for steelhead differ between the 2016-2017 run year (July 2016 to April 2017) and the 2017-2018 run year (July 2017 to April 2018)?

6. How did this affect your fishing?

7. Of the options below, what type of hook cannot be used when fishing for steelhead in Idaho? Check all that apply

- Single point, barbless hook with a gap larger than 5/8 inches
- Barbless hook with a gap smaller than 5/8 inches
- Barbed hook with a gap smaller than 5/8 inches
- Treble hook, barbless with a gap smaller than 5/8 inches

Local Ecological Knowledge

The following questions are being used to assessed the shared knowledge of steelhead. Please answer to the best of your ability.

8. How has the steelhead fishing in 2020 compared to the first year you got your fishing license? *Mark only one oval.*

- More fish
- No change
- Less fish

I did not fish this year

9. How has steelhead fishing changed in the last 10 years? *Mark only one oval.*

More fish

No change

Less fish

10. In your lifetime, how has abundance of steelhead changed? *Mark only one oval.*

More abundant

No change

Less abundant

11. Do you think the steelhead fishery is better, the same, or worse than when you first started fishing? *Mark only one oval.*

Better

Same

Worse

12. Who has the most positive influence on the number of steelhead reaching the areas you fished steelhead in Idaho this year? Please rank the following from most positive (first) to least positive (fourth). *Mark only one oval per row.*

	Anglers	State government	Federal government	Businesses
First				
Second				
Third				
Fourth				

13. Where does the most mortality for Idaho's wild steelhead occur? *Mark only one oval.*

- Fresh water rearing
- Migration to the ocean
- In the ocean
- Migrating upriver as an adult

14. How has survival in any of the above stages changed in your lifetime? *Mark only one oval per row.*

	Improve	No Change	Worsened	N/A
Fresh water rearing				
Migration to the ocean				
In the ocean				
Migrating upriver as an adult				

15. On average, how many years do steelhead remain in the ocean prior to returning to the rivers? *Mark only one oval.*

- 0 years
- 1 year
- 2 years
- 3 years
- 4 years
- 5 years
- 6 years

16. Please check whether the majority of steelhead within the following water systems are wild or hatchery steelhead: *Mark only one oval per row.*

	Hatchery Steelhead	Wild Steelhead	I don't know
Clearwater River			
Selway River			
South Fork Clearwater River			
Lower Snake River (Hells Canyon)			
Upper Salmon River			
Middle Fork Salmon River			
South Fork Salmon River			

17. When do most adult steelhead arrive in Idaho? *Mark only one oval.*

January

February

March

April

May

June

July

August

September

October

November

December

Local Ecological Knowledge Communication

18. Have you shared information on steelhead with the Office of Species Conservation? *Mark only one oval.*

Yes

No

19. If yes, what type of information have you shared?

20. Has the Office of Species Conservation shared information with you about steelhead? *Mark only one oval.*

Yes

No

21. If yes, what type of information have they shared with you?

22. Have you shared information on steelhead with the Idaho Fish & Game? *Mark only one oval.*

Yes

No

23. If yes, what type of information have you shared?

24. Has Idaho Fish & Game shared information with you about steelhead? *Mark only one oval.*

Yes

No

25. If yes, what type of information have they shared?

Demographic Information

26. How old are you?

27. Which county do you live in?

28. During the 2020 steelhead season, what Idaho county did you fish the most in? If you fished in multiple counties, please list them all.

29. Do you have a fishing license this year? *Mark only one oval.*

Yes

No

30. What was the first year you got your own fishing license?

31. How many years have you fished for steelhead?

Thank you for your time and responses.

APPENDIX B

Idaho Fish & Game Questionnaire

Idaho Fish & Game Questionnaire

INFORMED CONSENT

The purpose of this study is to examine knowledge about steelhead in Idaho. You are being asked to participate because you work for Idaho Fish and Game.

If you agree to be in this study, you will participate in a brief (~15 minute) questionnaire. Besides questions about steelhead, you will be asked your age and your work experience. There are no perceived risks to participation, and you may stop at any time. We hope that this survey will provide insight into how knowledge about steelhead is built and maintained among different groups of stakeholders.

Clicking the next button below you are over 18 years of age and consent to participate in this questionnaire.

If you have questions about your rights as a research participant, you may contact the Boise State University Institutional Review Board (IRB), which is concerned with the protection of volunteers in research projects. You may reach the board office between 8:00 AM and 5:00 PM, Monday through Friday, by calling (208) 426-5401 or by writing: Institutional Review Board, Office of Research Compliance, Boise State University, 1910 University Dr., Boise, ID 83725-1138.

