

**Building Bridges:  
Western and Indigenous Science in Cross-cultural Knowledge Production**

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**ABSTRACT**

The term Traditional Ecological Knowledge (TEK) was coined by Western science to refer to the knowledge held by Indigenous peoples about their environment and the cultural framework within which that knowledge is created, transmitted, and practiced. TEK has been exploited by Western science historically, with little or no regard for the communities from which the knowledge originated. To disrupt this cycle I attempted to conduct culturally sensitive chmuuek (*Lynx rufus*) sex identification genetics research for the Yurok Tribe, while simultaneously creating language materials for the Yurok Tribe Language Program conveying Western Ecological Knowledge (WEK) through a Yurok lens. I had a 51.4% amplification success rate out of 35 scat DNA samples, with 16 males and 2 females. Using a chi-squared goodness of fit test, I found this to be a statistically significant difference ( $\chi^2 = 10.889, df = 1, p - value < 0.05$ ). However, these results might have been skewed by female chmuuek avoidance of roads where the scat samples were collected. Additionally, DNA concentration was inconclusive as a predictor for amplification success. I wrote a Yurok immersion children's book with the help of Yurok language educators entitled *Kue Chery-ker'-ery Chmuuek E-see 'We-chek (The Little Bobcat and His Mother)* that conveyed WEK of chmuuek diet and behavior. According to interviews conducted with Yurok language teachers using the book in their classrooms, the collaboration was a success due to its community centered creation process and niche role as a teaching tool.

**KEYWORDS**

Traditional ecological knowledge, western ecological knowledge, Yurok language revitalization, chmuuek (bobcat, *Lynx rufus*), felid sex identification

## **FOREWORD**

I wrote this thesis while at the institution of University of California, Berkeley, which stands on Ohlone land. Guahu si Isabel Johnson. Na'an nana-hu Sablan, familian Dongat yan Bobo. I have introduced myself in the CHamoru language and identified the specific family branches from which I am a descendant. CHamoru people are Indigenous to Guåhan and other islands in the Marianas. As an Indigenous person, I am accountable to those relationships and the relationships I built with Yurok researchers while conducting this research. I am not of the Yurok Tribe, but my experiences as an Indigenous person were crucial to my interest in and decisions relating to this research.

I was accepted into a Research Experiences for Undergraduates program at Humboldt State University (HSU) in the summer of 2017 called Rroulou'sik, "rising up" in Wiyot, the language of the Indigenous people on whose land HSU stands. The program is meant to support Indigenous students in environmental research and connect them to projects of concern to local tribes in Northern California. Upon acceptance, I was connected with my mentor, Seafha Ramos, a Yurok tribal member and researcher at HSU.

## **INTRODUCTION**

In the United States, Western science has functioned as a tool of colonization to dispossess Indigenous peoples of their land, culture and fundamental rights as human beings. From the decades of forced sterilization of Native women by the Indian Health Service to the suppression of fire by the U.S. Forest Service on Native lands, Indigenous nations have had reason to be skeptical of Western scientists (Huntsinger and McCaffrey 1995, Lawrence 2000). If Western scientists wish to rebuild relationships with Indigenous nations, they must decolonize their mindsets and methods through scientific practices that reconnect Indigenous peoples to their land by revitalizing their social relations, knowledges and languages (Wildcat et al. 2014). Some Western scientists have begun this process with the growing recognition of traditional ecological knowledge (TEK) as Indigenous science (Baker 1996). This is an important step, as it combats the false perception that only Western societies have science, whereas Indigenous societies only have

traditional knowledge. Just as important is the use of the term Western ecological knowledge (WEK), which allows comparisons between the two paradigms on equal terms (Maweu 2011).

Depending on context, TEK is a term coined by Western science to refer to: 1) the knowledge that Indigenous peoples hold of their environments, 2) a system of responsibilities and relationships that Indigenous peoples practice with their environments, or 3) a knowledge production system of Indigenous peoples (Whyte 2013). Relationality is a key part of Indigeneity, and fundamental to understanding TEK (Wilson 2008). Relationships hold individuals accountable for their actions and ground them in a particular place and culture. They are also fundamental to knowledge production and dissemination. However, there are no universal definitions of TEK and understandings vary between Western and Indigenous viewpoints. While TEK is becoming more prominent in various academic fields, it is rarely contextualized in the Indigenous cultures from which it comes (Ramos 2016). This leads to Western scientists using TEK without fully understanding the significance of the knowledge.

Species conservation and resource management are two areas in which TEK has come to play an important role. Agencies such as the U.S. Forest Service and the Department of Fish and Wildlife are taking cues from Indigenous peoples on management practices such as cultural burning, maintenance of vulnerable locations and life stages of species, and appropriate harvesting tactics (Richards 1997, Anderson and Lake 2013, Yuan 2016). Cultural burning, for instance, is the practice of setting low intensity fires to prune back plants and refine those natural resources for cultural purposes like basket weaving (Yuan 2016). But while Western scientists and government agencies are benefitting from TEK, Indigenous nations rarely see positive effects from the research done on them. In some cases, their knowledge is actually used against them. For example, the Chukotka, Inuit, and other Indigenous communities brought attention to the negative impact that climate change was having on the polar bear (*Ursus maritimus*). Their knowledge was used to justify listing the polar bear as threatened, which led to the introduction of hunting restrictions that did not take into account the relationship that these Indigenous communities had with the polar bear (Rinkevich et al. 2011, Ramos et al. 2016). While the recognition of TEK's value and the reestablishment of Indigenous management practices is a good start, the fact that this does not often benefit Indigenous peoples is troubling (Ens et al. 2015).

