

Confluences



Confluences

A Journal of Exploratory Research and Analysis

Normalized thought meets a formidable challenge at the confluence of change and becoming. Where the stratifying frictions supporting the conserving pace of tradition are outstripped by the pace of waters falling through smooth spaces, we enter a *confluence of forces holding still and letting go*, defending proprieties and transgressing their authority to define the horizons of our aspirations. We enter this space in many facets of our life, but several interesting portals emerge when we are under the influence of contemporary music; in proximity to animal sentience; bearing witness to global warming and our shifting relation to the world's oceans; gathering meaning from the embedded world of another time and place; outstripping the separation of our rational senses and the artistic drive of our imagination; tapping into the ever-smoother space of superconductors and the super-currents of energy and information they help to transmit; or trying to understand "cryptic" species to screen more effectively for potential human environmental impacts. The research articles published here represent the Capstone Research efforts of seniors in the University Honors Program. The articles present projects conceived from personal interests and mentored by faculty who are familiar with the research and scholarship driving these efforts of discovery.

While the stirrings of personal interest are a crucial element in the cultivation of sound research practices, they should not be confused with the stirrings of sound research practices themselves. The stirrings of sound research emerge only from a special growth in perspective, and the goal of good mentoring is to awaken these stirrings and override the restrictive limits of personal interest and its attendant beliefs. We thank our faculty

mentors, over a hundred so far, who have worked with our Capstone students over the past ten years to frame and conduct effective research projects.

In the process of acquiring new perspective in life, we need to cultivate new attunements, attitudes and convictions. But we also need to see how these orientations sensitize or desensitize us to the blind spots in our understanding. Are there not issues, concerns, opportunities and challenges relevant to our lives that we can only appreciate *from somewhere else*? As we grow older in life, we are fortunate to discover new points of entry to our surrounding world, but only by closing off or eclipsing *other* points of entry.

To see the world in a new light, to acquire new *entries* to the world, is to listen more attentively and to become responsive in a new way. The capacity to respond to issues and concerns otherwise masked from view demands a special openness and attention to what we find strange and challenging. We seldom see the world in a new light without first having the curiosity and willingness to explore unexpected or marginalized phenomena -- nor without learning to discern otherwise hidden facets of our filtered social and personal constructions.

We trust this collection of articles will stir your interest in some timely topics. The goal of these writings is to increase awareness of what is actually at stake, integrate this into the formation of compelling research questions, present findings based on analysis of criticism and exploratory questions, and suggest how these findings might influence more positive developments. These articles reflect efforts to raise *curiosity* to the level of *sound research* with respect to topics and issues we hope will spark interest in the minds of our readers. We invite you to flow into these confluences!

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*Seniors in the Honors Program are encouraged to tackle complex problems using methods and knowledge drawn from relevant disciplines. Honors Program faculty and research mentors offer critical feedback and guidance along the way. The primary objectives are for students to explore, gather and analyze information effectively, and to reflect on the implications of what they have discovered. Group discussions help to promote thoughtful questioning. The goal is to communicate knowledge, judgments, and original perspective on the basis of careful inquiry, exploration and analysis. Our seniors make presentations on their research at our annual **Honors Capstone Conference** (our Spring 2011 conference met on May 17th in the John Rogers Faculty Development Center and featured presentations on the research topics introduced in this journal). We hope you can join us for our next conference, in **May 2012!***

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Big Sur (Eddie Campbell)

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EAC

Beyond the Break – Eddie Campbell

Every Day is a Decision

*The death of one who loves you
no more
seems echoes away
from being there
again
even before she's gone
from your touch
and loving embrace
there on the floor
of carpet and blankets
cushioning bones so brittle
they ache at the thought of moving.*

*A pill
to make this disappear
gives refuge from pain
and truth.
her eyes still say
let's go on
just a little further
we'll be
alright.*

Prolegomena to a Viable Study of 20th and 21st Century Music

Ricardo Friaз

The history of music has been determined by musical notation. Musical notation is an alphabet, the letters of which indicate musical pitches that correspond to the diatonic scale. All music that can be re-created into sound prior to the invention of the recording is reliant upon musical notation, or a text. If there is an exception to this, it is the oral tradition of music, by which the melody of a given piece of music has been transmitted from the past by memory and performance. Thus the history of pre-recorded music, which I will call the Western musical tradition, has been the domain of the musically-literate and educated. Today, music can be recorded as it is performed, and access to recording technology is cheap and simple. This constitutes a vast democratization of the ability to create an enduring musical work; the consequences of this are still being felt. Music has changed, and the ways in which it has changed require attention.

To write about music has always necessarily meant referring to the text of music. This problem occurs in the history of literature and art, in different ways. With the advent of the printing press, the dissemination of written works was accomplished on a massive scale, and the criticism and theorizing of literature was accessible to much more people. The history of art is similar. The difference between other arts and music, however, is that the language and text of music is arguably experienced exterior to the music itself, an effect that has heretofore been aggravated by the absence of the record.

The history of the arts has experienced similar paradigmatic shifts. Visual art eventually achieved a reproducible character of its own through refinements in techniques

of lithographic reproduction, as discussed by Walter Benjamin in his highly influential essay on “The Work of Art in the Age of its Technological Reproducibility.” Lithographs “enabled graphic art to provide an illustrated accompaniment to everyday life,” and foreshadowed the culmination of reproducible visuals in the motion picture (Benjamin 20). The printing press had accomplished the same for the written word in the 15th century. Significantly, the status of film as a technologically reproducible art form receives special attention in Benjamin’s essay, and there are some affinities to recorded music.

From the early 20th Century it has been readily possible to point to an aural example or instance of a musical work. Prior to this, to speak of a musical thing was necessarily to refer to a text, or wispy memory of a musical performance. In *Rock Formation*, Steve Jones illustrates this point: “prior to the phonograph, music notation was the only means of preserving a composition short of memorization” (15). According to Jones, the first “technological method” of recording sound is traced to the year 1857, when a Frenchman named Leon Scott developed a machine that ‘wrote’ sound into a “cylinder of heavy paper coated with lamp black.” However, there was no way to play this “written” sound back; still, it remains significant as the first instance of writing sound without dictating it via musical notation. Interestingly, neither music boxes nor player pianos have the same significance as the phonograph in regard to musical reproduction, as they merely produced sound, without reproducing it. It is the reproduction of sound that is significant, and which allows a discussion like the following to take place.

The first song from Panda Bear's "Person Pitch" ends on a perfect 5th that falls slightly out of tune. This last note is clearly the highest note the singer, Noah Lennox, can reach. The musical notation of this song would all but erase the timbral history of this note. Certainly, all the components would be in place to recreate it. The sheet music for "Untitled #1" can contain detailed instruction on how to recreate the effect of this final note, even to the point of demanding a singer with a similar vocal range in order to create the strained sound of an overextended voice. What has always been missing in musical notation of all kinds, and remains missing in this example, is the actual 'timbre' of the sound, which here is the unique sound of Panda Bear singing that note.

In *Audiometry: Principles and Practices*, timbre is called a "wastebasket" attribute: if two tones are judged to be "different," and yet have the same pitch and the same loudness, then they must differ in timbre" (Glorig 55). The quality of timbre in music has traditionally received less priority than the trifecta of rhythm, harmony, and melody. With the advent of recording technology, timbre becomes possibly the most important attribute. In *The Ambient Century*, Mark Prendergast charts this development. He observes that "the importance to twentieth-century music of atmospheric sound, its timbre and personality—indeed its 'Ambience'—is a measure of how much innovative musical ideas intertwined with technological change," which points directly to the development of timbre in his own thesis for declaring this century one of 'Ambient' music (3). Obviously this is not necessarily a negative development; Prendergast, among others, finds that this century has produced interesting and rich music. It is fair to say that this innovation led to the electronic music of composers like John Cage, Otto Luening, and Charles Dodge, as well as rock and hip-hop. It is the last two that tend to be looked at with

suspicion, and threaten the validity of the genres as music proper. One such critic is Allan Bloom, who dedicates a chapter to music in his book *The Closing of the American Mind*, focusing on the negative effects "rock music" has on young people.

Bloom's thesis is that rock music, and generally the popular music of the time, provides "premature ecstasy," and as a result lacks "enthusiasm or great expectations" (80). He explicitly links rock music to drugs, insofar as turning off the CD player is tantamount to "[having] a serious fling with drugs—and getting over it". Rock music "encourages passions and provides models that have no relation to any life the young people who go to universities can possibly lead." The connection to drug use is made explicit here: young people who listen to rock music are satisfying their "sexual desire" and the lyrics "treat them as its only natural and routine culmination for children who do not yet have the slightest imagination of love, marriage or family" (74). In addition to being an addictive and exhausting drug, rock music is presented as a substance that awakens, satisfies, and exhausts lust in "children" through words that celebrate "puppy love as well as polymorphous attraction." Rock music's attraction goes beyond simple simpering lyric choice, for "young people know that rock has the beat of sexual intercourse. That is why Ravel's "Bolero" is the one piece of classical music that is commonly known and liked by them" (73).

In order to illuminate Bloom's take on the concepts that appear here, as well as to give context to the current connotations of the terms he invokes, I will clarify the points of his argument as well as attempt to understand his understanding of music and its consequence. Here Bloom's critique functions as an example for why new terms or methods are necessary to discuss the history of music. Because without a reevaluation of the methods currently used to critique music, people like

Bloom will continue to determine the course and opinion of musical study. For Bloom, music is a thing that “uses the passions and satisfies them while sublimating them and giving them an artistic unity” by way of the “cultivation of the soul” (72). Contrast this to his understanding of rock music:

But rock music has one appeal only, the barbaric appeal to sexual desire—not love, not *eros*, but sexual desire undeveloped and untutored. It acknowledges the first emanations of children’s emerging sensuality and addresses them seriously, eliciting them and legitimating them, not as little sprouts that must be carefully tended in order to grow into gorgeous flowers, but as the real thing (73).

The origin of this argument is unclear, but its pedigree is familiar. The line of thought is derivative of the idea that ‘classical’ music signifies intelligence and thought, in contrast to the popular music, which is for the ignorant masses. However, Bloom complicates this dichotomy further. While “Bach’s religious intentions and Beethoven’s revolutionary and humane ones” cultivate the soul, he argues, rock music is a drug insofar as it *expends* the listener.

The argument begins to look familiar: it would seem Bloom is linking rock music to deviancy. He actually clarifies this point, acknowledging that “my concern here is not with the moral effects of this music—whether it leads to sex, violence or drugs” (79). In fact, Bloom’s argument is that the “imagination of young people” is ruined by this music by way of its sabotage of the “esthetic education of man.” This is to say, rock music, in contrast to classical music, creates and perpetrates fantastic ideals that have no basis in real life. The formula of sex and decadence prevalent in rock, according to Bloom, “encourages passions and provides models that have no relation to any life the young people who go to universities can possibly lead,” and this exactly ruins their

education. No longer are the “young people” carried by the hope of real heroes and sensible passions; their senses are expended and their expectations will no longer be met, thanks to Mick Jagger, that “male and female” who could “enter everyone’s dreams” (78).

Through the course of the essay, Bloom actually makes very little reference to musical examples and citation. One of the few instances involves his anecdotal mention that “young people know that rock has the beat of sexual intercourse” which is why he refers to Ravel’s “Bolero” (73). While it is probably ridiculous in itself to conjecture that most young people enjoy this “seventeen minute” piece that Ravel described as “one long crescendo,” the claim that music can have the beat of sexual intercourse may merit some investigation (Calvocoressi 477).

This point highlights one of the problems involved in the discussion of music. There is a tendency to divide musical discussion into two mutually exclusive languages: that of the musicologist and that of the sociologist. Unfortunately, Bloom’s discussion seems to fail on both fronts. There is no musicological evidence to support the outlandish conclusion that rock music has the beat of sexual intercourse. Nevertheless, Bloom has found supporters, and this highlights the problem involved with the discussion of music. While Bloom does not indict the 4/4 “common time” of Classical music, he is somehow able to accuse rock music of the same crime in a manner that seems coherent. In *The Aesthetics of Rock*, Theodore Gracyk points out that “Bloom does not find a sexual beat in the Adagio of Mozart’s ‘Hunting Quartet’” even though the music itself is written in the same meter as many rock songs.