Research Project Information

Study Title: Local Ecological Knowledge Exchange of Steelhead

Principal Investigator: Dr. Kathryn Demps (kathryndemps@boisestate.edu) Co-Investigator: Mikaela Weisenfluh (mikaelaweisenflu@u.boisestate.edu)

Sponsor: This research is for Ms. Weisenfluh's Master's Thesis and is not sponsored by any agency

Local Ecological Knowledge

The following questions are being used to assessed the shared knowledge of steelhead

1. How has steelhead fishing changed in the last 10 years? *Mark only one oval.*

More fish

No change

Less fish

2. In your lifetime, how has abundance of steelhead changed? *Mark only one oval.*

More abundant

No change

Less abundant

3. Who has the most positive influence on the number of steelhead reaching the areas anglers fished steelhead in Idaho this year? Please rank the following from most positive to least positive. *Mark only one oval per row.*

	Anglers	State government	Federal government	Businesses
First				
Second				
Third				
Fourth				

4. How would you interpret the changing number of steelhead that has happened within your lifetime?

5. Where does the most mortality for Idaho's wild steelhead occur? *Mark only one oval.*

- Fresh water rearing
- Migration to the ocean
- In the ocean
- Migrating upriver as an adult

6. How has survival in any of the above stages changed in your lifetime? *Mark only one oval per row.*

Improve No Change Worsened N/A

Fresh water rearing

Migration to the ocean

In the ocean

Migrating upriver as an adult

7. In your experience, what would you consider to be the most significant changes to steelhead life cycle in your lifetime:

8. On average, how many years do steelhead remain in the ocean prior to returning to Idaho to spawn?

9. Please check whether the majority of steelhead within the following water systems are wild or hatchery steelhead: *Mark only one oval per row.*

Hatchery Steelhead Wild Steelhead I don't know

Clearwater River

Selway River

South Fork Clearwater River

Lower Snake River (Hells Canyon)

Upper Salmon River

Middle Fork Salmon River

South Fork Salmon River

10. Adult steelhead arrive in Idaho around...? *Mark only one oval.*

January

February

March

April

May

June

July

August

September

October

November

December

11. In what river do anglers fish for steelhead the most? *Mark only one oval.*

North Fork Clearwater River

Clearwater River

Selway River

South Fork Clearwater River

Upper Salmon River

Little Salmon River

Lower Salmon River

Middle Fork Salmon River

South Fork Salmon River

Boise River

Lower Snake River (Hells Canyon)

Other:

LEK Communication

For the following questions, please think of the things you have done personally in your professional capacity at the Department of Fish & Game.

12. In your everyday job, what type of information do you develop on steelhead?

13. What type of information have you shared directly with the Office of Species Conservation in the last five years? *Check all that apply.*

Genetic

Life History

Population size

Projected Adult Return

Smolt Survival

I do not share information directly with the Office of Species Conservation

Other:

14. Specific to your job, what type of information have you shared with anglers within Idaho the last five years? Check all that apply.

Fishing opportunities

Fishing reports

Threats to steelhead populations

Regulation changes

Run forecast

I do not share information with anglers

Other:

15. How have you shared information with anglers in the last five years? Check all that apply.

In-person conversations

Social media

Email

Blog forums

Public informational meetings

I do not share information with anglers

Other:

16. Have anglers shared information with you about steelhead? *Mark only one oval.*

Yes

No

17. If yes, what type of information did they share with you?

18. Based on your experience, how many hour(s) a day did anglers spend fishing during this steelhead season? *Mark only one oval per row.*

O hrs 1 hr 2 hrs 3 hrs 4 hrs 5 hrs 6 hrs 7 hrs 8+ hrs

Sunday

Monday

Tuesday

Wednesday

Thursday

Friday

Saturday

19. During the 2020 steelhead season, how many steelhead did anglers catch on average per day?

20. During this steelhead season, how many steelhead did anglers harvest on average per day?

21. Do you have experience fishing for steelhead outside of work? *Mark only one oval.*

Yes

No

22. If yes, how long have you fished for steelhead?

Demographic Information

23. How old are you?

24. How long have you worked for Idaho Fish and Game?

Thank you for your time and responses

APPENDIX C

Office of Species Conservation Questionnaire

Office of Species Conservation Questionnaire

INFORMED CONSENT

The purpose of this study is to examine knowledge about steelhead in Idaho. You are being asked to participate because you work for Office of Species Conservation.