Many Western scientists have studied TEK or incorporated it into their work, and resources have been designed to help Western scientists understand and TEK. But, while some Indigenous

communities are incorporating WEK into their practices, for example by hiring scientists in tribal wildlife programs, there is little literature about this. To address this issue, rather than treating TEK as a database of useful knowledge for outside researchers, some have suggested that TEK could play a role in fostering collaborative partnerships between Indigenous and non-Indigenous parties. In this way, diverse populations may be able to continually learn from one another, producing new solutions to natural resource management and climate change (Whyte 2013). But few studies have modelled how respectful, collaborative research might be undertaken.

In this paper, I describe my work with Native scientists and educators to incorporate WEK into forms that benefits their communities. Collaborating with Indigenous researchers of the Yurok Tribe, I conducted a wildlife genetics study and language revitalization project that used knowledge and methods from both TEK and WEK to inform my topic, methods, and end products from the research. Through this research I hoped to build a mutually beneficial relationship with Yurok researchers and elders in order to study the issues that they considered of importance, while simultaneously gaining a better understanding of my personal Indigenous identity. This study focuses on chmuuek (bobcat, *Lynx rufus*), a species native to Yurok ancestral territory. Chmuuek are of interest because they can act as indicators of ecosystem integrity, and may compete for resources with culturally significant species of concern, such as woh-pey-roks (Humboldt marten, *Martes caurina humboldtenis*) and le'goh (Pacific fisher, *Pekania pennant*) (Ramos 2016).

The genetics research investigates the ratio of males to females in chmuuek populations, expanding on previous work by a wildlife survey conducted on Yurok ancestral land. Population structure information is crucial to intelligent management practices, such as harvest regulations, and helpful to agencies such as the Yurok Tribe's wildlife program (Hiller et al. 2014). In addition, noninvasive DNA collection methods are a culturally sensitive approach due to Yurok beliefs that regard animals as people (Ramos 2016). Therefore, I investigated the effectiveness of scat sample DNA in sex identification for future studies that the Tribe may wish to conduct. This constitutes WEK being conducted through TEK in a culturally sensitive way.

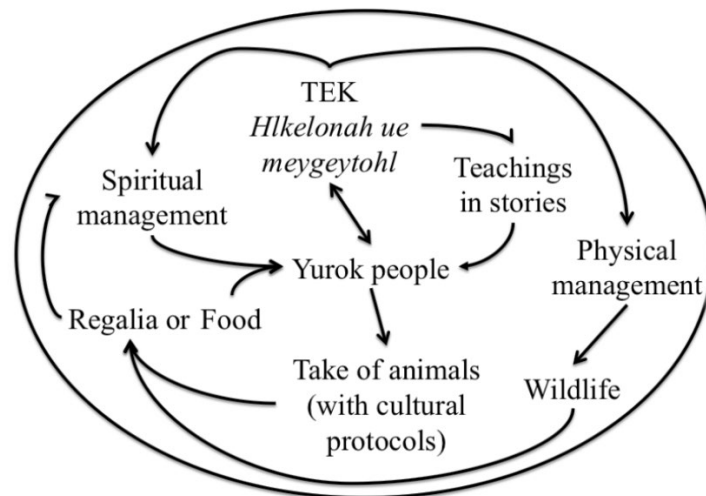
The language revitalization research reverses this process. I attempted to convey WEK through a Yurok lens by creating learning materials for the Yurok Tribe Language Program. The resulting children's book was written entirely in Yurok and conveyed chmuuek behavior and natural history knowledge collected in the wildlife survey. It was meant to be used by Yurok language teachers in local Head Start sites, elementary, middle and high schools. I then interviewed

the teachers who used the book to determine whether this collaboration was successful, how useful it was, what could be improved, and if it could be a model for future collaborations. As a whole, this study encompasses the entire cycle of knowledge exchange between TEK and WEK.

## BACKGROUND

### Yurok TEK – *hlkelonah ue meygeytohl*

The Yurok Tribe is a federally recognized Native American tribe located along the Klamath River, in northwestern California. TEK is conceptualized in the Yurok language as *hlkelonah ue meygeytohl*, or ‘to take care of the earth’ (Ramos 2016). This reflects a worldview that interconnects the Yurok people with wildlife management, spirituality, and the stories they tell to pass on their knowledge (Figure 1). It is important to frame Yurok TEK in this way, so as to not treat it as a database of knowledge that can be distilled into Western science but rather a way of knowing that is rooted in the language, culture, and spiritual practices of the Yurok people (Ens et al. 2015, Ramos 2016).



**Figure 1. *Hlkelonah ue meygeytohl*.** Yurok TEK and its web of connections. Used with permission (Ramos 2016).

Beginning in the 1850s, the Yurok Tribe was subject to land loss and forced ecological change from imposed forestry programs among other things, which suppressed Yurok economy, artistry, and spiritual practices (Huntsinger and McCaffrey 1995). With the increased autonomy associated with federal recognition, the Tribe has sought to regain management control of their

lands and reverse some of the damage (Ramos 2016). The Yurok Tribe established a formal government in 1993 and initiated wildlife program in 2008 (Yurok Tribe 1993). The Yurok Tribe has also organized language revitalization efforts since 1992 (Hinton 2017). Both the wildlife program and the language revitalization efforts are linked through *hlkelonah ue meygeytohl*.

Little of Yurok TEK is documented in scientific literature, but there are some examples with cultural burning and salmon. Cultural burning can aid in mushroom regeneration, basket weaving plant growth, restoration and preservation of black oaks, and the general health of the forest (Anderson and Lake 2013, Hummel and Lake 2015, Long et al. 2016). Tribes in California often set fires to arrest areas in earlier successional states to manage for landscape heterogeneity that can support increased plant and animal biodiversity (Anderson and Barbour 2003); this defies the Western narrative of “wilderness”. The absence of active management in national parks across California has caused a radical change in the landscape, illustrating that these ecosystems are not self-sustaining (Anderson and Barbour 2003). While natural wildfires due to lightning occur, California Natives drastically increased the frequency of fires to create the communities of plants and animals that the Spanish saw when they first arrived. Therefore, natural wildfires cannot be relied upon to maintain the native landscape. While government agencies like the U.S. Forest Service historically suppressed fire, in recent years they have made efforts to manage with fire and allow cultural burning once again (Charnley et al. 2014, Lake et al. 2017).

