Cave Diving Risk Perception and Behaviour

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Abstract

Cave divers are a very small part of the world population, an elite group of people with access to one of our most needed resources: water in our aquifers. Most people never notice cave divers until the media reports on a cave diving fatality. Cave divers should have an interest in their risk perception, in order to better make rational decisions for safe cave diving.

What affects a cave diver's risk perception? How do open water divers assess the risk of cave diving? How are open water divers different from cave divers?

This paper seeks to better understand the predictor variables involved in risk perception of cave diving in two groups of divers, as well as the differences between cave divers and open water divers.

1. Introduction

Cave diving is considered a high risk sport. In order to cave diver, a person must first become open water certified. Then, a diver may begin work on the four levels of "overhead" certifications--cavern, intro, apprentice and "full" cave. In addition, at the "open water" level, divers may refine their skills with courses in advanced open water diving, rescue diving, or the use of breathing gases other than air. Cave diving is considered to be "technical" diving, requiring greater skill due to greater risk. Commonly, cave divers have acquired additional certifications before beginning cave diver training. In order to pass a cave diving course, a diver must show themselves to be competent and safe to an instructor. Open water divers are taught to avoid overhead environments such as caves at all costs.

Even with this rule, open water divers do venture into overhead environments. Fifty seven to eighty percent of documented cave fatalities between 1969 and 2007 were divers without cave training. Open water divers don't always follow the "avoid the overhead environment" rule. However, while cave fatalities have dropped significantly over time, the percentage of fatalities involving trained cave divers has been rising, reaching 100% several years (Buzzacott et al, 2009).

How do divers perceive risk of cave diving? What factors influence the decision by cave divers to break safe cave diving guidelines? How are cave divers different from open water divers? An increased understanding in this area will educate all divers and help enhance safe diving practices.

Research Objectives

1. Determine whether the perception of risk of cave diving among cave divers is affected by various factors theorized to have an effect on risk perception.

2. Determine whether various factors influence a cave diver's decision to break safety guidelines.

3. Determine whether risk perception of cave diving among open water divers is affected by various factors theorized to have an effect on risk perception.

4. See if cave divers are the same as open water divers across various group characteristics, behavior choices and risk perceptions.

2. Literature Review

Risk perception is studied by several groups of people, leading to an incredibly diverse array of articles and studies. It can be difficult to wade through this material, which spans from the 1970s to the present. To best understand the area of risk perception and how it relates specifically to cave diving, one can split the research into three fields. First is the mathematical side of study. Second is the vastly different field of researchers who certainly apply math to understand their subjects, but whom report their findings from a sociological point of view that lends itself to easy understanding by the lay person. Lastly, there is a small contingent of researchers who have devoted themselves to researching scuba diving risk perception, and they approach their research with both a mathematical and a sociological point of view.

Of course, every researcher uses some level of mathematics and statistical analysis in his or her research. Some researchers present their findings in reports heavy laden with this analysis, which can be difficult to understand if you have not taken much higher level math or statistics courses. However, much insight can be gained from their explanation of why their research was necessary, and how they chose to run their research. Daniel Benjamin and William Dougan composed a two part paper over 4 years apart in which they researched estimates of risk of death. Their first paper summarizes the works of multiple authors from the 1970s through 1990 into succinct facts easily understood by the lay person, then explain how their research agrees, and sometimes disagrees, with those other author's works. They introduce quickly some themes that are present throughout most research in risk perception, such as the idea that people overstate risks from low probability causes, and understate risks from high probability causes (1997). If possible, my research will show whether this relationship

exists among cave divers to the same extent it does in the general population that Benjamin and Dougan analyze.

In the second part of their paper, Benjamin and Dougan add to their team David Buschena, and study the concept of risk over/under estimation more closely. Instead of just asking questions about risk perception, they add on a question with the same form, but asking specifically about risk perception for the age group that the respondent is in. They report finding that people do overestimate low probability risks, and underestimate high probability risks for the general population. However, for their own age group, they do a much better job of accurately assessing risk (2001). This might imply that cave divers will be able to more accurately assess risk for their high-risk sport than non cave divers, and is the reason I am surveying both groups.

While those researchers studied random students, a set of students at the University of South Alabama researched risk perception and behavior among narcissists. They determine that it is likely that narcissists take more risks because they are hypersensitive to reward, not because they have underestimated the risk (Foster et al., 2009). Their work compares well with research by psychologists, which suggests that reward is a driving factor for the general population as well.

Finally, Aalabaf-Sabaghi takes a step towards the sociological view in his research, which is mostly a look at traditional ways of measuring risk perception. Specifically, he focuses on risk of death. He comes to the conclusion that other researchers are correct in that some people will trade quantity of life for quality of life (2008). This is one of the fundamentals of economics: marginal benefit and marginal cost. In general, the sociological studies of risk perception all focus on the marginal benefit people receive, and the marginal cost, or perception of risk of the cost.

The second group to have researched risk perception heavily is the psychologists, who approach their research from a sociological standpoint. They use statistics to analyze their work, but tend to also write much more for the lay person. They also tend to do less laboratory experiments, instead analyzing

real world situations.

Robert Krider of Simon Fraser University gave a good overview of this field in a presentation on high risk consumption. His hypothesis is that people involved in extreme leisure "dislike uncontrollable risk and like controllable risks," and he uses a survey to compare members of an extreme leisure group to non members. His graphs certainly seem to support that hypothesis, which flies in the face of the traditional claim that participants in extreme leisure are careless or have improper risk perception. I have attempted to tailor my survey so I can see if cave divers behave similarly to Krider's hang gliders.