In a chapter called “Jungle Rhythms and Big Beat,” Gracyk discusses the rhythm of rock music, and in doing so explicates the concepts of rhythm, meter, beat, pulse, accent, and syncopation. These are the terms of the musicological tradition, which are taught in

universities today as the words to describe musical sound par excellence. Even new work in the cognition of sound by the brain maintains the terms. In *This is Your Brain on Music*, Daniel J. Levitin discusses rhythm by referring to ‘groove,’ which is “that quality that moves the song forward, the musical equivalent to a book you can’t put down” (166). Bloom’s discussion is couched in these same terms, and he ends up relying on their connotations in place of providing a real discussion or presentation of evidence.

It is obvious that Bloom is referring to the sound of rock music. The sound of rock music is different from the Classical tradition. Classical music has generally had a primary palette of timbres; much as rock music can often be expected to be a mix of drums, guitar, and vocals. Even when Wagner came to prominence with his “grandiose operatic orchestration,” he still composed with woodwind and string sections (Prendergast 2). Furthermore, Bloom finds that the sound, or timbre, of rock music itself conjures up wasteful, sexual experience. Gracyk takes issue with this claim by presenting an example from his own experience:

When I played Ravi Shankar’s performance of the Raga Gara to thirty students, most of them music majors, none of them thought it was “romantic” despite that description of it in the album’s liner notes. When I played the same group a Burundi song expressing homesickness, none of them felt homesick in response. The majority thought it was sexual (143).

This example demands the question of whether music can represent something consistent to all audiences: yet this key issue never arises in Bloom’s essay. Instead, there is only dismissal and sneering at music that does not function to advance the history and criticism of the Western Classical tradition. In his own appraisal of Bloom’s argument, Gracyk concludes, as I also do, that “Bloom is drawing on the stereotypes of rock that

flourish in the absence of serious thought about stylistic and aesthetic qualities as bearers of meaning” (143).

This concern, and misinterpretation, of the experience of timbre in the written history of music as contrasted with the recorded history of music can be framed in terms of the relation of music to noise. This discussion is taken on by Jacques Attali in *Noise: The Political Economy of Music*, and elaborated on by Paul Hegarty in *Noise/Music: A History*.

Noise is always framed as the negative aspect of sound. More than silence, which is often named as a necessary component of quality music, noise is “not only a judgment on noises, it is a negative reaction, and then, usually, a negative response to a sound or set of sounds” (Hegarty 3). Hegarty mentions that science attempts to classify noise as something that is borne of evolution in order to protect our ears from damaging frequencies, and goes on to conclude that “noise is cultural, and different groups of hearing machines will process sounds differently.” This discussion leads up to the thesis that “noise is an excess, is thought of as being too much, and for human hearing, this occurs almost entirely through cultural perceptions, and individual reactions within that framework” (4). Noise, or all aural experience, always happens to the subject; it is not a choice that is deployed at will. A gazing subject and a reading subject are always directing themselves towards the world, and sound possesses the distinction among the senses as something that is always intruding in.

Noise is not simply a “synonym for dissonance” (Hegarty 12). Consonance is generally explained as sounds that are aurally pleasing to the ear, and this definition is sometimes grounded scientifically, as Levitin explains when he points out that although “the neural mechanisms underlying consonance and dissonance are debated, there is

widespread agreement about some of the intervals that are deemed consonant” (72). A single note can never be dissonant on its own; it takes multiple notes that “[do] not conform to the customs we have learned that go with our musical idioms” (73). Like noise, dissonance is unwanted and culturally constituted, yet dissonance “works through its rethinking of consonance, and composers using it tended to think of their work as reinvigorating the Western tradition of music” (Hegarty 12). Noise is never described as such, even though Hegarty claims that all musicians, even those “against the existing institution of music... imagined at some level that they were contributing to advancing music.” Dissonance is named as a part of music; meanwhile noise is the name for the cause of the riot “at a performance of Stravinsky’s “Rite of Spring,” and for other violent protests against sound.

The history of noise outlined by Hegarty and Attali makes its own claim to be part of the history of 20th century music; yet both authors claim touchstones similar to Prendergast’s theory of the “Ambient Century,” which prefigures the history of music as on its way to the recognition that “all recorded music” is, by definition, “Ambient” (4). While Gracyk takes a narrower focus, his end is the same: an account, and implicitly a validation addressed to people like Bloom, of 20th century music. Levitin calls attention to how “Western music was largely dominated by pitch,” but “for the past two hundred years or so, timbre has become increasingly important.” The pitch-centric approach to music has resulted in “an arcane, rarified set of terms and rules that are as obscure as some of the most esoteric domains of mathematics. To the non-musician, the blobs of ink on a page that we call music notation might just as well be the notations of mathematical set theory.” It is precisely through the technology of recorded music that a relation to the sound of music can begin to take place, and an

artistic, heard work of sound can be looked at as a work of sound proper.

The history of what I have variously called the “classical tradition,” the history of “musical notation,” or the history of music in general has not necessarily been the history of *sound* or *noise*. Indeed, sheet music is precisely the excision of all noise; it is the purification of the sound abstracted into ovals on the page. I will go further and say that noise is the sighting of timbre. Timbre, the actual “heard” sound of music, can be thought of as the process of reducing the noise factor intrinsic to actually producing music.

Timbre here is another name for the difference between ‘good’ and ‘bad’ tone. This distinction works as a testament to the repression of noise in the history of music; pre-recorded music has been the preservation of good tone at the expense of bad tone. It is the rare 19th-century musical score that would have read: “play with broken, poorly cut reed,” or “to be played on a pianoforte with rusted strings.” Contemporary *avant garde* music is written and performed with instruments like the ‘prepared piano,’ which refers to a normal piano that has had miscellanea like bolts, screwdrivers, and strips of rubber lodged in its strings. The fact that music is now written for instruments prepared in such ways, and the sheer volume and quality of music that has been produced worldwide in the form of recorded music both speak to the need for a new lexicon and approach for analyzing contemporary music. Otherwise, the influence of someone like Allan Bloom, who proposes to invalidate the new music and all who listen to it in deference to conservative tradition, is likely to prevail in public discourse.

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Fillmore Jerry 1967 – Jim Marshall

Jumpstarting Sentience: Promoting Higher Consciousness In African Grey Parrots Through Early Language Acquisition

Breeann Wright

Scientists do not know exactly what consciousness is or how it comes about. They know that some aspects of it are unique to human beings, but they do not know why. Psychologists, biologists, and philosophers cannot even seem to agree on how to define consciousness; nevertheless, it is a much-investigated and contested area of study, as any definition of consciousness could pertain to the studies of neurology, psychological disorders, linguistics, philosophy, behavioral analysis, and numerous other fields. Often it seems that the only constant, when speaking of sentience or consciousness, is that consciousness is what humans have, by and large, and what animals do not. Occasionally, however, even this seeming constant may be called into question, in particular when examining the theories of primary consciousness, neuronal group selection, and species-specific variation in age of language acquisition.

Gerald Edelman suggests a differentiation between primary consciousness and higher-order consciousness, wherein primary consciousness involves being able to form concepts and complex discriminations, and is not unique to human beings, and higher-order consciousness requires primary consciousness as a starting point, but also makes use of higher-order processes, especially language. Individuals possessing primary consciousness only are incapable of placing themselves as selves in a time stream consisting of past, present and future. Additionally, only individuals possessing higher consciousness are capable of self-reflection, such as thinking "I am I," or of thinking about thinking: metacognition is purely a function of higher consciousness and cannot be accessed via primary consciousness alone. Unfortunately,

metacognition is also impossible to determine with simple tests, and can only be reliably verified by an individual's lingual self-report. In Edelman's model, individuals of many species may have innate access to primary consciousness, and therefore be able to discriminate between concepts such as color and size, or even have a limited sense of numbers, but still not have access to higher consciousness because possessing primary consciousness does not automatically engender higher consciousness. Rather, an individual possessing primary consciousness, given the right set of environmental and social stimulation, will undergo a process of neuronal group selection, or neural Darwinism, such that various sets of neuronal patterns are interlinked and cross-connected in increasingly complex ways, with the end result that higher consciousness is demonstrated to be a function of the exponential increase in complexity (Edelman, 1990).

Fundamental to Edelman's model is the concept of language. He notes that language does not occur without higher consciousness, and higher consciousness does not occur without language: the two are inextricably linked. If language is absent, then there is no potential for higher-order consciousness. Language, because of its own inherent complexity and networked symbols, functions as a catalyst for neuronal group selection and, therefore, also for higher consciousness. Remove language from an individual's development, it is hypothesized, and that individual has no chance for higher consciousness. However, directly testing this theory on human subjects is impossible due to ethical constraints, as with-holding language

from a developing child is not only highly illegal but also highly unethical.

With the concept of development comes the widespread theory of an age of primary language acquisition. This does not mean the period in time during which individuals can easily learn second languages; rather it refers to the period in time in which individuals learn a first language. An individual human must learn a first language, be it spoken, written, or signed, within this time frame; if no language whatsoever has been learned by the end of it, then it is generally assumed by linguists and psychologists that that individual will never be able to learn any language whatsoever. Referring back to Edelman's theory of neuronal evolution, this lack of language corresponds with a lack of neuronal group selection, so that such an individual would also never attain higher consciousness: the occurrence of higher consciousness would then require not only the stimulus of language, but also that the individual receive that stimulus within the right time frame, i.e., before the age of language acquisition has passed. This theory is, again, impossible to directly test on human subjects, but may be partially borne out by observations of feral children who were not exposed to language until they had passed the age of language acquisition, in humans about seven or eight years old. Most of these children never attain average levels of human awareness, and are animalistic in their behavior and cognitive processes (Newton, 2003).

The subject of nonhuman behavior is not a new one. Psychologists, biologists, and ecologists have paid considerable attention to quite a few species, creating catalogues of common behaviors and fine-tuning training methods. However, serious investigation into nonhuman cognition has been primarily limited to the great apes – particularly gorillas and chimpanzees – and dolphins, most frequently the bottlenose dolphin (*Tursiops truncatus*). These experiments have been

problematic, partially because of some problematic initial assumptions and partially because the species involved do not have the means to report back in a medium easily interpreted (Blumberg & Wasserman, 1995). While it is possible to assess an individual's intelligence by measuring performance on certain tasks, the only sure means of measuring higher consciousness, or sentience, is by self-report; without that self-report there is no way to either prove or disprove consciousness on the part of any individual or species. Many psychologists believe this limitation rules out meaningful experiments that would deal with animal consciousness rather than with animal behavior.

The previous theories indicate, however, that it may be possible to induce or facilitate self-awareness in a non-human species that possesses higher consciousness through early language acquisition. My goal is to identify a species appropriate to the research – that is, to select a species which demonstrably possesses primary consciousness, and which is easily accessible at infancy and for long periods of time thereafter so that researchers can apply language as a stimulus before the subject a) has passed any species-specific age of language acquisition, and b) has acquired the necessary physiological structures for self-report in order to confirm higher consciousness at the end of the experiment. The species selected should also have been the subject of study in the past, so that results from previous experiments could be compared to results from the new experiment. Dolphins and dogs, whether or not they have access to primary consciousness, do not meet the requirements for self-reporting, i.e., they cannot report through the medium of language because their physiological makeup prevents sign language and known human languages; gorillas and chimpanzees cannot report vocally, though there have been attempts to teach individual great apes sign language. Research indicates that experiments

with these species have reached a dead end. I propose to focus on a different species, specifically the Congo subspecies of the African grey parrot (*Psittacus erithacus*).

Dr. Irene Pepperberg is famous for her work with African grey parrots and language. In 1977 Pepperberg bought an African grey parrot which she named Alex, an acronym for Avian Learning EXperiment. In the decades since then, Pepperberg has conclusively demonstrated that African grey parrots have the ability to form concepts and discriminate between complex situations, and thus certainly have primary consciousness at the very least, but she has not yet determined how far their cognitive abilities may extend. Her primary bird, Alex, displayed comprehension of a number of concepts, but did not demonstrate complete facility with the English language, and therefore could not be a candidate for determining the presence of higher consciousness. This apparent lack of linguistic ability could be related to Alex's age when he was purchased; while Congo African greys do not usually begin vocalizing before they are a year old, they learn most of their vocal and social cues well before then (Hallander, 2003), and Alex was 12-13 months old at the time of purchase. It is entirely possible, even probable, that the age of language acquisition in Congo African grey parrots falls far before one year of age. Although without experimentation there is no way to determine exactly what that age might be, subject birds should optimally be as young as is feasibly possible.