But Yurok TEK is not always respected, and the relationship between the Yurok Tribe and government agencies is sometimes tense. Having lived along the Klamath River for thousands of years, the Yurok Tribe has an intimate understanding of the river’s fisheries. In 2002, in the peak of the drought, the Yurok Tribe and others warned California government officials not to divert water from the Klamath River to farmers in the valley. When the government ignored them, water levels in the Klamath River dropped and water temperatures rose, resulting in the deaths of 70,000 adult Chinook salmon, one of the largest salmon kills in recorded history (Region 2003, Belchik et al. 2004). The Yurok Tribe also advocates for the removal of dams along California’s rivers. Dams flood surrounding areas, leaving many basket weaving plant-gathering sites underwater. But more importantly, dams have negatively impacted salmon’s ability to spawn and maintain their populations. Dams block salmon and prevent them from returning to the stream of their birth to lay eggs (Yuan 2016).

I hope that my use of Yurok TEK will be respectful and return value to the people rather than being purely extractive for my own personal gain. I also hope that this study may serve as a model for productive collaborations between outside researchers and Indigenous communities.

## **Yurok language**

In 2013, there were around 300 basic Yurok speakers, 60 intermediate speakers, 37 advanced speakers, and 17 conversationally fluent speakers (Romney 2013). In the 1990s, the number of native speakers fell to six. This is the result of a long effort by the United States to eliminate the use of the Yurok language starting in the late 1850s with forced enrollment in boarding schools (Yurok Tribe 2006). Language revitalization has always been a priority for the Tribe and is one of the issues cited in their 1993 constitution (Yurok Tribe 1993). In this study, I worked with the Yurok Tribe's Kee Laa-yo-lue-mehl Scholarship Teacher Candidates Program, which trains Yurok language teachers to work in local high schools and colleges.

Language forms the core of TEK, which passes on knowledge and conveys concepts that cannot be translated. For example, the term “wildlife” has no counterpart in the Yurok language, as animals are considered people (Ramos 2016), and are categorized according to an animal-specific counting system in which four-legged mammals are referred to as “hoor-e'-mus” (those who run around; Ramos, *personal communications*).

The language we use to describe knowledge often indicates which types of knowledge we consider important and valid. Respecting the Yurok language while working with *hlkelonah ue meygeytohl* is vital to disrupting the cycle of subsuming Indigenous names to “true” or “correct” scientific names, which contributes to a power imbalance between Western scientific and Indigenous communities (Barron et al. 2015). For this reason, I use Yurok names for species here in place of Western scientific names.

## **Study species – chmuuek**

I expanded on a recent survey of native species on Yurok ancestral land that focused on members of the mesocarnivore community such as chmuuek (bobcat, *Lynx rufus*), woh-pey-roks (Humboldt marten, *Martes caurina humboldtensis*), le'goh (Pacific fisher, *Pekania pennanti*), and

wer-gers (gray fox, *Urocyon cinereoargenteus*) to investigate their habitat associations (Ramos 2016). Mesocarnivore diets consist of plant material and 50-70% meat (Van Valkenburgh 2007). They are important both ecologically and culturally in Yurok ancestral lands (Ramos 2016). Due to their wide-ranging habits and reliance on various prey populations, they can also act as indicators of ecosystem integrity (Slauson et al. 2010).

Chmuuek are particularly important because they potentially compete for resources with culturally significant species of concern, such as woh-pey-roks and le'goh (Ramos 2016). Chmuuek are solitary carnivores with a polygynous mating system. This leads males to have large home ranges that incorporate as many of the smaller home ranges maintained by female chmuuek as possible (Ferguson et al. 2009). While male home ranges overlap with those of other males, female home ranges are exclusive of each other and are strongly tied to food abundance, as they rear young with no male assistance (Anderson 1988).

Chmuuek diet can also differ based on sex. Females tend to include higher percentages of small prey such as rats, mice and lagomorphs than males, which typically have more mesomammals (Fritts and Sealander 1978a, McLean et al. 2005). This may be due to sexual dimorphism that allows males to be more efficient hunters and mitigate intraspecific competition (McLean et al. 2005).

I focused on chmuuek sex ratios, which are hard to determine due to the difficulty of studying a species that is shy and reclusive (Woolf et al. 2002). Such information is crucial for intelligent management practices, such as harvest regulations (Hiller et al. 2014). Sex ratio studies based on chmuuek that have been harvested by hunters may be inaccurate due to misidentification (Hiller et al. 2014). Some studies have found that males are vastly more prominent in the population, while others found almost 50:50 ratios (Fritts and Sealander 1978b, Parker and Smith 1983, Hiller et al. 2014).

Conventional chmuuek survey methods like capturing, tagging and radio-collaring are often time-consuming, expensive, and logistically difficult (Sawaya et al. 2011). Such methods might also conflict with the Yurok belief that animals are people and should be treated with respect (Ramos 2016). DNA samples from scat have an 85% success rate at identifying individual bobcats (Ruell and Crooks 2007). However, the success rate of using DNA from scat regarding sex identification has not been investigated.

## METHODS

I conducted genetic sex identification work on chmuuek that was beneficial to the Yurok Tribe due to their interest in chmuuek populations on their land. I then took the WEK gained from that research and conveyed it through a Yurok children's book for the Yurok Tribe Language Program. Thus, my methods comprised two parts. *Hlkelonah ue meygeytohl* was of the utmost importance to the selection of my methods, in order to ensure that they were culturally respectful of the Yurok (Lyver et al. 2015, Ramos 2016). To accomplish this, my mentor Dr. Seafha Ramos, oversaw every step of my research. I had regular meetings with her to update her on my work and get approval for any new ideas or changes to my research process.