One of the authors who seems to heavily influence the sociological side of Krider's research is Richard Celsi. Celsi has two great papers that thoroughly explain his idea of the "transcendent benefits" that drive a person's consumption of high risk sports. In one paper, he focuses mainly on defining terms and explaining his ideas (1992). In a second, much longer research project, Celsi and his team of researcher apply their ideas to the study of a group of sky divers. The results of the study appear to be able to carry over well into other high risk sports, such as cave diving, and I have tailored some of my survey questions in order to check my research against some of his conclusions (1993). While Celsi's work is a great read, his findings will probably be less repeatable, due to his research methods. His research would be strengthened by inclusion of statistical analysis. He did use outside researchers to review his work, to attempt to remove bias, but that is not as strong as other's use of math to prevent bias. It would be much easier to research cave divers the way Celsi researched skydivers, but I feel the results would not be as meaningful.

Wade Vagias approached risk perception from a similar angle as Celsi, but focused on whitewater rafting. As his study was much shorter, lasting only the duration of the trip, he relied more on surveys than Celsi, and thus used more statistical analysis than Celsi. His study seems to be very powerful because he studies changes in his two samples over time, and thus can make several

inferences about people and risk perception. His studies suggest that Celsi is correct about the transcendent benefits and reasons for participation in high risk sports. They also suggest that people have higher views of risk before they try a high risk activity, and that possibly, those who try the harder, or higher-risk "version" of the sport, will have the higher risk perception. The first finding is consistent with Celsi's opinion that people have lower risk perception when they have seen that they can control some of the risks (2005). The second finding is something I hope to replicate in my own research. While his study was limited by the one-shot nature, and the short time period, his work was strengthened by his strong statistical analysis. Because it produces similar results as Celsi, it appears to strengthen Celsi's findings as well.

The last subset of research on risk perception deals much more closely with scuba diving. One article that provides a good segue is not focused on diving, but does survey divers. Jacqueline Gray and Margaret Wilson published a paper in 2009 which focused on risk perception and travel. Not only do they interview scuba divers specifically for their research, but their concepts have loose analogies to scuba diving (2009). After all, cave diving is high tech travel to a location by trained individuals. The same factors that cause travelers to avoid a city for vacation might also be roughly applicable to keeping cave divers from visiting a cave. This paper makes one think that another good study of cave diving would be risk perception of death vs. risk perception of getting decompression sickness, and an examination of the heuristics that cave divers use to estimate risk.

Another very interesting study with applications to my research focused on changes in risk perception, similar to Vagias, but among scuba divers, as they progressed through their open water certification class. Their study used surveys given to the students at various points in their training. Unlike Vagias, they also tested for perceived competence. Their research concluded that initially, there might be a rise in perceived risk, followed by the drop that Vagias observed. They linked this to a drop in perceived competence, followed by a rise, which is similar to what Celsi found (2008). I will not be

testing for perceived competence directly, but I have included some questions in my survey which I hope will be enough to let me compare results with this study.

There is also research which focuses more on diving risks. This research is helpful for determining actual risk, to compare to perceived risk. For example, a 2007 paper by Adam Beckett and Mary Kordick used online surveys to assess dive injury risk. Then, research conducted by Dr. Peter Germonpre in Belgium of a similar nature focuses mostly on cave divers in the United States of America and international diving risks (2006). Finally, Peter Buzzacott, Erin Zeiglar, Petar Denoble and Richard Vann composed a detailed study of cave diving fatalities in America between 1969 and 2007. Their work analyses every fatality to determine what kills cave divers, and is one of the most exhaustive and thorough works on the subject.

Because the field of risk perception has many facets, it is interesting to study from two vantage points. My research must combine the statistical and experimental side with the sociological and psychological analysis. I can learn from the surveys and experiments run by researchers approaching risk perception from the statistical viewpoint, and their thoughts have helped me to set up my surveys. I am also finding the sociological viewpoint papers to be interesting, in explaining why it is that people would enjoy a high risk sport. It is understandably hard to measure things like “transcendent benefits,” but I will attempt to explain benefits in terms of utility. Perhaps the more interesting studies, in terms of usefulness to my research, are those that look at changes in risk perception over time, as people begin to try out a high risk sport.

I have attempted to structure my survey questions in ways that will allow me to compare my data with that of other risk perception research studies. The goal is to provide more validation to my own work, by showing how it produces similar results to other somewhat similar studies. I have yet to find any research on cave diver's risk perception, and it will be interesting to see how my results compare with the risk perception research of other high risk sports. The strongest results come from the

research with the most statistical analysis, while the easiest way to study cave divers is with little statistical analysis. It will be difficult to mesh Celsi's reading style, which is easy to understand and fun to read, with the strong analysis of researchers like Vagias and Foster. Krider uses a good mix of both psychological and mathematical research in his studies, and my goal is to do the same to create a paper that has meaningful conclusions despite the limitations and errors that will undoubtedly exist in my results.

3. Methods and Data

3.1 Survey Responses

Data is obtained through survey responses. Two surveys, one for open water divers and one for cave divers, were run online for several weeks. These surveys were advertised across several online forums, appealing to several types and locales of divers. Cave diver surveys were placed on the Cave Divers Forum[1] , The Deco Stop[2], North Carolina Divers Forum[3], Dive Matrix[4] and Scubaboard[5]. The open water surveys were placed on all of those forums as well, except Cave Divers Forum. Cave Divers Forum is mostly used by cave divers. The Deco Stop is a forum for technical diving, which includes cave diving as well as open water diving. North Carolina Divers Forum is mostly open water divers but includes cave divers. As the name suggests, it is home mostly to divers from North Carolina. Dive Matrix seems to be slightly more popular along the west coast, and includes cave and open water divers. Scubaboard is slightly more populated with open water divers, but it includes divers from all around the world. People from many parts of the United States responded saying they had completed the survey. However, no location data was acquired through the surveys. Additionally, one cave diver survey and eight open water diver surveys were completed by the Scuba Dive Club at the University of

1 www.cavediver.net
2 ww.thedecostop.com
3 www.ncdivers.com
4 www.divematrix.com
5 www.scubaboard.com

Central Florida at a club meeting. Survey questions can be viewed in Appendix D and E.

3.2 Testing and Confidence Levels

All regressions and T-Tests used the P and/or T test. Statistical significance was determined at the 95% confidence level. If results were significant at the 90% confidence level, a special notation was made to acknowledge this fact.