African grey parrots seem, then, to be the ideal choice: first, individual birds have demonstrated the capacity for primary consciousness, and second, African greys can report back vocally, in the same medium that humans do. If, given the prerequisite of primary consciousness, language does indeed either encourage or induce neural Darwinism in order to form higher-order consciousness, then there is a possibility that the brain of any

species possessing primary consciousness could re-order itself if it receives the proper stimuli from an early enough age. A new type of experiment is warranted: the proposed experiment will use African grey chicks to search for an answer to the question of nonhuman higher-order consciousness.

African grey chicks require certain types of stimulation at certain ages, much like human infants, but unlike human infants it is uncertain as to exactly when some of these earliest stages take place. It would be easy to misgauge a chick's developmental patterns and miss the critical window of language facilitation. So, under optimal circumstances, researchers would raise two chicks, from the time of their hatching, making every effort to mimic the chick's natural environment, while another two chicks serving as the control group would be raised as one would normally raise them for a pet environment. The control birds would not interact with the researchers until they were weaned, as is normal for chicks intended to become pets. All four birds would be randomly chosen.

However, time, availability of researchers, and monetary constraints render using four birds impractical for my study. For this reason the study will be done with one bird and will use results from laboratory and pet birds as controls. Two researchers will work with the bird from a domestic environment, preferably a house or apartment, and refrain from changing the environment for at least the first eighteen months in order to avoid stress as a confounding variable.

For the first month, the researchers will attempt to mimic parent African greys when caring for the chick, except for replacing parrot vocalizations with human ones similar to those made by a human parent talking to an infant. The chick should be encouraged to vocalize using human phonemes and even simple words, such as names, food, water, and touch, but will most likely remain silent during this time period. Though it is clearly

impossible for humans to brood baby birds as the parents would, at least one researcher should be present at all times, maintaining a low-level stream of dialogue, interspersed with careful handling and feeding of the chick.

From five to seven weeks, the researchers should start transitioning the chick out into the main living area. The researchers should continue speaking to each other and the bird, but add basic language games similar to those played with young human children, such as identifying objects (toys, food) and object attributes (color, shape, size.) The bird should be encouraged to vocalize, but it is more important that the bird demonstrate understanding of whatever language is used by the researchers – being asked to touch a color, for instance, instead of vocally naming the color, or being asked to go to a specific person instead of vocalizing the person's name. This should be presented as an engaging and pleasant game for the bird, not as a frightening or harsh task. If the bird shows any signs of stress, of anxiety, or of disengaging from the activity, the researcher should immediately switch to a preferable activity, based on previous observations of the bird's behavior. Similarly, the researchers should involve the bird in common household activities, from vacuuming to folding laundry to eating dinner; the bird can be taught the names of different objects and activities, as well as performing simple activities such as using its beak and feet to sort silverware or place socks in one pile. At least one researcher should still be present at all times, and the bird should not be confined to a cage.

Once a bird demonstrates comprehension of simple language, or once it is seven to eight weeks old and investigating its environment on its own, the researchers can begin demonstrating the model/rival method, wherein one researcher gives instructions and a second demonstrates correct and incorrect responses. The researchers should involve the

bird in this activity as a game, where the respondent is rewarded for correct answers, such as being given a grape after successfully identifying the object as a grape, as round, or as purple. The bird may vocalize requests for water, food, treats or games; but researchers should offer an alternative, e.g., of touching a symbol or performing a variable action, if the bird does not vocalize – the researchers would need at least five variables and thirty possible combinations to draw from. The variables could include color, shape, size, material, number, or any other category; the bird should learn to distinguish between the variables relatively quickly, at which point the researchers can proceed from using one variable to two, and then three. At this point in time, the bird should also be acclimated to a flight suit or harness so that later in the experiment it can be taken outside safely and without stress.

From about twelve weeks on, researchers should still be present for most of the day and preferably at night, but the bird can be acclimated to short absences. The bird may be taken outside in the car, on walks, to bird-friendly stores, to parks, and to campuses. Researchers should name the things encountered and work to make the activities engaging. If the bird is disinterested or frightened, the researchers should withdraw the bird from the environment and try again later. During this time period the researchers should continue to work with the model-rival method and language games.

The bird should wean between 14-16 weeks. Data can be collated on its apparent understanding of human language at any point after this, regardless of whether or not it is vocalizing. This could be done by selection tests, such as giving multiple criteria for a set of objects, or directed performances in exchange for rewards such as play, food, or attention. As an example, the bird might be asked to find the largest blue square on a tray with twenty objects of different shapes, sizes,

and colors; alternately, the bird might be given a series of commands on which each subsequent command depends on the bird having acted out the prior command. Testing sessions may be run once a week to evaluate progress with these “games”.

Further data on the bird's usage and understanding of language should be collected whenever it begins to vocalize using actual phonemes and/or words. Once the bird has been vocalizing for four months, researchers should run modified IQ tests, such as varying levels of Wechsler Intelligence Scales adjusted for non-human physiology and spatial coordinates, and compare the bird's results to the results of variously aged humans. Additionally, the bird's demonstrated cognitive abilities could be compared with the results from the ALEX project. Other tests could then be added under advice or at the researchers' discretion.

The primary anticipated limitations to the implementation of this experiment are time and people. Due to the time constraints of raising the chick, and the necessary social interaction, a minimum of two people will be necessary. In addition, this project will need to run for an absolute minimum of 18 months, preferably two years, and the researchers in question will need to be familiar with the intricacies of hand-raising African grey parrots. Facilities will probably not constitute a problem, as the goal is for the bird to live in a home environment; otherwise the bird could become neurotic due to lack of social interaction and stimulation, as is typical for this species when kept without adequate companionship.

What should researchers expect to see from this project? It is possible that there will be no dramatically different results from any of Dr. Pepperberg's results working with Alex, Wart, and Griffin. The hypotheses on which the experiment is based may themselves be flawed. However, such a long-term and carefully monitored experiment,

whatever the outcome, would be cause for re-evaluating the theories of higher consciousness and its interlink with language, and might mark off one possible avenue of investigation. In the case of negative results, more studies with other species might be indicated, and under other circumstances, in order to further examine the limits of the hypotheses themselves.

If results demonstrate a higher level of cognition than that achieved in the Alex experiments, but fail to conclusively demonstrate higher consciousness, they would pose an interesting question: could the neural evolution have progressed further under different circumstances, with perhaps a different method and a different subject? Such a result might validate the hypotheses but prove that African greys do not make adequate subjects; further experimentation would, again, be warranted.

There is also the remote potential for results to indicate a higher consciousness which meets every level of tests, housed in an avian brain. If this were to be the result, then firstly it would very strongly confirm the hypotheses of higher consciousness as neural evolution facilitated by language; second, it would give rise to numerous questions for psychologists, linguists, neurologists, ethicists, and cognitive scientists. Exactly which neural capacities are necessary for the neural evolution of higher consciousness? Could other species replicate the results? What would be the implications for human cognition – could this demonstrate a fundamental misconception in the way that we, as a species, view ourselves and our thoughts? Any result, essentially, will be of interest, as it is likely to close down some avenues of exploration and open up others. But certainly one of the latter two results would be the most fascinating of all, with far-ranging implications that cannot be entirely glimpsed by investigators at this point in time.

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Intimations of Sentience
Atop Half Dome – Jim T

Oceans-21 and the Future of Ocean Policy in the United States

Adam Jorge

On November 11, 2010, the Onion News Network published their free parody newspaper with the following headline on the top of the page— “Report: Global Warming Issue From 2 Or 3 Years Ago May Still Be Problem” (Onion 1). The mock report stated:

“Global warming, if you remember correctly, was the single greatest problem of our lifetime back in 2007 and the early part of 2008,” CGD [Center for Global Development] president Nancy Birdsall said. “But then the debates over Social Security reform and the World Trade Center mosque came up, and the government had to shift its focus away from the dramatic rise in sea levels, the rapid spread of deadly diseases, and the imminent destruction of our entire planet.” (Onion 1)

Of course this is a fictional report... partly. The satire employed in this article uses entirely fictional accounts, but one can't help but realize the truth behind everything said. Seemingly frivolous matters like the location of the Ground Zero mosque take precedence over the greatest challenges this world is facing.

Discussion of climate change blazed through public attention and changed the social and political landscape; but as the heated debate around Al Gore's *An Inconvenient Truth* has cooled, attention to the dynamic nature of our planet has declined, leaving our environment and natural resources at increased risk for destruction and depletion. In this paper, I intend to discuss Congressman Sam Farr's bill, H.R. 21, and its role in protecting our environment and natural resources through ocean conservation. Our federal government must implement functional, cohesive, and enforceable comprehensive ocean policy to address ocean-related issues ranging from landscape

aesthetics to fishing practices. I believe that H.R. 21, the Oceans, Conservation, Education, and National Strategy for the 21st Century Act (OCEANS-21), would have provided a framework for establishing a national ocean strategy and would have taken a necessary step to implement progressive ocean policy. However, because of the partisan nature of the current Congress and the demand for funding, OCEANS-21 was partially absorbed into the Consolidated Land, Energy and Aquatic Resources Act (CLEAR). The CLEAR Act serves to press a comprehensive energy agenda and address the Deepwater Horizon oil spill in the Gulf of Mexico, but is largely ineffective in tackling our oceans' most concerning issues.

In this study I will provide a brief background on major events and motivations for changes to United States ocean policy, briefly summarize and explain the importance of provisions within OCEANS-21, address the prudence of the bill in the current political and world environment, and finally provide an analysis and discussion of problems with its partial incorporation into the CLEAR Act.

Background

The natural placement of the United States of America between the Pacific and Atlantic Oceans grants it several unique advantages: first, the U.S. is naturally protected from attacks and invasions by the benefit of geography; secondly, regions with a coastline are almost always blessed with an abundance of fish, aquaculture and tourist-drawing climates; and third, oil concentrates its massive quantity offshore, deep beneath the surfaces of the Pacific and Atlantic oceans, yielding enormous potential for extraction and economic wealth. However,

America has relatively few enforceable protections for our invaluable ocean territories, and as commissions, conservancies and government agencies explore impacts on ocean regions, human impact on the environment becomes increasingly apparent and frightening in its implications.

Eugene H. Buck and Harold F. Upton, authors of the Congressional Research Service's report, "Ocean Commissions: Ocean Policy Review and Outlook", state that the need for a national comprehensive ocean policy directive was recognized as early as 1966, when a presidential Commission on Marine Science, Engineering, and Resources was formed to evaluate the role of the United States government regarding our oceans (Buck i). The Commission recommended that the federal government reorganize and restructure itself to allow for more effective ocean management. Out of this discussion, the National Oceanic and Atmospheric Administration (NOAA) took shape and began to provide an agency arm to help administer regulations and enforcement. This effort proved to be timely, as shortly after NOAA's formation, Santa Barbara faced a devastating oil spill.

The 1969 oil spill in Santa Barbara, California left 200,000 gallons of oil contaminating beaches, waters and coastline and decimating native bird, porpoise and other sea life populations (sbwcn.org). This spill fell under the jurisdiction of the State of California, having occurred in state waters, but the need for effective disaster relief measure became apparent. The well took eleven and a half days to cap; but it took years for the ecosystem to fully recover. The disaster drew national attention to the spill, prompting Richard Nixon to state:

It is sad that it was necessary that Santa Barbara should be the example that had to bring it to the attention of the American people. What is involved is the use of our resources of the sea and of the land in a

more effective way and with more concern for preserving the beauty and the natural resources that are so important to any kind of society that we want for the future. The Santa Barbara incident has frankly touched the conscience of the American people. (sbwcn.org)

The Santa Barbara spill proved to be the first massive ocean disaster motivating a national response. This event led California to develop strong resistance to offshore oil drilling as a method to control these disasters. However the need for federal policy was seen in cleanup efforts, which were performed by civilians, state workers, and Union Co. employees (sbwcn.org). As the next decade passed, more discoveries were made about fish populations and the need for fishing regulations, as well as water pollution levels and oceanic biodiversity, prompting the need for more thorough evaluation and more comprehensive public policy. Buck and Upton state, "By the late 1980s, a number of influential voices had concluded that U.S. ocean management remained fragmented and was characterized by a confusing array of laws, regulations, and practices" (Buck i).