### Study area

I conducted original analysis of chmuuek DNA samples that had been collected previously during a wildlife survey on Yurok ancestral territory, which includes many different jurisdictions and land types such as the Yurok Reservation, Redwood National and State Parks, Six Rivers National Forest, and timberlands managed by Green Diamond Resources Company (GDRC) (Ramos 2016). The study area was about 770 km<sup>2</sup> (123°47'9.5' W, 41°27'20.84" N). It contains pieces of the Yurok reservation, lands being purchased from GDRC by the Yurok Tribe, and lands still under management by GDRC (Ramos 2016). The area's climate is an inland expression of the maritime region, with distinct wet and dry periods, moderate temperatures, and high rainfall during the winter (Slauson et al. 2007).

### Scat collection and species identification

Ramos (2016) collected scat samples opportunistically along road transects within the study area during the summer (June 21-September 20) of 2013. DNA was extracted from the scat using the DNeasy Blood & Tissue Kit at the Conservation Genetics Laboratory at the School of Natural Resources and the Environment, University of Arizona (Tuscon, AZ), (Qiagen Inc.). Ramos then performed PCR amplification on each sample. Using the online Basic Local

Alignment Search Tool (BLAST), the species of each sample was identified by selecting the first hit for each query, with a maximum identity  $\geq 95\%$  and an e-value of 0.0 (Ramos 2016).

### **Sex identification and DNA concentration of chmuuek samples**

I acquired my chmuuek scat DNA samples from Ramos' work at the Conservation Genetics Laboratory at the School of Natural Resources and the Environment, University of Arizona (Tucson, AZ). There were 35 chmuuek DNA samples in total. For each sample, I used a nanodrop machine to determine the DNA concentration of each sample (Desjardins and Conklin 2010). DNA samples from scat can oftentimes be poor-quality and degraded so it is essential to determine the DNA concentration (Pilgrim et al. 2005). Therefore, an inability to determine sex due to unsuccessful amplification may have been due to poor DNA quality.

I used the protocol from "Felid sex identification based on noninvasive genetic samples" to perform PCR amplification on each sample (Pilgrim et al. 2005). I attempted to prepare a PCR mix that had a DNA concentration of 2ng/ $\mu$ l. However, due to the range of DNA concentrations of my samples, for samples beneath 4.25ng/ $\mu$ l I was unable to achieve the end concentration of 2ng/ $\mu$ l. The rest of the samples were diluted to 2ng/ $\mu$ l.

My protocol utilized Amelogenin forward and reverse primers, which target X and Y chromosomes (Pilgrim et al. 2005). I then conducted gel electrophoresis on my PCR products using agarose gels. The gels were dyed in ethidium bromide, viewed on a UV-transilluminator, and photographed. The difference in X and Y chromosome lengths, 214 and 194bp respectively, allows identification of males and females based on whether they express two DNA bands or only one (Pilgrim et al. 2005).

As positive controls, I used chmuuek male and female blood and bone samples collected in Hoopa, California (Integral Ecology Research Center, Blue Lake, CA) to compare my scat DNA samples against. I used QIAGEN blood & tissue extraction kits for these.

### **Language pods**

The Kee Laa-yo-lue-mehl Scholarship Teacher Candidates Program provides three levels of teaching credentials for teachers to teach Yurok language classes in local high schools and

colleges. They hold language pods, meet ups of three or four teacher candidates for several hours, to casually practice speaking Yurok. In order to become familiar with the language and how the language program was already teaching people to speak Yurok, I attended several language pods early on. Fun activities such as bocce ball were used to create an active learning environment, as teacher candidates practiced vocabulary related to describing the sizes of the balls, the action of throwing them, etc. The visual aspects of learning were emphasized.

In addition to observing the Kee Laa-yo-lue-mehl program, I drew upon my own experience attempting to learn my native CHamoru language. As a traditionally oral language, we did not have a written system for most of our history. For Guåhan, it wasn't until the Spanish colonized the island that the language began to be written down, and it wasn't until the 1960s that the spelling of CHamoru was standardized (Taitano 2014). Additionally, CHamoru has a history of suppression in favor of colonizer languages such as Spanish and English. For instance, in 1922 the U.S. Naval Administration collected and burned all of the CHamoru dictionaries (Taitano 2014). In many ways, the treatment of Yurok and CHamoru as Indigenous languages is similar. Just prior to beginning my research I discovered a children's book entirely in CHamoru for the first time titled *I Malingu Na Påtgon (The Lost Child)* (Mendiola 2016). I learned to read the book with the help of my mother, which was an important step in my quest to become fluent in CHamoru. This experience combined with my Yurok language pod observations led me to decide to create a Yurok children's book as a language resource.

### **Yurok children's book drafts**

I first wrote a draft story in English about a chmuuek mother teaching her cub to hunt, including as much info about chmuuek behavior and habits as possible. My mentor edited the story and translated it into Yurok to meet Level 1 grammar. We then took the draft to the Yurok Language Institute, where teacher candidates attend Yurok grammar classes and learn about teaching methods. Language teachers there critiqued the story and provided more edits. I also gave community members a chance to contribute their own illustrations for each page of the book. I then incorporated all of the text edits and illustrated all remaining pages. The completed book was then presented at the Yurok Language Camp, an immersive weekend experience open to all Yurok

language learners. Afterward, my mentor made the materials available for Yurok language teachers to use in their classrooms.