3.3 Objective 1 Methods and Data

It was theorized that several classes of factors might have an influence on risk perception of cave diving by cave divers. Most important was a measure of risk perception to use as a response in regression analysis. To assess risk perception, respondents were asked to say how many of a certain type of person, out of one thousand people actively participating in some activity in a given year, would be expected to perish, on average. The number one thousand was chosen based on guesses by several dive industry professionals as to how many cave divers there might be actively diving in a given year. The goal was to find a realistic number, to avoid confusing respondents with unrealistic denominators.

It was expected that there might be some link between risk perception and certification level. Cave diving fundamentally has three certification levels, with restrictions being loosened as one achieves a higher certification. These levels have traditionally been “intro,” “apprentice” and “cave” or “full cave,” “full” in the vernacular. Cave divers were asked to state their perception of risk for open water divers as well as these three cave certification levels, while indicating their own certification level. However, less than ten percent of respondents were in either the intro (9%, n=10) or apprentice (8%, n=9) certification levels. With such a small amount of responses, it was decided that no meaningful interpretations could be drawn by comparing risk perception among the different certification levels individually. Therefore, only the “full” risk perception numbers were used, and certification information was not used in objective 1.

The first class of factors thought to affect risk perception were biological factors: age and sex.

On the survey, respondents filled in their age and selected a gender.

Experience data was also collected as a second suspected set of factors in risk perception. Cave diving respondents supplied an approximate number of cave dives, years cave diving and years of total diving. Diving injuries could be included in this category as well, and respondents were asked if they had ever gone to a doctor as a result of an injury sustained while diving.

The last class of factors examined were those relating to involvement in risky behaviors. Respondents were asked to honestly divulge information about their diving practices and history, as well as some information about risky behaviors outside of diving.

Inside of diving, respondents were asked if they had ever broken any of the generally accepted cave diving guidelines. This included lack of a primary guideline, lack of jump lines and lack of proper gas management. Cave diving instruction commonly teaches that a continuous guideline is to be run to the exit. Most popular caves have a guideline, but often require a diver to run a line from outside the cave to the start of the guideline, somewhere inside the cave. Side passages in the cave contain separate lines, and divers must connect a "jump" line to these in order to preserve the continuous guideline. Gas management rules call for, at minimum, divers to turn their dive and begin exiting once one third of their usable breathing gas (after "gas matching" to find the usable cubic feet of gas to correct for tank size disparity) has been used.

Solo diving is a controversial activity, not officially recognized by training agencies as going against any guidelines. However, it is considered by many to be a risky activity, so respondents were asked to report if they have done any solo cave diving. Lastly, respondents were asked to indicate if they had used any mind altering substances within 12 hours of a dive.

Outside of diving, respondents were asked to check off any hobbies they participate in; several of these were "risky" activities, while others were rather "non risky," in common perception. In the end, it was decided that it was easiest to stick with involvement in one activity commonly considered

high risk: motorcycle riding. Finally, respondents were asked if they smoked, a behavior which is the focus of many risk perception studies.

Respondents were also asked to indicate their risk perception about driving, in a question almost identical to the diving risk perception questions. The purpose of this question was to see if cave divers displayed correct risk perception of driving. At a minimum, even if the magnitude of responses is off, this question will allow for a check to see if cave divers display betas of the same sign for risk perception among various topics. However, this question has limitations. First it is not versed like any risk perception studies among driving, which are usually done in terms of driver miles. However, it was decided that changing the format of the question might have an effect on the responses that would affect the ability of the question to serve as a test. Secondly, the survey asked only a few questions that could be turned into indicators for driving risk perception. Diving behaviors cannot be expected to have much impact on driving risk perception. Still, this is a valuable question and test.

3.4 Objective 2 Methods and Data

Objective 2 uses the same data and general procedures as objective 1. However, in this test, the following of commonly taught safe cave diving practices was used as the response variable. This test was designed to determine if various factors played a role in the decision to break one of these commonly taught safe cave diving practices, as explained in section 3.1. Cave diving experience was expected to play a role, so years cave diving and number of cave dives were used. Biological factors also might play a role, so age and sex were used in regression as well. Lastly, “full” risk perception was used. These five factors were used in a multivariate linear regression model to determine if any of them had an impact on a cave diver's decision to break a commonly taught safe cave diving practice.

3.5 Objective 3 Methods and Data

The methods and data for objective 3 are almost identical to objective 1, except there is less analysis possible given the survey data. Because open water divers cannot be expected to be familiar

with almost any aspect of cave diving, it was difficult to ask them many detailed questions. To begin, their risk perception on cave diving was boiled down to a single question, as they would not be able to distinguish between various certification levels. Then, they do not have the option to break or bend any of the cave diving safety guidelines. They do, however, have the ability to go cave diving without certification. Two questions were asked about their overhead diving experience. The first asked if the respondent had gone diving in an overhead environment, within view of daylight-- roughly the definition of a cavern. The second asked if the respondent had gone diving in an overhead environment out of view of daylight-- roughly the definition of a cave. The question design was less than perfect and might have been misunderstood by respondents. However, regression analysis between consumption of cave diving by open water divers and risk perception of cave diving might still show some interesting results.

It was easiest to do regression analysis on the biological factors of open water divers, age and sex. This test was very similar to the one for cave divers, and comparison between the two will mean more than other regression analysis among open water divers.

Analysis can be done on experience for open water divers, but this analysis might not mean anything, because the experience is only with open water diving, not cave diving.

3.6 Objective 4 Methods and Data

It has also been theorized that cave divers are different in some way from open water divers. The most obvious test, after realizing objective 1, is to test for a difference in risk perception between the two groups. Cave divers were tested for risk perception among various degrees of certification; open water divers cannot be expected to know or to see a difference between risk for those certification levels, so they were asked only about risk perception on cave diving as a whole. A two sample T-Test can be run between the cave diver's “full cave” risk perception and the open water diver's cave diving risk perception, to see if there is any difference.