This conclusion proved to be true, as the United States soon witnessed another tragic oil spill and was still without a responsive policy. The 1989 Exxon Valdez oil spill released approximately 250,000 barrels of oil into the water, leaving Prince William Sound toxic to every living and inanimate thing in the area. Everyone from Alaskans to oil executives doubted that any entity was capable of handling a spill of the magnitude of the Exxon Valdez disaster (Davidson 79). The truth about this spill resounds throughout oil spill history: the contingency plans of carriers and oil companies are flawed, baseless and ineffective. Alyeska, the company behind the spill, boasted a disaster management plan that could theoretically recover at least 100,000 barrels of oil within 72 hours; however, at the end of three days

the company was barely able to recover 3,000, prompting Alaska's Department of Environmental Conservation commissioner, Dennis Kelso, to say that "Alyeska's contingency plan is the greatest work of maritime fiction since Moby Dick" (Davidson 79-80). Neither the state government nor the oil industry was able to appropriately manage the disaster. Briefly put, the Exxon Valdez spill made evident the neglect of natural resources by U.S. national government; and demonstrated clearly that the future of the United States's oceans resources should not be left in the hands of inadequate managers.

As even more time passed, government and interested voices continued to recognize the increasing need for an adaptive national ocean strategy. In 2000, Pew Charitable Trusts formed and funded the Pew Oceans Commission to investigate the status of our oceans and to develop a set of political management guidelines with environmental focus. After multiple trial-and-error attempts, the 106th Congress created the United States Commission on Ocean Policy through enactment of Public Law 106-256. The Pew Oceans Commission completed and released its final report, *America's Living Oceans: Charting a Course for Sea Change*, and in September of 2004, the U.S. Commission on Ocean Policy released *An Ocean Blueprint for the 21st Century*, delivering 212 suggestions to help develop appropriate ocean policy (i). These two documents have become today's canon for comprehensive ocean policy as well as creating the framework for OCEANS-21.

With the release of the Pew and U.S. Commission recommendations the United States was handed hundreds of methods for reform; yet there has still been seemingly little attempt to consolidate fragmented ocean policy into an expansive framework. Why is this? Until recently, there has been no political motivation to develop such costly and expansive law. But with the Deepwater Horizon spill in the Gulf of Mexico this past

year, Congress is finally beginning to see the value of renewed investments in both ocean and clean energy policy.

On April 20, 2010 the Deepwater Horizon semi-submersible drilling rig exploded, leaving 11 of the rig's 126 crew members lost and opening the Gulf to a never-before-seen oil leak (bp.com). As of November 28, 2010, the estimated amount of oil leaked into the Gulf stood at over 190 million gallons (google.com/crisisresponse). The magnitude of this disaster caught the attention of the United States public, Congress, the White House, and people all over the world. BP's response to the spill seemed fragmented and unsatisfactory, and the well was not capped until August 5th of this past year.

With the world watching, Congress and the White House kicked into gear. The Administration began a strong involvement in Gulf management, touring throughout coastal states and promoting action. President Obama assumed responsibility for the disaster, saying that this is now the time to promote a comprehensive clean energy policy. Secretary of State Hillary Clinton also restated Administrative support for U.S. accession into the United Nations Convention on the Law of the Sea (Buck 12). Much time and energy was spent critiquing BP's response. A London newspaper, *The Telegraph*, offered up the following opinion:

Making six conclusions about what the oil industry should learn, the [Oil Spill] commission found that neither BP nor the US government were prepared for the disaster. The committee also noted that too much time had to be spent collecting new data on what was going on beneath the surface of the water. It recommended that in future, safety devices such as blow-out preventers are equipped with information-gathering devices – like the black boxes on aircraft. As well as looking at the post-explosion response, the report criticized the lack of forethought about a potential accident when a well is designed. The

findings are just one of many interim reports issued by the Oil Spill Commission, which last month released documents casting doubt on the cement used to seal the well. There are also numerous other bodies investigating the accident, which killed 11 men and caused the worst ever offshore oil spill on April 20... (telegraph.co.uk).

This candid take on the spill response is jarring; internationally, the United States' response can be seen as unprepared and non-cohesive. BP's slow-acting and ineffective response, however, seems to be usual and expectable, especially when compared to Alyeska's response during the Exxon Valdez crisis. After decades of oil spills and responses, progress has been non-existent, and as the spills increase in magnitude we need larger, more appropriate solutions. BP failed, as did the U.S. government at the federal level. With this background fueling current debates regarding our oceans and the demand for energy, it is possible to track and understand better why we need OCEANS-21.

OCEANS-21: Provisions and Analysis

H.R. 21 was introduced 6 January 2009 by Representative Sam Farr. At the time, the bill had accumulated 71 co-sponsors and was largely based upon the recommendations from the Pew Oceans Commission and the U.S. Commission on Ocean Policy. H.R. 21 initially incorporated the following provisions:

- * Declares that the purpose behind the bill was to secure for all coming generations healthy marine ecosystems.

- * Declares and specifies a national ocean policy and requires federal agencies to act within the regulations of the policy.

- * Reestablishes NOAA and consolidates the powers of the National Weather Service and the Science Advisory Board under NOAA.

- * Establishes a National Ocean Advisor in the Executive Office of the President.

- * Reestablishes the Committee on Ocean Policy, originally established by executive order.

- * Establishes a Council of Advisors on Ocean Policy within the Presidential Cabinet.

- * Designates nine regions in which coordinated regional efforts are to be taken to implement a U.S. national ocean policy.

- * Requires the NOAA Administrator to establish a Regional Ocean Partnership within each of the 9 regions and prepare a Regional Ocean Strategic Plan for the each specific area.

- * Establishes the Ocean and Great Lakes Conservation Trust Fund to accumulate and manage monies in the event of a natural disaster or the necessity of restoration efforts.

- * Mandates payments to coastal states to assist in the development and upkeep of Regional Ocean Strategic Plans.

- * Requires the Postal Service to print a stamp that would allow the public to voluntarily opt-in to purchasing a special stamp that would allocate revenues to marine conservation and restoration efforts.

These provisions are a good start, but do they go far enough? Prior to its assimilation into the CLEAR Act, OCEANS-21 directed legislative attention to the oceans themselves. Implementing the bill would have meant lawmakers and enforcers would be pursuing long-term goals, and policy would no longer be piecemeal attempts at resolving singular problems. But are the above measures enough to adequately address changing ocean environments?

Domestically, there are more improvements that can be made to the prescribed ocean policy within H.R. 21. Upton and Buck state in their CRS report that after more than half a decade since the Pew and U.S. Commissions' published their

recommendations, some progress has been made; however, hundreds of the Commission's concerns have never been addressed (Buck 13). Biliانا Cicin-Sain and Robert W. Knecht discuss the necessary steps to shaping the future of a national ocean policy in their book "The Future of U.S. Ocean Policy: Choices for the New Century". Cicin-Sain and Knecht list the seven necessary areas of improvement: 1. Create area-based approach methods as a structural basis for U.S. policy; 2. Develop a national policy of goals and principles for sustainable fishing and resource management practices; 3. Implement an ethical system to structure codes of stewardship; 4. Implement conflict resolution and decision-making devices for international ocean policy; 5. Create a proactive, anticipatory response system to address potential crises and conflicts; 6. Achieve a level of "horizontal integration" by establishing agencies, committees, and interagency coordination efforts; 7. Achieve a level of "vertical integration" by creating a system of joint state-federal management and revenue sharing (Knecht 286). OCEANS-21 provides provisions for 1, 2, 4, 6 and partially 7. The bill would have provided launched a well-balanced and strong infrastructure for a National Ocean Policy. However, establishing a domestic policy would only partially address oceanic needs.

In his article "Abandoned Seas: Reversing the Decline of the Oceans," Peter Weber discusses the need for international ocean policy:

In addressing high-profile environmental issues, oceans law has advanced steadily in recent decades. International negotiators have worked out agreements on oil spills, ocean dumping, whaling and sealing. Some types of marine pollution have abated, as has the exploitation of some marine mammals. But the major treaties have largely overlooked the less charismatic but more pervasive issues of land-based sources of pollution, habitat destruction, and

overfishing, even in terms of setting standards. Without global agreements to address these critical issues, the broader goal of protecting Earth's greatest commons will be difficult, if not impossible, to achieve. International law will not guarantee protection, but it will provide a basis for responsible and effective management by individual nations. (Weber 39-40)

Weber is correct. The United States may be able to control its own impact upon its own ocean territories if a bill like OCEANS-21 were ever signed into law, but steps must be taken on a world scale to address the greater problems of overarching world-health. However, introducing and implementing a National Ocean Policy provided in legislation like H.R. 21 would provide the backdrop for U.S. involvement in international ocean policy.

Edward Wenk, Jr. echoes Weber's sentiments, saying, "We must consider another set of players in this game—the 111 other nations who front on the sea... it is now a matter of deliberate United States policy to do everything possible to make exploration of the oceans a global, multinational affair, and this necessarily brings in a number of countries" (English 170). The truth of the matter seems to be that introducing domestic ocean policy is only the first step to solving the global ocean problem. Entering into an international agreement would allow the U.S. to prioritize ocean issues on its own agenda and begin work on pressing ocean issues.

Discussion: The Urgent Need for Change

Modern problems with ocean management come from a variety of sources: because of vague rules and divided authority, enforcement is deflated; fishing practices are often unregulated, and there is an abundance of illegal fishing occurring outside government view; and marine pollution both on and off-site threatens the very ecosystem.

Other major management tools have not been significantly updated for decades. All of these matters should be of primary importance to the federal government, yet no major change is in sight. The world is changing and with the changes the demand for marine resources is skyrocketing. Population increase, trade and the globalization of the world economy have placed enormous stress on our oceans. Mário Soares, in his 1998 book "The Ocean Our Future", describes some of the various pressures the modern world has placed on the seas:

Such costs [of resource exploitation] may be localized and the effects of relatively short duration, as is the case with some oil spills... But they may also be widespread, highly uncertain, and have long-lasting or irreversible effects, such as the fundamental change that has taken place in the ecology of semi-enclosed seas as a result of land based pollution... An estimated 70% of the world's fish stocks are already being exploited at or beyond sustainable limits, but fishing generally continues unabated despite extensive regulatory arrangements. The pressure on the oceans is not only due to over-harvesting but also to the cumulative impact of land-based activities. This includes many of the effects of coastal development, especially the destruction of wetlands, mangroves and coral reefs, sedimentation and the dredging of sediments, damage to watersheds and the impounding of water supplies to support urban development in coastal areas. (Soares 97-8)

Without doubt these problems illustrate the need for change. The increasing acidification of the ocean is warping the development and life-cycle patterns of species, and the cause is oceanic absorption of carbon. One report published by NOAA states that oceans have absorbed about 50% of carbon pollution from the burning of fossil fuels, and this creates a chemical reaction ultimately resulting in higher concentrations of hydrogen ions in ocean environments

(pmel.noaa.gov). Effects of acidification include softening of shells in creatures like lobsters, crabs and urchins as well as decreased survival rates amongst these species, and replacement and growth of skeletons in reef-building corals. Larval marine species, algae and plankton, and other species suffer from life-cycle decreases. Although current science is too uncertain to allow for quantitative analysis, the damage from this problem alone could greatly affect the U.S. seafood economy, which is currently the third largest in the world yielding approximately \$60 billion annually (pmel.noaa.gov). According to NOAA's "State of the Science Fact Sheet," nearly 50% of federally managed fisheries utilize coral reefs and related habitats to support their fisheries and aquaculture, and damage to the phytoplankton and algae can potentially reduce food supplies for species within the food web, leaving the ocean to be a wasteland of bacteria and microscopic organisms (pmel.noaa.gov). This sort of environmental change is real, problematic and potentially devastating to U.S. environment and industry.