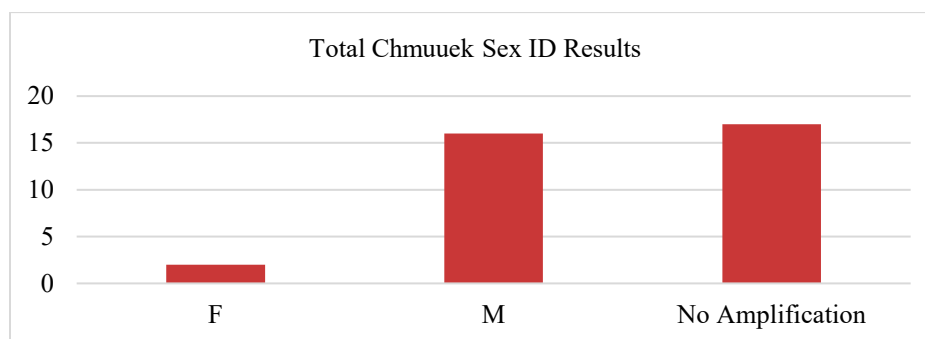
### Yurok language educator interviews

Due to the small number of Yurok language educators, I was able to conduct semi-structured phone interviews for all but Dr. Seafha Ramos. Interviews were roughly 45 minutes long. A written list of interview questions acted as an outline for my conversations (Appendix A). These questions were be edited and approved by Dr. Ramos. However, the course of the conversations expanded far beyond the original question set for each interview.

## RESULTS

### Chmuuek sex ratios

I found that 18 of 35 DNA samples amplified, for a 51.4% amplification success rate. Of those 18, 2 were female and 16 were male (Figure 1). Using a chi-squared goodness of fit test, I compared the 1:8 ratio of the results against a 1:1 ratio, and it found a statistically significant difference between them ( $\chi^2 = 10.889, df = 1, p - value < 0.05$ ).