If you agree to be in this study, you will participate in a brief (~15 minute) questionnaire. Besides questions about steelhead, you will be asked your age and your work experience. There are no perceived risks to participation, and you may stop at any time. We hope that this survey will provide insight into how knowledge about steelhead is built and maintained among different groups of stakeholders.

Clicking the next button below you are over 18 years of age and consent to participate in this questionnaire.

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Research Project Information

Study Title: Local Ecological Knowledge Exchange of Steelhead

Principal Investigator: Dr. Kathryn Demps (kathryndemps@boisestate.edu) Co-Investigator: Mikaela Weisenfluh (mikaelaweisenflu@u.boisestate.edu)

Sponsor: This research is for Ms. Weisenfluh's Master's Thesis and is not sponsored by any agency

Local Ecological Knowledge

The following questions are being used to assessed the shared knowledge of steelhead

1.How has steelhead fishing changed in the last 10 years? *Mark only one oval.*

More fish

No change

Less fish

2. In your lifetime, how has abundance of steelhead changed? *Mark only one oval.*

More abundant

No change

Less abundant

3. Who has the most positive influence on the number of steelhead reaching the areas anglers fished steelhead in Idaho this year? Please rank the following from most positive to least positive. *Mark only one oval per row.*

	Anglers	State government	Federal government	Businesses
First				
Second				
Third				
Fourth				

4. How would you interpret the changing number of steelhead that has happened within your lifetime?

5. Where does the most mortality for Idaho's wild steelhead occur? *Mark only one oval.*

- Fresh water rearing
- Migration to the ocean
- In the ocean
- Migrating upriver as an adult

6. How has survival in any of the above stages changed in your lifetime? *Mark only one oval per row.*

	Improve	No Change	Worsened	N/A
Fresh water rearing				
Migration to the ocean				
In the ocean				
Migrating upriver as an adult				

7. In your experience, what would you consider to be the most significant changes to steelhead life cycle in your lifetime:

8. On average, how many years do steelhead remain in the ocean prior to returning to the rivers?

9. Please check whether the majority of steelhead within the following water systems are wild or hatchery steelhead: *Mark only one oval per row.*

	Hatchery Steelhead	Wild Steelhead	I don't know
Clearwater River			
Selway River			
South Fork Clearwater River			

Lower Snake River (Hells Canyon)

Upper Salmon River

Middle Fork Salmon River

South Fork Salmon River

10. Adult steelhead arrive in Idaho around...? *Mark only one oval.*

January

February

March

April

May

June

July

August

September

October

November

December

11. In what river do anglers fish for steelhead the most? *Mark only one oval.*

North Fork Clearwater River

Clearwater River

Selway River

South Fork Clearwater River

Upper Salmon River

Little Salmon River

Lower Salmon River

Middle Fork Salmon River

South Fork Salmon River

Boise River

Lower Snake River (Hells Canyon)

Other:

LEK Communication

For the following questions, please think of the things you have done personally in your professional capacity at Office of Species Conservation.

12. Specific to your job, have you shared information with anglers? *Mark only one oval.*

Yes

No

13. If yes, what type of information have you shared? Check all that apply

Steelhead life cycle

Fishing opportunities

Policy changes

Steelhead life histories

Steelhead distribution

Steelhead behavior

Handling of steelhead when caught

Steelhead angling methods

Other:

14. Have anglers shared information with you about steelhead? *Mark only one oval.*

Yes

No

15. If yes, what type of information have they shared with you?

16. In your office, what type of information has been used this year to make policy changes?

17. Based on your experience, how many hour(s) a day did anglers spend fishing during this steelhead season? *Mark only one oval per row.*

O hrs 1 hr 2 hrs 3 hrs 4 hrs 5 hrs 6 hrs 7 hrs 8+ hrs

Sunday

Monday

Tuesday

Wednesday

Thursday

Friday

Saturday

18. During the 2020 steelhead season, how many steelhead did anglers catch on average per day?

19. During this steelhead season, how many steelhead did anglers harvest on average per day?

20. Do you have experience fishing for steelhead outside of work? *Mark only one oval.*

Yes

No

21. If yes, how long have you fished for steelhead?

Demographic Information

22. How old are you?

23. How long have you worked for Office of Species Conservation?

Thank you for your time and responses.