Cave divers and open water divers can also be compared on open water risk perception, and as both surveys included an identical question of this nature, the test is simple. Another two sample T-Test will take care of this, as well as the last risk perception comparison. This last test will compare open water diver and cave diver risk perception of driving. Through these three risk perception comparison tests, it will be possible to see if one group consistently has higher risk perception. While any difference will be interesting, it is believed that most people would expect cave divers to have lower risk perception on every test, because of the assumption that people who consume some "risky" behavior have flawed or lowered risk perception.

However, these comparisons on risk perception might not mean much if the groups vary widely in either sex or age. If risk perception is affected by either age or sex, which objectives 1 and 3 will show, then an age or sex difference between the groups will change the validity of the risk perception comparison tests. For this reason, two sample T-tests will be run between the age and sex of the groups. If there is a difference, it will be difficult to correct to improve the usefulness of risk perception comparison tests, and it might be easier and more useful to attempt to collect a larger sample, assuming that there is a roughly equal spread of sex and age between the groups.

The last sets of comparison that might yield important differences between the group deal with behavioral choices. Three comparisons relate to medicine: knowledge of CPR, carrying of a first aid kit, and history of injuries. For example, it might be that one group knows CPR more than the other, which might be related to risk perception. The same effect might be observed with the first aid kit. The most interesting of these three tests will be the history of injuries: does one group go to the doctor more often for dive related injuries? However there are some limits to the usefulness of these tests. Because of the self reported nature, there is no way to validate people's claims. It is also difficult to know their competency of CPR: does a "yes" response mean they actually know CPR and would be able to administer aid to an injured person, or simply that they once took a CPR course? A better question

would have asked if the respondent carried a valid CPR card, but even then, there are people who received CPR certification without really learning the material. When it comes to first aid kits, there is no definition of what constitutes a real first aid kit. Some people with "yes" responses might only have a bottle of aspirin. Others might carry emergency oxygen with a fully stocked first aid kit resembling that of a small hospital emergency room. Lastly, people might visit a doctor for any one of a myriad of dive related injuries. Even if the groups report identical injury rates, one group might suffer from more life threatening injuries.

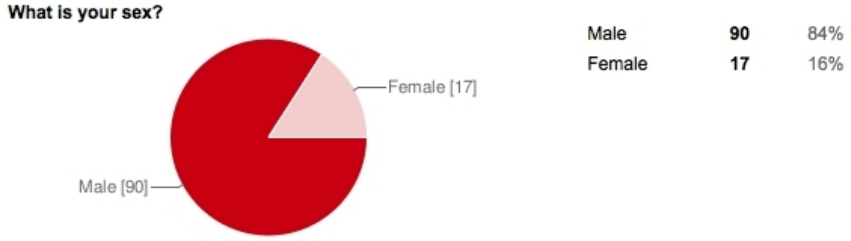
The last set of comparisons between the groups consists of risky behavior consumption. There are three comparisons possible here with the survey data. The first involves smoking behavior. The second involves the use of alcohol or other mind altering drugs within 12 hours of a dive. The third is the use of motorcycles. It is expected that cave divers might smoke less, as an extreme sport like cave diving requires one to be healthy. Similarly, cave divers might be less willing to use mind altering substances before a dive. However, many people expect that someone who participates in a high risk sport might also participate in other high risk activities, such as motorcycle riding.

4. Results

4.1 Objective 1 Results

4.1.1 Cave Diver Group Characteristics

To fully understand results of regression analysis, it is helpful to know about the sample. 108 alleged cave divers responded to the survey. The average age was 41.3 years while the most often reported age was 42. The youngest respondent was 20, while the oldest was 68.

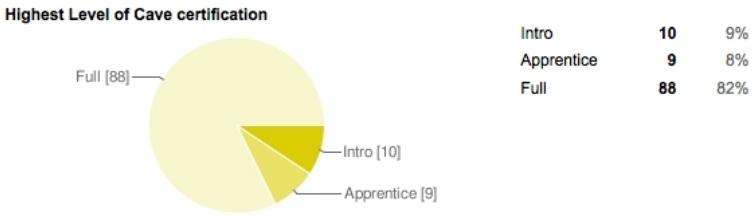


Most of the respondents were male (84%) though almost twenty percent were female (16%). This

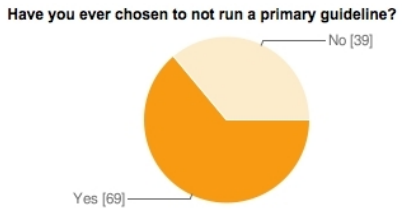
seems to be roughly consistent with observations at dive sites, where males are more common than females, though females are not hard to find. Respondents reported an average of 307.648 cave dives, but there was a broad range (4998 dives), with a minimum of 2 and a maximum of 5000. The most often reported number of dives was 100. The average number of years diving was 15.14, with 2 being the shortest, and 50 being the longest, and 10 being the number most often reported. Respondents had an average of 6.37 years cave diving experience. 40 years was the highest number reported, 1 the shortest and 3 the most common.

On average, respondents reported thinking there would be 1.54 fatalities per 1000 certified full cave divers actively diving in a one year time span. However, all risk perception numbers, starting with the average, were strongly affected by an outlier. 107 of the 108 responses had a response of 5 or less. There was one response that indicated a belief that 20 full cave trained individuals, out of 1000, actively diving in one year, would die in a cave diving incident. It was difficult to deal with this outlier. The respondent's other risk perception answers were in line with the other respondents. There seem to be two ways of dealing with this outlier: either delete it, or assume a data entry error. It is possible that the respondent meant to indicate that 2 out of 1000 would perish, rather than 20. However, it was decided to ignore this number for all analysis. The average without this outlier was 1.37.