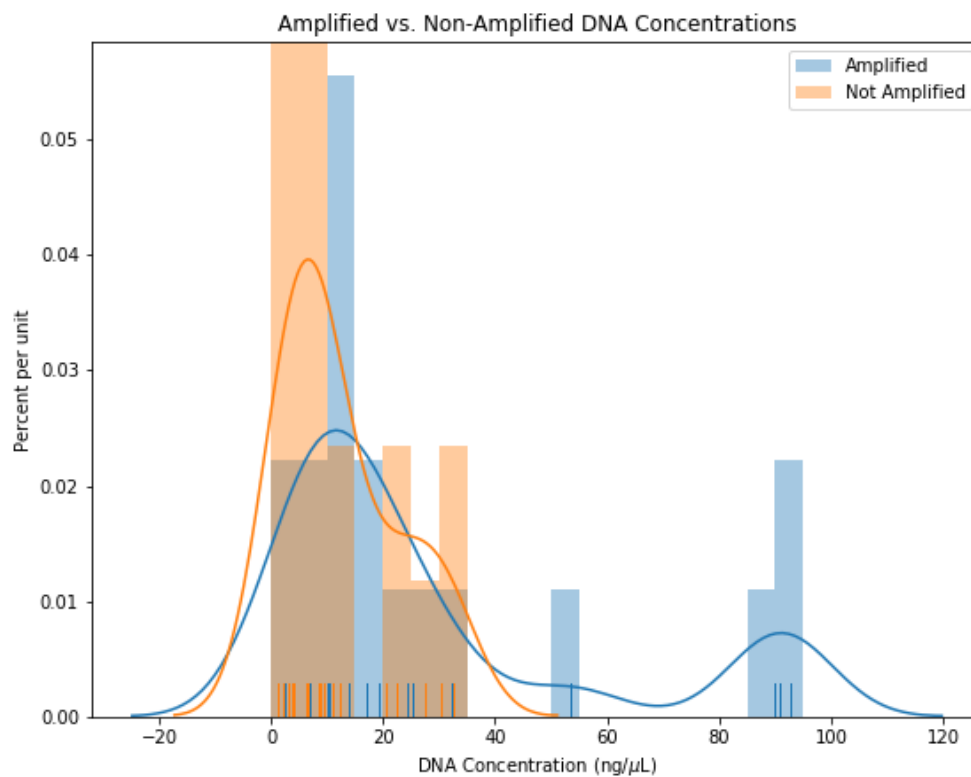


**Figure 1. Chmuuek sex ID bar graph.** Total number of DNA results that were female, male, or did not amplify.

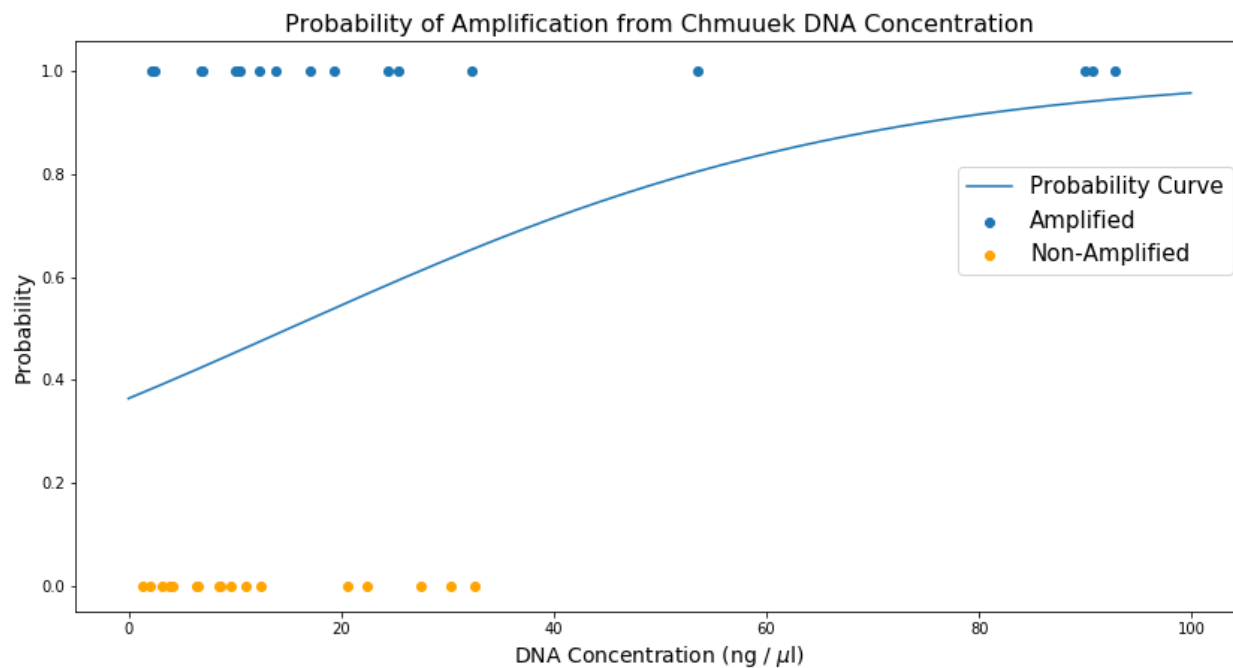
### DNA concentration analysis

The DNA concentration distributions of the amplified versus non-amplified samples overlapped quite a bit (Figure 2). In order to determine whether DNA concentration could predict

amplification, I used logistic regression (Figure 3). The logistic regression had a p-value of 0.0949,  $> 0.05$ , and therefore was not statistically significant.



**Figure 2. Amplified vs. non-amplified DNA samples.** Based on DNA concentration.



**Figure 3. Probability of Amplification from Chmuuek DNA Concentration,** Logistic regression graph.

## Yurok children's book

I completed a Yurok children's book titled *Kue Chery-ker'-ery Chmuuek E-see 'We-chek* (*The Little Bobcat and His Mother*) (Figure 4). In addition to the book, I made an accompanying set of flashcards teaching important vocabulary relating to the story (Figure 5). I also recorded an audiobook version with recorded audio of my mentor reading the story in Yurok (Ramos and Johnson 2018), which provides a resource for those unsure of pronunciation.

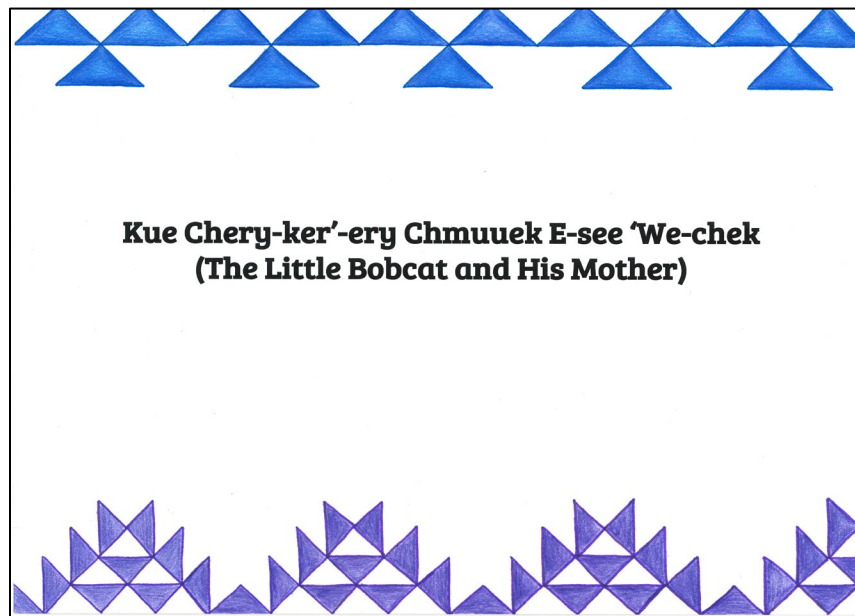
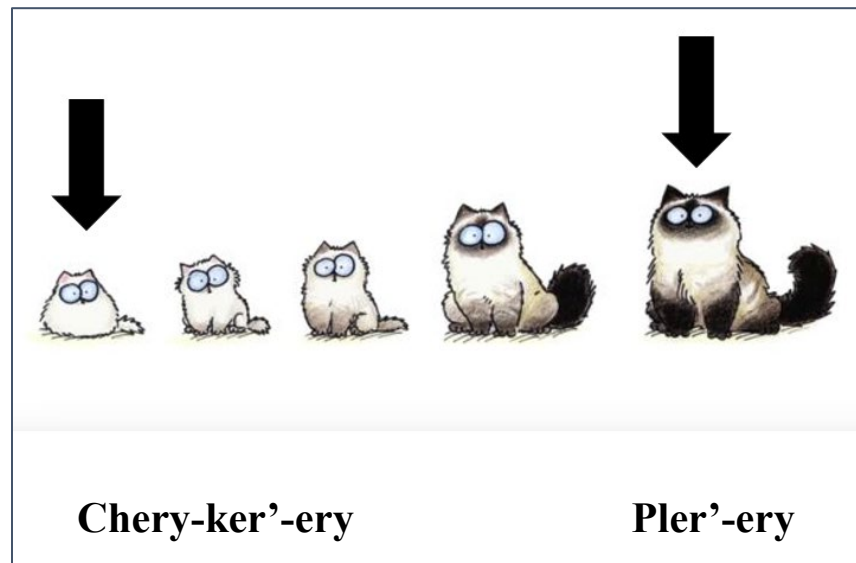


Figure 4. Title page.



**Figure 5. Example flashcard.** Chery-ker'-ery means small hoor-e'-mus (those who run around) vs. pler'-ery which means large hoor-e'-mus (Ramos, *personal communications*).