Fishing practices are another area of concern, as the abuse of aquatic resources generates problems, not just for the U.S., but also for world markets. Soares says, "World-wide, the value of ocean resources ignored in market transactions is very high, and the potential cost to humanity when markets for coastal and marine resources fail is significant enough to warrant serious international concern" (Soares 104). Adjusting the presence and diversity of species jeopardizes the state of ocean ecosystems, and by extension, oceanic markets:

More generally, a change in the composition of species will simultaneously change both the ecology and economics of the system. The most sensitive components of food webs, energy flows and biogeochemical cycles are those where the number of species carrying out key functions is very small. There are limits to

the depletion of species or pollution of such systems beyond which they lose resilience and are unable to deliver ecologically or economically valuable goods and services... The management problem is how to ensure that the institutions governing the allocation of coastal and marine resources... protect the resilience of coastal and marine ecosystems (104).

The above passage perfectly summarizes the role of ocean governance: to protect the ability of ocean resources and environment to regenerate—to heal itself and continue supporting the diversity of life it does, human beings included. Mankind is just as tied to the ocean as the fish harvested for consumption. If practices cannot be regulated and made sustainable, then neither can humans depend upon these resources. Sustainability is equivalent to ensuring the presence of this industry for succeeding generations; in one sense the need for sustainability is a need to establish a legacy, and without it the composition and culture of the world may be permanently damaged.

Conclusion

I believe the motivation and strength behind OCEANS-21 to be admirable and powerful. Introducing a National Ocean Policy like that in H.R. 21 would be hugely beneficial to the United States on multiple levels. Not only does an intensified regulatory process allow for environmental recovery, it also provides a structure for government to actively govern on an important issue. It is good policy, but the necessary steps to orchestrate the proposed National Ocean Policy proved too extensive and costly for the current political environment.

The needs described in the previous section should be motivating Congress to take appropriate action. But the legislative process is not friendly to legislation like H.R. 21 outside of times of great prosperity. H.R. 21 introduced too much potential for high-cost without the promise of a revenue return. This

high-investment, no fiscal benefit approach led the bill to be diluted and placed on the back burner. The importance of this bill, however, is especially relevant in the 111th Congress, which was forced to approach the BP oil spill from an innovative angle. Preventative and anticipatory disaster relief planning could have greatly assisted the communities, industries and environments affected by the largest oil spill to date; and it comes as no surprise that in the absence of any plan all the public saw was private industry and government entering into another responsibility dispute.

The inability of our government to deal with an issue like Deepwater Horizon demonstrates an inept policy-making core. I believe that we are fast approaching a time when it will be too late to make the fixes necessary to repair environmental damage to sustainability. Our process, designed for long-term stability over reactive, responsive approaches, does not allow us opportunities for enough action within a short period. The demand for funding immediately removes support for a measure, even if it is good policy, thereby ending the potential for truly world-altering legislation. Additionally, introducing expansions to government (i.e. National Ocean Advisor, U.S. Committee on Oceans, consolidation of powers to NOAA, etc) is unwelcome, especially in the current environment of conservative tea-party sentiment.

As I progressed through an internship in which I witnessed the failure of the few big bills that were discussed, like the Defense Appropriations Act, I began to feel that our government is no longer friendly to progress; it seems that good policy is ignored so that the politics of the day are allowed to thrive. I believe the Onion article referenced earlier addresses just this point. My belief has always been that the role of government is to lead the world to health and wellbeing, and that this has not been accomplished in recent years.

Instead, leaders are frightened of election losses and are therefore at the mercy of the public and their parties; the time period of each Congress is too short, and each one adjourns long before differences can be resolved. There need to be systemic changes that lead to compromise and facilitate a reevaluation of legislative ethics. Currently, it seems more important to not-vote on a bill and allow it to expire until the next Congress can attempt it once again.

If the public is to be served, and the important aspects of our nation truly sustained for celebration now and in the future, then the United States must prove that its system allows for forward-moving action. When OCEANS-21 was absorbed into the CLEAR Act, most of its substance was lost. Suddenly, the necessity of comprehensive ocean policy evaporated, and the motivation behind ocean policy reform stood to address the BP spill. The only true evidence of OCEANS-21 in CLEAR falls to Title V, which creates a specific Gulf Coast Restoration Fund to help fund the marine disaster in the Gulf (H.R. 3534 Title V). CLEAR, however, represents a solid comprehensive clean-energy policy with great potential for public benefit; it passed the House of Representatives on July 30, 2010 with a vote of 209-193 and has since been placed on the Senate calendar, where it will remain, inactive, and most likely die, unless a sweeping progressive wind carries it through during the remainder of this lame-duck session. In one fell swoop, our process has left two solid and necessary pieces of legislation wounded and dying on the Capitol steps.

There is much that needs to be done if the United States is going to take steps to ensure the continuing wellbeing of the geography, biology and industry that make it a world power. Currently, we are losing sight of national and international needs and our perspective is shrinking down to a tunnel vision narrowly focused on political sound

bites and a handful of hot topics. Progress can only come from process, and right now, our government is providing neither.

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Translucent Balance
Monterey Bay Aquarium — Jim T

Knights in Shining Armor? The Portrayal of Arms and Armor in Medieval Literature

Marina Long

Those who have read *Beowulf* know that it can sometimes be a hard text to understand. This can be especially apparent to a student who knows next to nothing about the time period in which the story was written. Many medieval works, in fact, pose a particular problem for modern students due to the general lack of knowledge about the medieval period and its history, politics, social structure, culture, arts, and craftsmanship. One especially fascinating yet poorly understood area is medieval arms and armor. Most people today, when they think of a medieval knight, picture a “knight in shining armor,” clad from head to toe in plates of steel. In fact, this picture was true for only a very short period of time at the end of the Middle Ages.

During most of the Middle Ages, knights and other elite warriors primarily wore shirts of maille (taken from French, and pronounced in English like “mail”), a fabric woven of tens of thousands of small rings of steel wire. They might also wear leggings, known as chausses (also French, pronounced in English as “chah-ses”), of maille as well. The only piece of armor that consistently had plates of metal throughout the middle ages was the helm, which protected the head. Later, once armoring technology improved, knights began to wear small metal plates or plates made of hardened leather in addition to maille. Periods in which these types of armor -- maille, leather, and smaller plates of steel -- were worn are also the period that produced many great works of medieval literature. *Beowulf* is from the time of maille shirts, while “The Song of Roland”, another long poem, written in French in the twelfth century, is from a period in which warriors wore longer maille shirts, rode horses, and

more often had maille chausses as well. *Sir Gawain and the Green Knight*, a long poem about a knight who was a member of King Arthur’s Round Table written in Middle English in the fourteenth century, is from the period in which knights began to wear leather and some plate armor.

To a student who knows nothing about the armor in the time period in which these works were written, the battle scenes contained within them, often with many references to arms and armor, are likely to be confusing. Such confusion may alienate the reader from medieval literature in general. I hope that through the information I present in my study, the benefits of teaching about medieval arms and armor in preparation for reading medieval literature will be apparent and that the connection between historical study and literary study will also become clear.

So: how does familiarity with armor and weapons from the medieval period affect our reading of battle scenes in medieval literature (and therefore, our reading of the literature in general)? I contend that such knowledge will enhance our reading by allowing us to recognize differences between realistic and fantastic portrayals of a battle. Our knowledge of the realism or fantasy of a particular scene can help us discern what the author intended to do with the scene and the effects it would have created in a medieval reader or listener. This, in turn, will influence how it affects modern readers, since we often take our current knowledge and apply it to the text we are reading to come up with our own interpretation of the work.

Although answering this question will be most beneficial for students of medieval literature, it will also be helpful for the casual

reader of medieval literature, though they are likely to benefit less from it than will a person who is deliberately trying to extract meaning from the text rather than simply enjoying it. Additionally, students of medieval arms and armor may find this interesting as a new way to look at this subject--through the eyes of the poets who lived at the time this armor was made and used. More broadly, anyone who has studied one or more of these works and has been confused or frustrated by their lack of knowledge about or understanding of the accoutrements referenced in one or more of these works may find this study helpful.

Theoretical Background

There has been surprisingly little research conducted on the use of armor and weapons in medieval literature, except for the purely symbolic meaning of the weapons and armor presented in the story. For instance, there are articles on the axe the Green Knight carries in "Sir Gawain and the Green Knight", but they deal with the symbolism of axes in general and not with a comparison of the specific axe used to real axes that were used at the time (Walls 13-18). The type of inquiry that discusses the symbolism of a weapon will tell a reader the meaning (to use the example above) of the inclusion of an axe in the story, while a comparison with real objects of the period will help us discover why specifically that type of axe was used, and what this choice would mean to the intended audience.

The works that I will be drawing from most heavily will be works about historical, and particularly, extant (meaning that there exist physical examples) medieval armor and weaponry. For instance, I am drawing on R. Chartrand's *The Vikings*, which contains a great deal of detailed information about the arms and armor of the people, period, and place about which "Beowulf" was written. This book is a compilation of previously published journal articles, and is therefore very authoritative and accurate. The book also provides photographs of the extant arms and

armor from the time, from which my final study will benefit.

Another text helpful to my study is *Arms and Armour of the Medieval Knight*, by David Edge and John Miles Paddock. Edge and Paddock are highly respected and frequently cited authorities in the field of medieval arms and armor. Their study provides considerable information about armor and weaponry of the twelfth and fourteenth centuries. It gives a period-by-period account of the weapons and armor of the knightly era. Because of the organization and depth of information, this is the book that I would recommend to those who are interested in finding out more about any particular century in armor history.

I also referenced studies by Ewart Oakeshott, one of the more famous and respected authorities in this field. He is most noted for his system of classifying swords, which is used throughout the community of those interested in medieval weapons, from researchers to re-enactors of medieval battles and martial arts. The books I am using are part of a five-book series he wrote about the medieval knight and various aspects of his equipment and training. Specifically, I have consulted the books *A Knight and His Armor* and *A Knight and His Weapons*. These books are most relevant to the topic of my study, and are written in easy-to-understand language that, while being accessible to an everyday reader, also provides a large amount of information. This is a source I would recommend to those wishing to learn more about medieval armor and weaponry in general, because it gives a good overview of the subject.

I am approaching the literature from a "New Historicist" perspective in this study. The New Historicist perspective is a literary theory that argues that the historical background of a work is helpful and even essential to understanding the work itself. New Historicism looks at the culture surrounding the work at the time when it was

written to see what it might have originally meant to the intended audience. This theory stresses the intentions of the author over the ideas the reader brings to the work (Klages 123-125). I value both, but I am using this perspective to look at these works because of the importance of understanding the historical and cultural context surrounding a work. This understanding will in turn influence the ideas of the reader, changing how the reader looks at the work and, quite possibly, more closely aligning the reader's own ideas with the original intentions of the author.

I will define other terms as they occur in the descriptions of the armor and weapons of the warriors in each of the periods I am studying.

Methods

I am designing this study as a comparison of the weapons actually used in the time period of the work of literature against what is actually depicted in the work. I am using well-known and often-used works such as "Beowulf" and "Sir Gawain and the Green Knight" as my primary literary sources, while my sources for the armor and weapons used are reputable books on the subject from such experts in the field as Ewart Oakeshott. I look at three major time periods of medieval history as far as armoring technology goes: the Dark Ages (specifically, around 700 A.D. to around 1000 A.D.--the time of the Vikings), the twelfth century (the time of the crusades) and the fourteenth century (when leather and plate armor began to be used). I begin by describing the armor of each period, then I pull passages from the work or works I have selected for that time period. I show the similarities and differences between the historical record of the arms and armor and how the armor is presented in the literature. Finally, I discuss why the author might have chosen to make their battle scenes accurate or inaccurate, and what conclusions we might draw from that choice.

Findings and Discussion

One example of the findings in my final study is the various references to swords in "Beowulf" and how they relate to real swords of the time. The following description of a typical sword of the Dark Ages, when "Beowulf" was written, is followed by a discussion of the ways in which the swords described in "Beowulf" are similar or different to those in reality, and what added meaning this reveals. Swords in the Dark Ages were generally twenty-four to thirty inches long, had broad blades that stayed wide through most of the length before coming to a point in the last few inches.