Most divers were "full" cave certified (82%) while slightly less than 10 percent were Intro (9%) or apprentice (8%) certified. This study did not list all of the various certifications available through all of the cave certifying agencies. It did instruct people to choose the equivalent level of certification, which is considered debatable. For instance, a NAUI and GUE trained Cave 1 could reasonably select apprentice *or* "full." However, to adequately represent all agencies and their certification levels would have yielded even less useful information that this



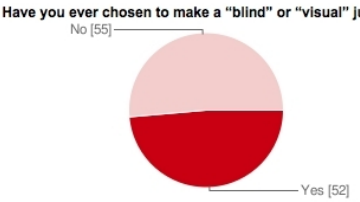
summary of certifications.



Yes	69	64%
No	39	36%

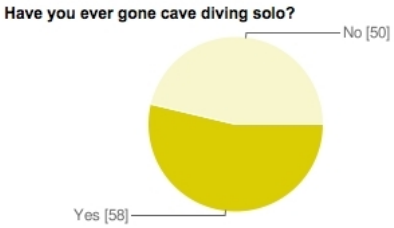
When it came to guidelines, the results were interesting. 64% of cave diving respondents indicated that they have chosen not to run a primary guideline. This is not as striking as some of the other responses, as many cave diving sites have lines that end in a "safe exit," requiring no primary guideline, yet requiring a positive answer to this question; the question was not perfectly written.

Visual jumps are more interesting in an analysis of risk perception, and here less than half (49%) admitted to making them. This question also has some room for error, as there is some latitude in defining a visual jump, and even more room for discussion when it comes to assigning risk to various visual jumps. For example, many divers do not consider a visual jump onto a line that is complete[6] a "blind" jump.

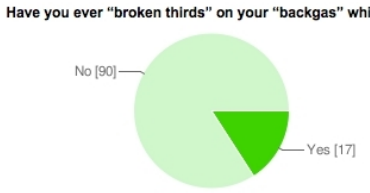


Yes	52	49%
No	55	51%

While solo diving has not been officially condemned by any training agencies recently, it is commonly brought up as a factor of fatalities. Slightly more than half of all cave diving respondents reported making a solo cave dive.



Yes	58	54%
No	50	46%



Yes	17	16%
No	90	84%

Sixteen percent of respondents reported breaking the commonly taught safe cave diving practice of gas management, which seems somewhat alarming. Cave training indicates that ultimately, gas management is the cause of most fatalities (Buzzacott et al, 2009).

6 Ie: completing a circuit by returning to a line that has an unbroken path to the safe exit, without connecting the final jump in order to avoid a cleanup dive to remove the last connecting reel.

However, that 16 percent report breaking thirds on backgas might not mean much. They might be divers who accidentally went over thirds by a minutely small amount, yet still felt obligated to report this error. It is also possible that they subscribe to less strict gas management theories, which is especially likely for stage dives. There are cave divers who, when doing double or more stage dives, and who use the "1/2+200" planning method for stages (which involves subtracting gas from the thirds on backgas, so thirds is still in effect, just not in every cylinder), that do not subtract the extra gas used from the second stage, in high flow caves. Most likely, not every person who answered "yes" is breaking thirds in some irresponsible way, the question might have been misleading.

4.1.2 Risk Perception Regression Analysis (data in Appendix A)

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Regression Analysis: Full RP versus Sex, Age

The regression equation is
Full RP = 2.79 + 0.655 Sex - 0.0373 Age

106 cases used, 1 cases contain missing values

Predictor      Coef  SE Coef      T      P
Constant     2.7850   0.5294   5.26  0.000
Sex          0.6547   0.3347   1.96  0.053
Age        -0.03729  0.01223  -3.05  0.003

S = 1.25040   R-Sq = 12.9%   R-Sq(adj) = 11.2%

Analysis of Variance

Source           DF       SS      MS     F      P
Regression        2   23.851  11.926  7.63  0.001
Residual Error  103  161.041   1.564
Total           105  184.892

Source  DF  Seq SS
Sex      1   9.307
Age      1  14.544
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The first regression analysis focused on the biological factors of age and sex. Regression with both of these factors showed that sex was not significant in determining risk perception (p=.053). However, age proved itself to be significant (p=.003). Of note is the negative coefficient on age. The interpretation of this information shows that as a cave divers ages, his perception of risk in the sport will drop. This finding is the opposite of what many would expect, as the common belief is that the younger population will perceive a lower risk in most things. The coefficient is small, but so are the risk perception numbers in general, with a range of only 5. This finding might be affected by the average and modal ages in the low 40s for cave divers. Further research might be warranted in this area, but this finding suggests that younger cave divers do not necessarily have an unnecessarily low perception of risk compared to older cave divers.

The next area of analysis dealt with experience levels in a multivariate regression with "full"

risk perception as the response variable. Years of diving experience (p=.163), years of cave diving experience (p=.958) and number of cave dives (p=.552) all failed to show any statistically significant impact on a cave diver's risk perception of cave diving.

Risky behavior consumption was also expected to have an impact on risk perception, both in and out of the water. Responses to the breaking or bending of cave diving safety guidelines, including the use of primary guidelines (p=.199), the use of jump/gap lines (p=.502), gas management (p=.250) and solo diving (p=.167), were used in regression with full cave risk perception. However, none of these variables showed any statistical significance. For out of the water risky behavior consumption, responses about smoking (p=.075), drug use (p=.068) and motorcycle use (.575) were compared to full cave risk perception in regression analysis. Once again, none of the expected predictor variables showed any statistically significant impact on risk perception. Most interesting, while both smoking and drug use would be significant at the 90% confidence level, motorcycle use was not. Motorcycles are commonly referred to as a high risk device, and it was expected to be just as significant as smoking or drug use.

4.2 Objective 2 Results (data in Appendix A)

The next objective was to study various factors to see if they are determinants of the decision to break commonly taught safe cave diving practices. In every case, a guideline was used as the response variable and five factors were used as indicators: years spent cave diving, number of cave dives, age, sex and "full" risk perception. Generally, it was expected that greater experience would lead to more guidelines broken. Lower age and a male gender were also expected to lead to more guidelines broken. Lastly, a lower risk perception was believed to lead to more guidelines broken.