### Yurok language educator interviews

I interviewed four people: Dr. Seafha Ramos, a Yurok tribal member and Associate Researcher at HSU; Robert R. Kinney, an educator at the Klamath, Knapel and Eureka “south site” Yurok Tribe Head Start programs; Chrystal Helton, a Family Service Coordinator at the Klamath Head Start site; and Brittany Vigil, a Yurok Language Specialist for the Yurok Language Program. My interview with Dr. Seafha Ramos was conducted by written response, and the others were by phone.

## DISCUSSION

### Chmuuek sex identification

The chmuuek sex ratio findings suggest that the chmuuek population in the study area is heavily skewed towards males ( $\chi^2 = 10.889, df = 1, p - value < 0.05$ ). However, there are numerous reasons why the data may be inaccurate. First and foremost is the small sample size. Only about half of the 35 samples amplified to give me a definitive sex identification. Additionally,

the method of scat collection may have been flawed. All of Ramos' transects were along roads, and chmuuek have been shown in multiple states to avoid areas in proximity to roads due to the perceived risk despite the often suitable habitat for prey that brushy roadsides provide (Poessel et al. 2014, Litvaitis et al. 2015, Ramos 2016). Female chmuuek in particular are less likely than male chmuuek to have territories that cross major roads or be located near urban development (Poessel et al. 2014). Therefore, it is possible that the high prevalence of male chmuuek in the scat samples was due to different ways that chmuuek sexes react to the presence of roads.

### **DNA concentration analysis**

It was inconclusive whether DNA concentration can be used as a predictor for amplification success (logistic regression,  $p - value < 0.05$ ). While scat DNA samples have a higher success rate (85%) when trying to verify individual genotypes compared to hair snag samples (10%), they have a lower success rate than tissue, bone, or blood DNA samples (Ruell and Crooks 2007). The specific protocol that I used to identify chmuuek sexes uses the amelogenin region found outside the pseudoautosomal region of the y-chromosome (Pilgrim et al. 2005). It is an improvement over sex identification tests that amplify the y-specific *SRY* locus, but it still relies on nuclear DNA, which is extremely difficult to obtain from fecal samples as compared to mitochondrial DNA (Murphy et al. 2000, Pilgrim et al. 2005). This method of sex identification requires the y-chromosome to be intact, whereas species identification can use DNA barcodes from mitochondrial DNA, therefore scat samples may not be the best source of DNA (Meyer and Paulay 2005).

Additionally, many other variables can affect the quality of scat DNA samples, such as time scat remains in the field, environmental conditions, species diet, and collection methods (Murphy et al. 2000). The scat samples I used were not dried and preserved in the original wildlife survey, which could significantly affect the quantity and quality of DNA obtained (Murphy et al. 2000, Ramos 2016). Future studies hoping to conduct sex identification surveys should collect more samples, and should dry and preserve them.

## Yurok language educator interviews

In the months following the completion of *Kue Chery-ker'-ery Chmuuek E-see 'We-chek* (*The Little Bobcat and His Mother*), the book was printed by my REU's program director Dr. Matthew Johnson, and distributed by my mentor Dr. Seafha Ramos. Copies were given to Eureka High School, McKinleyville High School, all three Yurok Head Start sites, the Native American Library at HSU Indian Tribal & Educational Personnel Program, and the Yurok Tribe Language Program (Ramos 2018). The book's success was far greater than I could have ever have anticipated, and I was honored to hear back from Yurok language educators about the positive impact it was having in their communities.

While Yurok immersion books written entirely in Yurok with no English do exist at a variety of difficulty levels, *Kue Chery-ker'-ery Chmuuek E-see 'We-chek* is valuable because it was written specifically as a teaching tool for the Yurok Tribe Language Program. Brittany Vigil, a Yurok Language Specialist for the Yurok Language Program, highlighted how the book was particularly helpful in teaching Yurok classifiers. One example is that “words like little and big are not adjectives in Yurok, they're verbs” (Vigil 2018). So not only did the book provide an amusing story, it was able to teach specific aspects of Yurok grammar.

The Language Program's funding is grant based and focused on specific outcomes such as the teacher candidacy program (Vigil 2018). However, they do have a large database of digital resources on Google Drive, comprising of songs, curriculum, frameworks, e-books, and more available for teachers as needed (Vigil 2018). The Language Program also got funding to develop four new books this year. But due to funding limitations, it is difficult to purchase multiple copies of Yurok immersion books to have on hand at all their sites. Because *Kue Chery-ker'-ery Chmuuek E-see 'We-chek* was funded through my REU program, it provided material support to the Yurok Tribe Language Program.

Multiple Yurok language educators commented that they appreciated the emphasis on community engagement. Robert R. Kinney is an educator at the Klamath, Kepel and Eureka “south site” Yurok Tribe Head Start programs. He was present at the Yurok Language Institute when I presented the book with my mentor for edits. He stated that:

“I was so happy to see [the book] coming to fruition because I took a snapshot of the whiteboard you and Seafha used that day. It was inspirational to see the people who know the Yurok language say, oh well let's try it this way or let's try it that way. It was a collaborative effort and that's what made it special.” (Kinney 2018)

This is significant because it illustrates that the book was made in conversation with the Yurok language community, not merely presented at the end when the book was a finished product. Giving communities opportunities to provide feedback is essential to healthy collaboration. With regards to my approach he said:

“I feel you are coming from a place of I have these resources, how can I help you produce literature with scientific knowledge, instead of letting the Yurok Language program know that there is only one way to produce said literature.” (Kinney 2018)

This indicates that the key to the success of the book was that I asked Yurok language educators and the community how I could best utilize my skills and resources to their benefit rather than assuming I knew best.