Swords were used for cutting more than for thrusting, as the point was too blunt to do much damage. Whether this was because the fighting techniques of the time de-emphasized thrusting or because the technology to make swords could not produce a more acute point is up to debate. Dark Age swords tended to have short, thick, stubby crosses (the part of the sword that protects the hand, between the blade and the handle) that were straight on Anglo-Saxon swords and curved toward the blade on Danish swords. "Beowulf" was a story about Danes written by Anglo-Saxons, so the shape of the cross would be historical either way. The pommels of all swords of this period, knobs on the end of the handle of the sword to balance it and keep it from slipping out of one's hand, were oblong and "lobed" rather than round; there were usually either three or five decorative lobes, or small bumps, on the pommel. (Edge 27)

The best Dark Age swords were made of pattern-welded steel, constructed in a very complex and time-consuming process that involved twisting rods of steel with differing carbon content together and forging them into a single rod, from which a sword was then made (Chartrand 136-137). This produced a wave pattern, resembling marbled frosting on a cake, on the sword. Having seen this pattern myself in replica swords, I can say

that not only does it give the blade strength, but also lends it a surprising beauty.

The pattern is noted in the literature of the time as well. In *Beowulf*, when Beowulf is preparing to fight Grendel's mother, he says, "And let Unferth have that ancient heirloom, that well-known man have my wave-patterned sword, hard-edged, splendid." (*Beowulf* 1488-1490). Beowulf's sword was well-made, the best type of sword one could have in that time. That he would leave it to Unferth if he were to die facing Grendel's mother shows that he must have been quite confident that he would survive and return. In contrast, Unferth's sword Hrunting, which he gives to Beowulf to be used in Beowulf's fight against Grendel's mother, is never described as patterned. It is only etched with poison, which although a benefit, does not compare with the strength lent to a blade by making it with patterned steel. Surely, if Hrunting were a sword of patterned steel, that would have been mentioned along with the poisoned edges. Therefore, one can assume Beowulf's sword was of considerably better quality than Hrunting.

The poisoned blades of Unferth's sword are also interesting to consider--they may serve as a way to characterize this somewhat morally ambiguous character. Unferth first scorns Beowulf, engaging him in a battle of insults (commonly known as 'flyting'), then lends him his family's heirloom sword, which would have been incredibly valuable to him. This makes the reader wonder what type of man he really is. Perhaps the poisoned blades are supposed to indicate his real nature to us as readers. Also, during the fight against Grendel's mother, Hrunting fails Beowulf by breaking (again demonstrating its inferiority to Beowulf's sword). Again, is the author of "Beowulf" intending this to be a slight on Unferth? There is no definitive answer, but nonetheless it is an interesting speculation to consider.

Swords were heirlooms, as described in the passage from *Beowulf*, passed down from one generation to the next, father to son. The value of a sword increased as it got older, as was the case with other parts of a warrior's equipment--for example, Beowulf's byrnie, or hip-length maille shirt, which he inherited from his grandfather Hrethel. (*Beowulf* 454) This may have been because they were tested and found to be strong; it may also be because of the sentimental value such items would have acquired over the years. Either way, Beowulf is garbed in expensive, valuable, well-crafted armor and weapons, as a great hero should be. To the audience of the time, it would have been readily apparent just from his armor and weaponry that Beowulf was a powerful hero, wealthy and of noble birth. Modern readers may not be able to fully appreciate these items as status symbols, but through further research and study, we can certainly understand that they signal Beowulf's might and heroic nature.

Conclusion

My provisional conclusions are that through discussions such as the preceding one about the swords in *Beowulf*, one can see that knowledge about the weapons and armor of a time period can be helpful in gleaning more meaning from medieval text. Also, knowing what the objects looked like can help aid the reader to picture the events of the story in his or her mind. This, in turn, creates a more enjoyable reading experience. When readers enjoy the text, they are more likely to approach these and other works of medieval literature with an open mind and a willingness to read them that most readers, unless they are medieval enthusiasts, do not possess. Therefore, I conclude, at this point in my study, that knowledge about the arms and armor of the medieval period helps to make one a better, more informed reader of medieval texts.

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A Knight and His Armor
Orazio Mural (Darmouth College) – Jim T

Artist and Spectre: Divine Vision in the Earthly Work of William Blake

Robert Searway



My first encounter with William Blake, though perhaps not as magnificent as a fiery star descending to my foot (as Blake depicted both his brother Robert's and his own encounter with the poet Milton above), came during my freshman year in college when my professor admitted he had not studied Blake extensively and did not fully understand him. From that moment I was intrigued, and have come to find that not understanding Blake has been and remains a common theme even among English literature studies. Though he was considered mad and neglected artistically for much of his life, modern scholars have begun to change his fortunes. Blake still has something, even if only a fleeting confusing vision, to offer in his art and idea of art. Northrop Frye, one of the most influential scholars in Blake's modern resurgence, writes in his preface to the Italian translation of *Fearful Symmetry* of Blake's impact on his own critical work, of "the expanded view of literature which Blake imparted to me [Frye]" (422). In the Introduction to *The Cambridge Companion to William Blake*, Morris Eaves writes, "Blake is an education—one of the

best reading teachers available, a radical challenge to the reasoning mind, a training ground for knowledge in as many areas as you are willing to open for yourself" (14). Blake did, however, hope for understanding within his own lifetime. In an advertisement for his last artistic exhibition, Blake implores the public: "those who have been told that my Works are but an unscientific and irregular Eccentricity, a Madman's Scrawls, I demand of them to do me the justice to examine before they decide" (*Complete Poetry* 527-528). Blake hoped to cultivate a new understanding of the human potential in Imagination. He hoped to change perceptions of reality, and believed in the power of art to cultivate the minds of his audience. In Blake's work, the artist possesses visionary power through Divine Imagination. Blake sought to fulfill this role of the artist with his own work and influence. Blake depicts the artist as possessing unified divine vision, and his own production of art, the manifestation of vision within the physical world, illustrates his belief in this visionary unity.

In his general mythology, Blake refers to the natural world of limited senses, the perceived reality of humanity, as the fallen generative world. This physical world splits, or generates, out of the original unity of existence, which Blake terms Eden, and continues to further generate into greater and greater physical existence, which makes it further fallen. Northrop Frye describes this development of Blake's thought simply, as "the conclusion for Blake, and the key to much of his symbolism, is that the fall of man and the creation of the physical world were the same event" (47). All existence once possessed unity: a scientific understanding might view such an idea of unity as the moment before the big bang, though Blake would not use scientific time scales or theories. The fall of man into separation comes from a perceived reality of separate existence, from viewing distinct selves and bodies in the physical world as ultimate existence. Eternal unified existence from which mankind fell, and from which the world generated, originally remained whole in Blake's form, or image, of Albion, the sleeping giant. The opening of Blake's *The Four Zoas* sees four aspects of man in unity, in "The Universal Brotherhood of Eden/The Universal Man" (3:5-6). The nature of Mankind remains unified, but has separated existence in the fallen world. People suffer because they perceive the physical world as truth.

Blake often uses Biblical imagery while deviating greatly from orthodox interpretation, so that he uses poetic images like Eden in his work although it no longer means the biblical garden. Comparing Genesis to Blake's myth, the very first verse already marks the fall. "In the beginning God created the heavens and the earth", which already establishes a generative world split and opposed from heavenly existence (Genesis 1.1.1). Applying Blake's myth further, the split of unity would come from

the sleeping giant, the biblical creator God. Separated humanity naturally comes from the process of creation and marks the actual fall of mankind into generative existence, which continues to generate and split further. Of the split and fall from the original giant, Frye writes, "The Particular 'Giant form' or 'Eternal' to which we belong has fallen, the aggregate of spirits we call mankind or humanity and Blake calls Albion...When Albion or mankind fell, the unity of man fell too...we are locked up in separated opaque scattered bodies" (50). The disruption of human unity into the generated world develops into separation, separate bodies and selves.

Blake then creates and illustrates the idea of the Spectre to mean individual existence in a world of separation and selfhood. The Spectre rationalizes time and physical space as mediating existence, and so comes to reside in and understand the natural world as abstraction and through abstraction. In his use of the term abstraction, Blake is referring to a generalization of existence, but not one based on the true understanding of existence as spiritual unity. The rational senses become a cage to the higher potential of imagination. The Spectre as Selfhood grows concerned with worldly needs, and possesses an insatiable hunger: "In pain the Spectre divided: in pain of hunger and thirst" (*Jerusalem* 6:13). The Spectre suffers constantly from worldly needs that it can never satisfy. Divided humanity in the world remains always concerned with physical needs, with feeding the body and caring for the individualized selfhood. Frye writes of the Selfhood as "an individual ego reflecting on his sensations of an outer space-world while existing in time, [and therefore] the natural man is a dying man" (64). Furthermore, the Spectre representing human Selfhood comes to dwell fully in and define existence by this divided nature. The Spectre exists with the concerns of a physical world,

feels its dying nature, and takes on the concerns of trying to live longer in the physical realm. From this reference point, the Spectre must dwell on its divided nature, scared of death: “And thus the Spectre spoke: Wilt thou still go on to destruction?” (*Jerusalem* 7:9). Humans come to accept their position in the generative world, take it as reality and live with the selfish mindset to take advantage of the perceived short period of life in this reality. The Spectre, human Selfhood, turns away from unified existence, loses the faculty of imagination that can believe instead in unified existence, and fully dwells in what Blake considers the abstract perception of physical spaces.

Blake believes that the artist, in contrast to the Spectre, has the faculty of Divine Imagination, can reconnect with the unity of Edenic existence, and is able to envision the unified Giant of Albion. Whenever Blake writes of art he speaks to the faculty of imagination and Divine Vision. In *Milton* he writes of “the Human Imagination: which is the Divine Vision & Fruition/In which Man liveth eternally” (32: 19-20). Concerned instead with divine nature, the artist does not fall into the same trap of selfish concerns like the Spectre’s selfhood. The true artist can even cast off the idea of the self. In Blake’s vision of Milton, the poet says “I come to Self Annihilation/ Such are the Laws of Eternity that each shall mutually/Annihilate himself for others good” (*Milton* 38:34-36). The artist—Blake considers John Milton an inspired artist—does not fear a death of the self. The Spectre, in contrast from a thoroughly selfish point-of-view, believes that self-annihilation only destroys. The Spectre believes casting off the Self can only become an evil and devastating action, while the artist recognizes the good that comes from casting off the self-centered ego. Divine humanity annihilates the self for the good of others; it does not hide in abstractions of the natural world as an end in itself and therefore

selfishly attempts to live in the physical world as ultimate. Frye describes how “the Selfhood must be annihilated before the true self can appear” (65). Frye understands true self not in the terms of one self in a body in the natural world—that would remain only a Spectre and Selfhood. The true self appears more like an artist with a vision of unity, with the understanding that selfhood in general is existence in abstraction. Frye then describes how “the only possible cure for the original sin of this selfhood of the natural man is vision, the revelation that this world is fallen and therefore not ultimate” (64). The artist looks to unified existence, and *must* look to unified existence. The artist must see the eternity that brings all people back together once the self is eliminated.

Blake truly believes that artists have prophetic power, and that the artist speaks for the divinity of imagination through their work. The artist’s visionary potential becomes prophecy so that the artist in Blake’s work also means “prophet”. Imagination, humanity’s faculty of higher spiritual vision comes directly from divinity. The artist sees and speaks the word of God as a prophet because all true vision comes from Godly nature. Frye describes Blake’s connection between art and prophecy: “the fully imaginative man is therefore a visionary whose imaginative activity is prophecy...It is the superior clarity and accuracy of the prophet’s vision that makes him an artist, and that makes the great artist prophet” (65). Blake himself explicitly called two of his poems prophecies, “American a Prophecy” and “Europe a Prophecy.” In the initial prose section of his Preface to *Milton*, Blake invokes a connection to the divine in his art. In prophetic undertones, he directs the reader toward a re-establishment with the Divine and eternal world: “if we are but just & true to our own Imaginations, those Worlds of Eternity [worlds created by Imagination] in which we shall live for ever; in Jesus our Lord” (1).