The first guideline a diver can ignore is to leave out a primary guideline to the safe exit point. It was expected that the more experience a diver had, the less likely they would be to run a guideline. However, neither years cave diving (p=.376) or number of cave dives (p=.117) were statistically

significant indicators. Age (p=.010) was significant, with a coefficient of -.013387. Sex (p=.028) was also significant with a coefficient of -.2763. This means that younger people and males are more likely to not run a primary guideline. Risk perception (p=.846) was not significant.

A diver might also choose to make visual jumps instead of running a reel. Years cave diving (p=.303), age (p=.824), sex (p=.615) and risk perception (p=.588) were all insignificant. Number of cave dives (p=.052) is extremely close to being significant at the 95% confidence level and is clearly significant at the 90% confidence level. Certainly, it appears that the more dives a diver has completed, the more likely they are to make visual jumps.

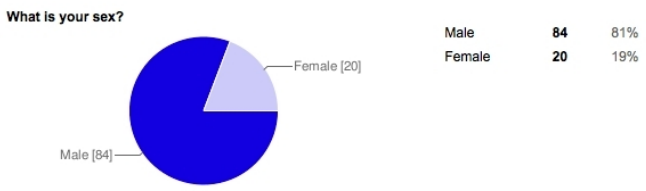
Gas management, as already discussed, is not necessarily the most meaningful statistic, due to a poorly worded question. The poor wording of the question might be reflected in the regression analysis, which shows nothing being a significant indicator at the 95% confidence level. Years cave diving (p=.057) is the lone indicator significant at the 90% confidence level. However, number of dives (p=.752) is not significant, leaving no good explanation for why years cave diving might be. If gas management guideline breaking was done on accident (as it is the only guideline that could reasonably be broken on accident), then years cave diving would be significant but number of dives should be as well; more dives gives more opportunities to make mistakes.

Solo diving is not against the common safe diving practices of most training agencies currently, but it has been vilified in the past and many divers still point to it as a factor in many fatalities. Solo diving could not be reliably predicted by years cave diving (p=.130), number of dives (p=.189), age (p=.409), sex (p=.126) or risk perception (p=.360).

4.3 Objective 3 Results

4.3.1 Open Water Diver Group Characteristics

To fully understand and interpret the results of regression analysis, it is useful to understand the



sample. Out of 107 open water diver responses, the average age was 39.5 years, with 21 being the most often reported age. The youngest was 18 and the oldest was 66. This group had, on average, 11.14 years of diving experience but only 1 year was the mode. Some respondents had less than one year of diving experience while the most experienced had 50 years experience. On average, these respondents had 570 dives, but 200 was the mode, with 0 dives after training being the least dives, to one response of 6000 dives. 81% of this group was male, with 19% being female.

4.3.2 Risk Perception Regression Analysis

(data in Appendix B)

Open water divers were also questioned about cave diving risk perception, but with fewer questions and predictor variables, given their lack of knowledge about cave diving. The first predictor variable set were the biological factors of age (p=.913) and sex (p=.003). This regression yielded a vastly different response than the similar regression among cave divers. For open water divers, age was not a good predictor of risk perception, but sex was. Most likely, this is due to the general lack of knowledge about cave diving among open water divers. Here, we see that being female is correlated to a higher risk perception; females have six times the risk perception of cave diving than males. This is a very interesting conclusion that might explain why more men decide to take up cave diving.

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Regression Analysis: OW Cave RP versus OW Age, OW Sex

The regression equation is
OW Cave RP = 2.44 - 0.0067 OW Age + 6.01 OW Sex


102 cases used, 5 cases contain missing values


Predictor      Coef  SE Coef      T      P
Constant      2.437    2.662   0.92  0.362
OW Age     -0.00673  0.06163  -0.11  0.913
OW Sex        6.013    1.997   3.01  0.003


S = 7.79231   R-Sq = 9.0%   R-Sq(adj) = 7.1%


Analysis of Variance

Source           DF       SS      MS     F      P
Regression        2   591.85  295.92  4.87  0.010
Residual Error   99  6011.29   60.72
Total           101  6603.14