Community input had many other benefits as well. Several of the illustrations in *Kue Chery-ker'-ery Chmuuek E-see 'We-chek* were drawn by community members. Chrystal Helton, the Family Service Coordinator at the Klamath Head Start site, brought up how those details are so important to the kids:

“Our kids know who these people are. If I am able to tell those first graders that so-and-so's dad drew that illustration, it draws them in. It's another tool to connect them to their community and place, places that make them feel safe and worth something.” (Helton 2018)

The process of making *Kue Chery-ker'-ery Chmuuek E-see 'We-chek* allowed various Yurok community members to connect with each other and to continue making those connections after its completion. These effects were not planned. I was genuinely surprised to see how many different aspects of the book the Yurok community was engaging with, in ways I had not considered previously.

The book was not only used for children. Dr. Seafha Ramos has used the book in academic settings. Just recently she played the audiobook at the end of a talk for the “EcoSeries” at HSU about the considerations of philosophical and historical contexts in culturally sensitive TEK

research (Ramos 2018). She also created lesson plans based on this book to use in her class “Case Studies in Environmental Ethics” at HSU, to talk about Yurok language revitalization efforts and how environmental ethics and worldviews are conveyed through language (Ramos 2018). The unique coming together of hlkelonah ue meygeytohl and WEK in *Kue Chery-ker’-ery Chmuuek E-see ‘We-chek* created a myriad of uses from Yurok language education to academic talks investigating the relationships of language and environmental ethics. As a result, the book’s interdisciplinary nature is beneficial to multiple groups in the Yurok community besides language educators.

While *Kue Chery-ker’-ery Chmuuek E-see ‘We-chek* was successful in many ways, there were limitations to what I was able to achieve. As a non-Yurok person, the storyline’s connection to Yurok culture was superficial. The book’s simple plot and focus on beginning Yurok learners was key to the success of the book. However, if I had attempted to make a book at a higher level of Yurok, my lack of Yurok cultural knowledge would have been detrimental. Regarding future collaborations like this one, interviewees were open to the possibilities but stressed that it was important to communicate and check in with Yurok speakers. By doing so, I was able to find a niche where my skills could be useful to the Yurok community rather than taking space from someone else more qualified for that role. This, more than anything, was key to the success of this collaboration. I hope future projects keep this in mind and apply these lessons to their work.

### **Limitations & future directions**

With regards to chmuuek sex identification, more replication and a larger sample size could shed light onto whether the population skews towards males or if that was due to the influence of roads. The genetic analysis I conducted in this study did not use microsatellites, and therefore could not distinguish between individuals. Future surveys should attempt to collect chmuuek scat samples away from roads and then compare the results to this study’s to determine the effect roads might have on the sex ratio of scat samples. It would also be interesting if DNA samples could be analyzed geospatially by sex and individual identification to look at home ranges in this population.

While noninvasive sampling methods such as scat sampling may be less efficient in generating useful data than direct samples such as blood or bone, respect for Yurok traditions and

belief systems is of the utmost importance and should not be discarded for convenience. That being said, effective scat sampling requires proper drying and preservation methods, especially for sex identification, due to the low quality of the DNA. DNA concentration did not prove to be a conclusive predictor for amplification success, but other variables may well indicate which samples will be best for sex identification.

Additionally, although this paper discusses collaborative possibilities between Indigenous and Western science and communities, my study was specifically conducted with the Yurok community. Each Indigenous nation is distinct with their own cultural values and beliefs and any conclusions made here cannot be applied to Indigenous peoples as a whole.

### **Broader Implications**

Future collaborative studies between Indigenous communities and Western scientists should continue to be pursued in manners that best suit the Indigenous community's needs and desires. Regardless of whether this study has accomplished this, moving forward with this type of work is essential to the long process of breaking the cycle of harm that Western science has wrought on Indigenous communities and potentially reversing some of the damage.

The genetics work did not definitively answer questions of chmuuek sex ratios and scat DNA sampling effectiveness. However, the process did illuminate how future research into these areas should be conducted in order to get better results. More importantly, this paper modeled the cycle of knowledge exchange between hlkelonah ue meygeytohl and WEK and what these kinds of mutually beneficial collaborations might look like. I was able to build the types of relationships I had hoped for in the Yurok community, especially with my mentor, and produce a book that has genuinely benefitted Yurok language educators. Projects like this have made me hopeful for the future of research informed by both TEK and WEK. I look forward to seeing more work like this in the future.

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**APPENDIX A: Interview Questions**

1. What level of Yurok language do you teach?
2. Did you use *Kue Chery-ker'-ery Chmuuek E-see 'We-chek (The Little Bobcat and His Mother)* in your classroom in the past year?
  - a. Yes
  - b. No
3. Did you use the book, the video recording, or both?
  - a. Book only
  - b. Video recording only
  - c. Both
4. How did you use the materials?
  - a. Lesson plan
  - b. Assignment
  - c. In class activity
  - d. Other (explain)
  - e. Not applicable
5. What were your goals with these materials?
  - a. How did it relate to the rest of the curriculum?
  - b. How helpful were these materials in achieving your goals?
6. Did you use any other materials over the course of the year that were similar in any way?
7. Do you plan to use this material again in the future? If so, how?
  - a. Would it be different than before?
  - b. What was successful, what was not?
  - c. How could the material be improved?
8. What was the response from the students?
  - a. How did that compare to other materials/lessons?
9. What kinds of language materials are not currently available/in existence that you wish were available to you? (Ex. Yurok language movies)
  - a. How did this book potentially fill the gap?
10. Do you identify as a scientist?
11. What has been your experience with scientists?
12. Does this relationship change if the scientist in question is Yurok?

13. Does this relationship change if the scientist is Indigenous but not Yurok?
14. This book was created as a collaboration between a Yurok tribal member, and a non-Yurok Indigenous student during a summer research program. Does this knowledge affect your perception of the book?
15. Do you think future collaborations should be pursued?
  - a. If so, how?
  - b. If not, why?