Early in and extensively throughout *The Marriage of Heaven and Hell*, Blake constructs the imaginative vision of his own spiritual self as a prophet. In one section, he resides amidst the good company of other biblical prophets: “Isaiah and Ezekiel dined with me, and I asked them how they dared so roundly to assert that God spake to them” (*MHH* 12). The character of Blake here asks where the prophetic message comes from. Isaiah voices the visionary poet Blake’s own answer to the question, “I saw no God, nor heard any, in a finite organical perception; but my senses discover’d the infinite in every thing” (*MHH* 12). In this passage Blake asserts the divinity of imagination and its ability to see beyond physical limitations. Blake terms these physical limitations abstractions, but the true imagination transcends them. God becomes the “Poetic Genius” (*MHH* 12). This association of the Divine with Imagination sets up the idea of the prophetic artist that remains a central vision throughout Blake’s works.

Prophetic vision, the gift of the artist, manifests in the active pursuit of creating art. Blake does not define a medium for art, he considers all forms of visionary expression artistic, but does refer to its final production. Frye writes of this aspect of Blake’s vision of the artist “whose perception produces art. These two are the same thing, perception being an act” (65). Blake stood against a total separation between artistic conception and artistic creation. In addressing a possible split between the two, Morris Eaves writes, “the division of idea from execution and of intent from accomplishment may become one of the signs that our art is as fallen as we are” (162). Though Blake’s idea of artistic creation always begins with vision, he believes that its manifestation should allow transcendence upward in unity. In his *Descriptive Catalogue*, Blake writes, “the distinction that is made in modern times between a Painting and a Drawing proceeds from ignorance of

art. The merit of a Picture is the same as the merit of a Drawing” (*Complete Poetry* 549). Both produce art, and any distinction between mediums Blake attributes to ignorance. Blake further writes “Painting is Drawing on Canvas & Engraving is Drawing on Copper & Nothing Else & he who pretends to be either Painter or Engraver without being a Master of Drawing is an Impostor” (574). Execution of work remains most important, whether onto copper, canvas, or paper. Bindman writes that Blake’s denunciation of Sir Joshua Reynolds, “who had been President of the Royal Academy during the whole of Blake’s early career...was not so much directed at the principles or models he advocated as against his hypocrisy in not putting his ideals into practice” (86). Reynolds painted portraits of wealthy patrons and gained wealth and the respect of those in power, but against what Blake believes is the true nature of the artist—engaging with work of imagination and divine vision (86). While Reynolds painted wealthy patrons, while Blake painted divine visions, such as *Ezekiel’s Wheels*, Blake’s interpretation of the divine vision of the biblical prophet Ezekiel—who lies at the bottom frame of the picture.



Within his central myth, Blake develops the character Los, whom he presents as the worldly manifestation of the true artist. Instead of engaging with a clearly determined

artistic medium, Los works as a blacksmith, so that Blake turns artistic practice into the physical labor that re-produces divine vision. Rather than describing at all times a physical individual in Los, Blake particularizes the creative artist. Los connects to the artistic archetype, thus to past artists like the poet Milton, Blake himself, and even Jesus as unifying visionary of apocalypse. In writing of Blake's mythical characters in *Jerusalem*, Robert Essick discusses their lack of "consistency or self-sameness over time" and the semi-permeable nature of their interconnection (260). Since Los also falls from the unity of primordial man, he becomes at times an individual, but also represents the faculty of creative imagination across mankind. Lack of definitive characterization actually grants Los further power to display the capability of embracing creative divine imagination. As a mythic figure, Los works within the generative world as the ultimate artist and his task is to reclaim unifying vision, and ultimately to bring back the unity of Edenic existence. His vision of a prior unity always manifests in work—his work at the forge as a blacksmith. He builds the great city of art, Golgonooza, a potential spiritual re-imagining of worldly space.

Los functions as one of the main characters of Blake's epic *Jerusalem*. This illuminated epic, Blake's longest work, deals with his central myth, the fall and apocalyptic reunification of the giant man, and casts Los's struggle with his Spectre into this central structure. At the beginning of the poem, Blake gives an opening address and declares the nature of his new epic: "I Again display my Giant forms to the Public...I cannot doubt that this more consolidated & extended Work, will be as kindly received" (3). The opening of the poem addresses Blake's sleeping giant Albion: "Of the Sleep of Ulro! And of the passage through/Eternal Death! And of the awaking to Eternal Life" (4:1-2). Robert Essick writes of *Jerusalem* as "a psychodrama

of being in which the principal forces take the form of prolific fragmentation countered by an anxious desire for everything to come to a grand unity" (257). The faculties of man, represented by various characters as Los represents imagination, divide and fall into passivity and near deathly sleep. Among this fragmentation of the world, Los never loses his artistic strength or his artistic drive to unify. Los in *Jerusalem* takes on Blake's own goals. Los proclaims, what becomes in essence Blake's own proclamation, "I rest not from my great task!/To open the Eternal Worlds, to open the immortal Eyes" (5:17-18). Los, unlike many of the other characters, never suffers long stretches of passivity fatal to the artistic visionary.

In *Jerusalem*, Blake writes of Los's split from his Spectre and need for re-integration to fulfill his creative capabilities. Blake does address the divide of the Spectre from Los, but Los never gives up fighting or gives in to his Spectre's view of the natural world. Blake writes of the divide, "His spectre driv'n by the Starry Wheels of Albion's sons, black and/Opake divided from his back; he labours and he mourns" (6:1-2)! The Spectre takes a position over Los; it tries to lord over him and take control of his perception. "The Spectre stood over Los/Howling in pain: a blackning Shadow blackning dark & opake/Cursing the terrible Los" (6:4-6). The Spectre's concerns are with physical needs, he remains "in pain of hunger and thirst," and tries to convert Los to the natural world, "to devour Los's Human Perfection" (6:13-14). Los, however, fights against this takeover with artistic work: "chaunted his song, labouring with the tongs and hammer" (6:11). The Spectre realizes his failure to control Los: "when he saw that Los/Was living: panting like a frightened wolf, and howling/he stood over the Immortal, in the solitude and darkness" (6:14-7:1-2). In the image accompanying the text, the engraving on plate 6, the Spectre flies over

Los's head, a bat-like shadow, and holds his hands to his head as if shrieking.



Los stares up at him undaunted, still holding his hammer, and the creative fires of the forge swirl around him and the Spectre. Still, both suffer the pains of division, but Los does not give in to passivity. He has a vision of potential unity and tells his Spectre “I know that Albion hath divided me, and that thou O my Spectre,/Has just cause to be irritated: but look stedfastly upon me:/Comfort thyself in my strength the time will arrive/When all Albions injuries shall cease...They have divided themselves by wrath. They must be united by/Pity” (7:52-58). Los never loses sight of potential unity; he never gives up artistic vision.

The internal struggle of the artist with his Spectre becomes the most important development of *Jerusalem*; the Spectre continually attempts to make him doubt and give in to the natural world, but Los instead forces the Spectre to work towards his art. Los tells the Spectre, “thou art my Pride & Self-righteousness: I have found thee out... For I am one of the living: dare not to mock my inspired fury...Take thou this Hammer & in patience heave the thundering Bellows/Take thou these Tongues: strike thou alternate with me: labour obedient” (8:30-40). The Spectre of Urthona, Los's spectre,

becomes a necessary part of creation as the artist's engagement with the natural world. Frye writes, “The Spectre of Urthona, properly controlled, is the obedient demon who brings his master Los the fire and metals and other physical needs of culture, brings the artist his technical skill” (289). In Jerusalem, Los uses the Spectre to work toward his art and vision: “I will compel thee to assist me in my terrible labours. To beat/These hypocritic Selfhoods on the Anvils of bitter Death/I am inspired” (8:15-17). Essick writes of the Spectre as “that portion of each male character necessary to the accomplishment of his task in the material world and yet resisting that goal” (259). Los needs the Spectre, but must turn its physical and limited perception of the world toward a higher vision of art.

Blake's own work represents a view of the artist conquering the Spectre to use it for artistic production. Blake's own creations, his engraved illuminated manuscripts, represent a demanding physical task and labour of passion. Blake's poetry shows the unity of all his artistic abilities, connecting his poetic inclinations with his artistic vision and his work as professional engraver. The image above of Jerusalem shows Blake's illustration of Los's division from his Spectre. The image represents many aspects of Blake's work. The poetry fully integrates with the accompanying image depicting its contents. Los stands at the forge, looking up at his shrieking Spectre, and the flames of creative energy surround the pair. Blake engraved both image and text onto large copper plates, which required a great physical effort. Blake actually used some of the same tools as Los the blacksmith to prepare the copper plates so that even in Blake's own, work creating the art of vision becomes an intensely physical labour.

Blake never achieved his artistic revolution, but his work reveals man who never gave up his own vision even if he gave up his hopes for the public's potential to

change. After his failed 1809 exhibition at the Royal Academy, which he had hoped would show the viability of large-scale public art through a new form of fresco painting, Blake largely withdrew from the public art world. Later in life, as Blake continued to work on his own, he came into contact with a young artist name John Linnell who provided money for Blake and commissioned further production. Linnell admired a series of watercolors depicting the story of Job that Blake had earlier produced for his friend and patron Thomas Butts and had him engrave the entire series (Bindman 105). Bindman notes Blake's "singularly rich interpretation of the biblical story," which shows how Blake never turned from his belief in Divine Imagination and its mythic representation (105).

The plates depict the Orthodox religious God as a false god who does not care for Job or Satan's temptations of him. Job instead finds relief in a vision of Jesus Christ, whom Blake always considered the figure of Divine Imagination manifest in man. The final plate of the series shows Job and his family rejoicing with song and playing musical instruments. Bindman writes how in this ending, "art and prayer thus become one and the same" (105). Blake's belief in art as the

means of reaching true unity and divinity remained with him throughout life.

Blake died poor and obscure in 1827, still believing in his vision of art even if the artistic revolution he promoted failed in his lifetime (Bentley 436). Though his artistic endeavors were deemed a failure during his lifetime, and his dream of turning London into a new artistic Jerusalem never transpired, Blake left behind a vision of artistic unity as opposed to the selfish desires of human Selfhood in his own work that still holds a potent message.

Ignored during his life and for the next century, in part because of his own idiosyncratic and difficult symbolism, Blake's work has gained new readers who have further rejuvenated his vision and led to his literary revival. His view of the incredible power of human imagination can still speak to a modern audience, if the audience feels willing to engage with his difficult work. Art and imagination still have the potential and the power to inspire our highest faculty if we allow them positions in our lives.



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Ceremonial Sacrifice

Orazco Mural (Dartmouth College) – Jim T

Perfecting a Super-recipe: A Study of Pb-doped $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{11-\delta}$ Superconductors

Rodolfo Lopez

Introduction to Superconductivity. When physicist Heike Kamerlingh Onnes, from the Leiden University of Netherlands, first liquefied helium on July 10, 1908, he “opened an entirely new chapter in low-temperature physics” (van Delft and Kes 2010). Upon opening the possibility of obtaining a temperature reading for metals at a nearly 0 Kelvin (K), the absolute lowest physical temperature at which all electron movements subside, Kamerlingh Onnes introduced the world to superconductivity.

Superconductivity is “the characteristic pertaining to certain metals, compounds and alloys in which their resistivity becomes zero” when placed in frigid temperatures (Giancoli). Resistivity is the amount or measure of “resistance” or “opposition” to permit electric flow, known as electrical current, in a material. A useful analogy to picture this characteristic is to compare “the flow of electric charge in a wire to the flow of water in a river, or in a pipe, acted on by gravity. If the river or pipe is nearly level, the flow rate (current) is small”, but if one end is somewhat higher than the other, the electric current is greater (Giancoli). Continuing with this analogy, the walls of a pipe, or the banks of a river and rocks in the middle, offer resistance to the water current.

These low temperature superconductors (LTS) possess two prominent, exceptional characteristics that set them apart from other materials:

1. They experience no internal resistance, allowing for “persistent currents” to be contained in the presence of an applied current. Without resistance, superconductors do not follow the correlation of internal current represented as a flowing river. Instead, they resemble a

nearly endless waterfall, with nothing opposing its current flow of descent. This lack of resistivity permits a current to continually flow within the material. Imagine a doughnut shaped superconductor, when an electrical current is applied, it will have this current traveling around its circular cross-section. These “supercurrents” pay homage to their name in that, according to Y.B. Kim and colleagues, the fastest magnetic field decay rate found in certain specimens has been 10 gauss per decade, a gauss being a scientific measure of the strength of the magnetic field induced by the persistent current, and are estimated to subside completely in 3×10^{92} years, or nearly an eternity! Typical conductors such as copper, gold, and platinum do not experience this persistency as superconductors do.