Source  DF  Seq SS
OW Age   1   41.01
OW Sex   1  550.84
```

The second possible predictor to risk perception of cave diving among open water divers is the open water diver's diving experience. It is possible that diving in general would make one feel as if they could safely cave dive. However, regression shows that there is no correlation between years diving

(p=.757) or the number of dives (p=.566) and risk perception of cave diving.

The other type of experience is that of open water divers in a cave diving situation. Responses to the questions of overhead experience, both in the cavern and in the cave zone, were used in regression analysis to see if there was a correlation. However, neither cavern diving experience (p=.215) nor cave diving experience (p=.135) were significant.

4.4 Objective 4 Results

4.4.1 Biological Differences

The last objective of this research is to examine the two groups of respondents to determine if there are statistically significant differences between them. It is simple to compare the responses across all of the shared survey questions. The most basic differences between the groups would be with the biological factors of age and sex. The T test for age between the groups shows that both have very similar means (39.6 years for open water divers compared to 41.3 years for cave divers), and that they are statistically insignificant (p=.297). In other words, the respondents were generally from the same age groups. This reduces the chance that age differences in the samples would affect risk perception results. The second biological factor is that of gender, and the tests there show that there is no statistical difference between the groups in terms of gender (p=.526). This similarity will keep the differences of risk perception between males and females low.

4.4.2 Risk Perception Differences

There might also be differences in risk perception between the groups. Keeping with the other tests in this research, this test was done using the "Full Cave Risk Perception" response only from the cave diver survey. The tests show that cave divers have a lower mean risk perception (1.54 vs. 3.31) and that is a statistically significant difference. (p value=.030)

When it comes to open water risk perception, open water divers felt that 66 out of 1000 open water divers who dove in a cave would die, whereas cave divers felt only 52 would perish. It is an

interesting comparison, but the difference of means is statistically insignificant (p value=.486).

The last risk perception comparison relates to driving. Here, open water dives showed a much higher mean risk perception than cave divers (36 compared to 10.2), which is interesting given how often cave divers suggest that "driving to the cave is the most dangerous part of cave diving," a common occurrence on the internet forums on which this survey was run. It also opens up the possibility that cave divers have some fundamental, risk perceiving difference. However, this does not show that they incorrectly perceive risk. This difference was statistically significant (p=.019).

4.4.3 Behavioral Differences

The groups might also be different in terms of CPR knowledge and availability of first aid kits. Cave divers reported knowing CPR 95% of the time, while open water divers only knew CPR 92% of the time (p=.366). This was not a statistically significant difference. Cave divers report carrying a first aid kit 74% of the time, while open water divers only had one 52% of the time. Given there are problems with the definitions in this question, there is still a significant difference in responses (p=.001), so it is likely that there is some practical difference even with the errors in question.

The groups can also be compared across risky consumption behavior out of the water, such as smoking and drug consumption before diving. 15% of open water divers report smoking, while less than 7% of cave divers own up to the habit. This is a statistically significant difference between the groups (p=.039). There was not a significant difference in drug usage before dives, with 30% of open water divers reporting this behavior, and 39% of cave divers (p=.150). Several survey respondents contacted me privately with notes about their survey, and some of the comments received indicated that only recently was consumption of drugs like alcohol before diving considered a problem.

The last comparison to be made is that of injuries among divers. Given the earlier problems explained with this question, there still might be something to be learned if either group reports having more doctor visits as a result of their diving. 11% of open water divers have seen a doctor as a result of

their dives, while 17% of cave divers have required a doctor's visit, not a statistically significant difference (p=.239). However, it is possible that cave divers have a higher occurrence of decompression illness, while open water divers have more occurrences of jellyfish stings and coral scrapes. Better questions would have lead to more informative analysis.

5. Results

5.1 Cave Diver Risk Perception

The results of this research were certainly not always what were expected. Risk perception among cave divers seemed unaffected by anything other than age. It makes sense that sex might not have much of a role in risk perception among cave divers, as an informed cave diver ought to be able to make a reasonable assessment of risk regardless of gender. However, the negative correlation to age seems striking at first. A positive correlation was more expected, as our society seems to believe as a whole that younger people are incapable of proper risk perception, and tend to have lower risk perception than the older people. This negative correlation does make sense, given some thought. For one, cave divers are better educated about cave diving risk than open water divers or non divers. Ideally, anyone with a cave diving certification ought to be able to make an accurate assumption of risk, and there should be perfectly flat risk perception across all factors. Also, cave diving instructors will presumably only certify people who have the proper attitude to cave dive safely. People with an immature attitude are likely to be the ones to have a lower risk perception, and no matter what age, cave diving instructors should tend to pass fewer divers with immature attitudes than those with mature attitudes. Lastly, the average age of cave divers was well past the “young adult” years when people are believed to have vastly lower risk perception. So, the slightly negative correlation is not indicative of a problem.

Experience in cave diving was thought to have some relationship to risk perception, as more experience ought to make one more aware of the risks or lack of risks. No correlation was found here,

and it might be due to the training, similarly to the age correlation. It could be that cave diving training makes one aware enough of the risks that additional experience is not needed before one has an idea of the risk involved.

It was also unexpected that rule benders/breakers did not have a statistically lower perception of risk. This regression seems to suggest that the people who bend and break guidelines have roughly the same risk perception as those who hold staunchly to all guidelines. This has an interesting impact for cave divers who hold that rule bender/breakers are necessarily reckless and do not understand the risks.

5.2 Cave Diver Guideline Breaking Factors

It was expected that cave divers who break commonly taught safe cave diving practices would have several statistically significant indicators. It was expected that divers with more cave diving experience would be more likely to break guidelines, as they are lulled into a false sense of confidence and lowered risk perception. The lack of significance here is interesting. It suggests that divers of all experience levels break guidelines at similar rates.

Next, age and sex were expected to impact diving behavior. Younger divers were expected to break guidelines more often, and males were expected to break guidelines more often. Once again, we see people breaking guidelines at every age and across both genders equally.

Finally and most importantly, it was expected that those with a lower risk perception of cave diving would be more willing to break guidelines. However, risk perception seemed to never have any significant impact on the guideline breaking decision. This is the most interesting and confusing finding of this study. This finding in particular seems to support the idea that cave divers who break rules are not viewing the risk any differently or less fully than other cave divers.

5.3 Open Water Diver Risk Perception

Open water divers also showed interesting results. It was expected that age and sex would be similarly correlated to the age and sex results among cave divers. Regression showed that this was not

the case, and that only sex was a predictor variable. It also showed that sex had a large impact. However, this does make sense. For non cave divers, cave diving ought to be considered risky, and it shouldn't make much difference what age the respondents are. A small difference of risk perception among younger respondents might be expected, but as most respondents were around the same age as the cave diver respondents (low 40s), it is impossible to test for this. More 15-25 year old respondents would be needed. Additionally, it is easy to believe that women would naturally have a higher risk perception, as males in our culture are taught that exploration is a virtue. Non cave divers and cave divers alike enjoy cave diving for the exploration aspect, and women are taught by our culture to be less likely to enjoy exploration. It is possible that in other cultures, the sex difference would be flipped, as it is likely a culture aspect. A study across several cultures would be needed to test for this.

At first, it was expected that more experience with open water diving would equate to lower risk perception of cave diving, but this was not the case. Apparently, no amount of diving experience leads most divers to think cave diving is a less risky endeavor. However, there are plenty of cases of open water divers dying in a cave. Either there is an error in the question, or there is another variable that makes an open water diver have a lower risk perception of cave diving. One possible predictor variable might be exposure to caves in open water training. As cave diving was actively discouraged in open water certification classes between the 1970s and 1990s, open water deaths in caves dropped off at an alarming rate (Buzzacott et al, 2009).

5.4 Differences Between the Groups

This research has also found some interesting differences between the groups. The biological differences mostly helped with the validity of the results of the regressions. The more interesting results were found in other differences.

In risk perception, cave divers had lower risk perception of cave diving. This likely stems from their increased training. Open water divers are assumed to have little to no understanding of the

contents of a cave diving certification course. Without knowing what cave divers are taught to keep them safe, it is hard to believe that they can be very safe. Cave divers are also taught in most courses that their training will keep them safe, which would make them think that cave diving certifications would make them safe.

However, this does not explain the risk perception of both groups on open water divers in a cave environment. Even though cave divers are taught that open water divers in a cave environment are more dangerous than a cave diver in a cave environment, they had a lower risk perception than the open water divers! It was not a statistically significant difference, but it was originally expected that cave divers would have a much higher (to the point of being statistically significant) perception of risk for open water divers in the cave environment than open water divers. It is also interesting to note that open water divers reported such a high risk perception of themselves in a cave. It is possible that the increased education by the cave diving agencies has begun to affect the open water divers, and they are seeing that cave diving without certification is dangerous.

Driving risk perception only has meaningful results if you can compare it to actual driving risk. This study does not do this for several reasons, but some basic research indicates that it is possibly lower than both of these estimates. Thus, it is possible that cave divers have lower risk perception in general. Before one can make this result valid, more research would need to be done, and more data would be required from cave divers. This question did not turn out to be as useful as previously thought, though it does leave open the possibility of future research.

Cave divers and open water divers both report knowing CPR in almost identical amounts, while cave divers carry first aid kits more often. This could be due to a myriad of reasons. One might be the difference in diving location. Open water divers frequently dive off of boats which would be responsible for providing first aid. Cave divers often dive in isolated areas far from aid, and no one is around to provide first aid for them. The study by Beckett and Kordick found only 90% knowing CPR,

whereas my reported rates were 92% for open water divers, and 95% for cave divers.

It is interesting that more open water divers report smoking, but difficult to draw very many conclusions from this. Cave divers might dedicate more of their lives and time to diving, whereas open water divers might not have as much incentive to reduce harmful behaviors such as smoking. Drug usage before dives was almost identical, though, so there might some outside factor that affects smoking while leaving other harmful behaviors untouched. Beckett and Kordick found that 18.5% of their respondents smoked, while my results indicate 15% of open water divers and 6% of cave divers smoke.

And while cave divers do see a doctor as a result of a diving injury more often, the open ended nature of the question does not allow much interpretation of the results. The difference is statistically insignificant between doctor's visits in general. A better question would have asked about several different injury rates.

5.5 Further Research

Obviously, this study was far from perfect. The surveys should have been available through more avenues to ensure that all divers had a chance to complete them. The questions were not always perfect. A pre-survey might have caught some of the problems found in the questions. However, the data is interesting and should lend support to further research in this area.

Further research should be done to find out how true the sample mean is to the population mean, for cave divers. It would be especially interesting to gather more information on cave divers younger than 30, as the younger cave divers are definitely different from the older ones. Technology changes have allowed for much different diving recently, changing the practices among the younger divers.

For similar reasons, it would be interesting to compare risk perception data between different technology choices for diving, such as backmount, sidemount, and rebreather. It is possible that these

groups will have different factors affecting their risk perception.

Another interesting study might be done among those who are cave diving certified but who have stopped cave diving. Their interesting perspective might lead to interesting insights on risk perception of cave diving. These research results should serve as a guide to future researchers to help expand cave diving risk perception studies.

Works Cited

Aalabaf-Sabaghi, Morteza. “Risk Perceptions and Rationality in Measures of Risk.” Journal of Computational and Applied Mathematics Vol. 233 (2009) pp. 46-50

Beckett, Adam and Kordick, Mary Frances. “Risk Factors for Dive Injury: A Survey Study.” Research in Sports Medicine (2007) 15:3, pp. 201-211

Benjamin, Daniel K. and Dougan, William R. “Individuals' Estimates of the Risks of Death: Part I—A Reassessment of the Previous Evidence” Journal of Risk and Uncertainty Vol. 15 (1997) pp. 115-133

Benjamin, Daniel K., Dougan, William R., and Buschena, David. “Individual's Estimates of the Risks of Death: Part II—New Evidence.” Journal of Risk and Uncertainty 22:1 (2001) pp. 35-37
Germonpre, Dr. Peter. “The Medical Risks of Underwater Diving and their Control.” International SportMed Journal Vol.7 No.1. (2006) pp. 1-15

Buzzacott, Peter L., Zeiglar, Erin, Denoble, Petar and Vann, Richard. “American Cave Diving Fatalities 1969-2007.” International Journal of Aquatic Research and Education 3 (2009) pg 162-177

Celsi, Richard L., Rose, Randall L. and Leigh, Thomas W. “An Exploration of High-Risk Leisure Consumption through Skydiving.” Journal of Consumer Research Vol. 20, 1993

Celsi, Richard L. “Transcendent Benefits of High-Risk Sports.” Advances in Consumer Research Vol. 19, 1992

Foster, Joshua D., Shenesey, Jessica W., and Goff, Joshua S. “Why Do Narcissists Take More Risks? Testing the Roles of Perceived Risks and Benefits of Risky Behaviors.” Personality and Individual Differences Vol. 47 (2009) pp. 885-889

Gray, Jacqueline M. and Wilson, Margaret A. “The Relative Risk Perception of Travel Hazards.” Environment and Behavior Vol 41. (2009) pp. 185+

Krider, Robert E. and Wathieu, Luc R. “Living on the Edge and In the Instant: Formalizing the Utility of Intense, High-Stake, Real-Times Experiential Consumption.”

Morgan, Cass and Stevens, Cheryl A. “Changes in Perceptions of Risk and Competence Among Beginning Scuba Divers.” Journal of Risk Research 11:8 (2008) pp. 951-966

Vagias, Wade. “The Role of Risk Perception in a One Day Whitewater Rafting Trip.” Proceedings of the 2005 Northeastern Recreation Research Symposium