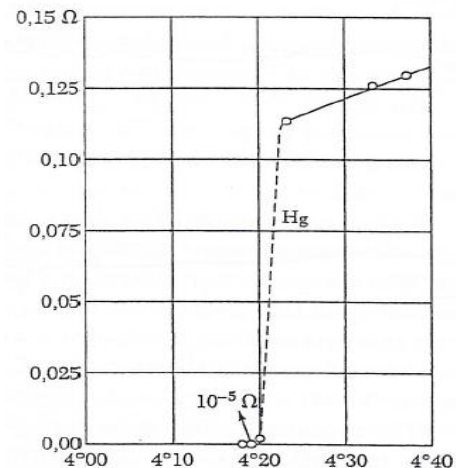
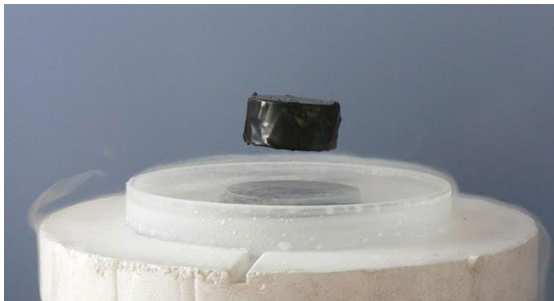
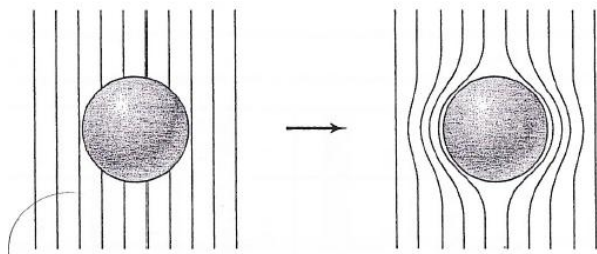


Figure 1: Resistance of a specimen of mercury versus absolute temperature (K). This plot by Kamerlingh Onnes marked the discovery of superconductivity.

2. *They undergo the Meissner Effect in the presence of a magnet.* Before delving into what the Meissner Effect is, it is important to understand the concept of transition temperatures. Transition temperatures, or critical temperatures (T_C) as I will be calling them in the context of this study, are the specific temperatures at which a material experiences superconductivity. When a typical magnet of sufficient strength is cooled below the T_C of a superconductor, this superconductor will levitate atop the magnet at a fixed distance. This effect is known as the Meissner Effect, and it is the backbone concept behind novel magnetic levitation rail system designs.



A typical superconductor undergoing the Meissner Effect above a cooled magnet.



Meissner effect in a superconducting sphere cooled in a constant applied magnetic field: on passing below the transition temperature the magnetic field lines are ejected from the sphere.

“Kamerlingh Onnes observed the first superconducting state of a material when he cooled mercury below a temperature of 4.2K and found that the resistance suddenly dropped to less than $10^{-6}\Omega$ (ohms),” nearly zero (van Delft and Kes 2010). For years to come, other metals were found to have superconducting characteristics. In the 1960’s “certain alloys of niobium were made that became superconductors at 10-23K. It was generally believed on theoretical grounds that there would be no superconductors above 30K” (Sheahen). However, everything soon changed in 1986 with the birth of what is now known as high temperature superconductivity (HTS).

The infant field of high temperature superconductivity (HTS), aside from ordinary superconductivity, began to take shape when “in late 1986 news spread that J. George Bednorz and Karl Müller of the IBM research laboratory in Zurich, Switzerland, reported the superconductivity in lanthanum copper oxides doped with barium or strontium at temperatures up to 38K” (Sheahen). Soon after, many scientists began to stake their claim in superconductivity, all rushing to find a material with an even greater T_C . Once a T_C of 77K was reached, high temperature superconductivity was born.

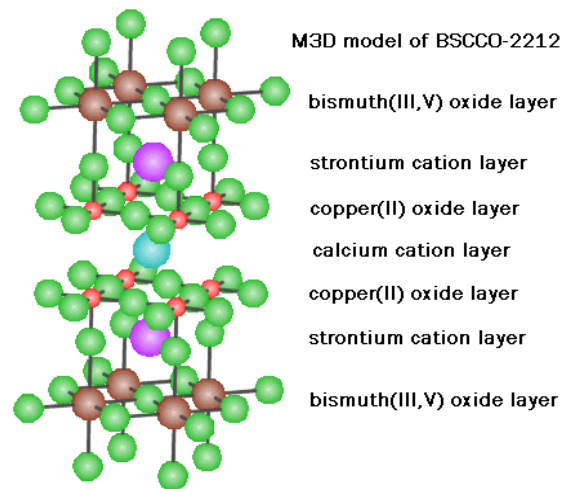
One might ask what the importance of a 77K T_C might be. How is that a significant number and why does it come into play with HTS? The answer itself is a question of how low can you go. Liquid helium which can cool materials to about 4K (at a high cost of nearly \$7 per liter) which is much more expensive compared to liquid nitrogen, which cools at 77K, and can be obtained by the truckload at a mere 6¢ per liter. This colossal price difference marks the disparity between the superconductors that require helium, LTS, to those only needing nitrogen, HTS. Known physical laws prevent a superconductor functioning at room temperature, and so,

many researchers have detoured in finding the highest T_C possible in exchange for researching and developing the capacities and characteristics of known materials.

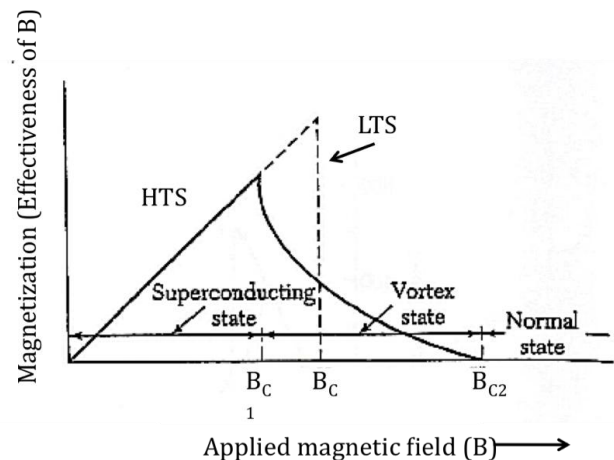
Unfortunately, HTS are not perfect. Like most ceramics, HTS are very brittle, preventing their immediate use as wires for telecommunication or power lines. Equally limiting is the fact that they do not carry sufficient current to be used in the real world just yet. This leads us to bismuth strontium calcium copper oxide ($\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{11-\delta}$) or BSCCO for short.

The crystalline, or atomic unit cell, of BSCCO is anisotropic (its properties are quite different and complex in various directions) and consequently shears off easily along a certain plane, thus allowing for it to be shaped and deformed with less difficulty than other ceramic HTS. This material can be wound up for wire applications, for example. Although having this advantageous characteristic, the complexity within the structure of these “new school” superconductors limits the strength of magnetic flux pinning. Flux pinning is the phenomenon where the magnetic field lines become trapped or “pinned” inside a superconducting material. This “pinning binds the superconductor to the magnet at a fixed distance and is only possible when there are defects in the crystalline structure such as impurities” which are purposely added to the material, much in the way salt is incorporated in many recipes to amplify the flavor of other ingredients (Eck 2007). “Nonmagnetic impurities [such as lead] have no very marked effect on the transition temperature” of superconductors (Kittel 2004). Flux pinning is desirable in high-temperature ceramic superconductors in order to prevent “flux-creep” (flux escape), which can create a pseudo-resistance, hence reducing the critical current density (J_C) and critical magnetic field (B_C), reducing the efficiency and capacity of the superconductor.

In the case of HTS, they only exhibit a partial expulsion of an incoming magnetic field from its borders, consequently having two critical magnetic fields: B_{C1} and B_{C2} . When an HTS is in the presence of a magnetic field in the range between the two critical magnetic fields ($B_{C1} < B < B_{C2}$) the material is said to be in the vortex state, in that it experiences optimal superconducting electrical properties. It is within the vortex state that university and industrial investigators are enthusiastically searching for different ways of exploiting the electromagnetic properties of HTS.



The complex unit structure of BSCCO.



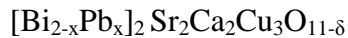
Magnetization versus applied magnetic field with the critical magnetic fields for both LTS and HTS.

Theoretical Results/Discussion

With respect to BSCCO, it has been found after multiple tests with varying proportions, that doping it with a specific amount of lead (Pb) will not alter the structure of the material, but theoretically increases the critical current density (J_C). Our investigations will adequately map the impact of Pb doping on critical current density as well as other essential properties.

Procedure of Sample Preparation

The bulk superconducting material $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{11-\delta}$ is a polycrystalline structure made by solid-state reaction method. Two samples of doping ratios 0.1, 0.3, 0.4, and 0.5 were made by the nonstoichiometric mixture of bismuth oxide (Bi_2O_3), lead oxide (PbO), strontium carbonate (SrCO_3), calcium carbonate (CaCO_3), and copper oxide (CuO), resulting in 10g of product. Nonstoichiometric mixtures are combinations in which the atomic composition cannot “be expressed as a ratio of small whole numbers” (McMurry and Fay). Varying the Pb doping levels, the empirical formula for BSCCO is now represented by:



where “x” denotes the ratio amount of Pb doping and “ δ ” is a varying ratio amount of oxygen that does not affect the superconducting properties of the material appreciably.

Each sample mixtures were placed in small ceramic crucibles into a Thermolyne 48000 series furnace, heated up to 850°C (1123K) at a rate of 35°C/hr . This temperature is maintained for 100 hours before cooling down to room temperature at 60°C/hr . After grinding the product down to a fine powder, the above procedure is repeated a second time for proper composition.

Considering the length of time required for the baking procedure of each sample, concrete results for this study are yet to be presented, but the “critical current density studies will include devices, made available to us by a collaborator in Japan” (Zhang). To begin, a direct electrical current will be applied from a power supply to the superconductor. A predetermined amount of current is applied, one that the undoped BSCCO material is known to contain, then slowly increased until the superconducting state is exterminated; this will give the set amount of J_C , which the doped material can hold.

The hypothesis emerging from extensive literature review is that the ideal doping ratio of lead within BSCCO should be between 0.3 and 0.4. This undefined ratio amount will attribute “high magnetic flux pinning within the material, as well as a higher load of critical current density, J_C ” (Zhang, Liu, et al. 1991). The sample that meets these criteria will contain the ideal Pb doping, within the limits of our study, opening wider the door for the development and application of a high temperature superconductor such as BSCCO for feasible real-life purposes. Possible fields of application include telecommunications and magnetic resonance imaging.

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Death of Knowledge
Orazco Mural (Dartmouth College) – Jim T

Phylogenetics of Freshwater Sculpin

Charlene Emerson

Introduction. Reconciling observed genetic variation with evolutionary history is often a daunting task. Phylogenetics is a method of study that is particularly well-suited to addressing this task by combining the measureable genetic variability of individuals, populations, or species with proposed evolutionary relationships and processes (Barracough & Nee 2001). Historically, phylogenetic trees have been generated using a single locus approach, where variation within a single gene is used to create a phylogenetic gene tree. However, this single gene method may fail to account for the full variation across a genome.

Shortcomings of the single locus approach are most apparent in complex organisms, such as the freshwater sculpin (genus *Cottus*). Freshwater sculpin exhibit highly ambiguous morphology, as well as wide and overlapping distributions – resulting in considerable difficulty in species classification (Moyle 2002). Analyzing multiple genetic loci in such species, instead of a single locus, may provide a fuller picture of species variation.

I propose to use freshwater sculpin as a model to compare this modern multiple loci approach with the single locus approach. By comparing a species tree, generated by concatenating multiple nuclear markers, with the single gene trees, I hope to achieve greater understanding of evolutionary relationships within seven Eastern Pacific *Cottus* species, as well as discerning the advantages and disadvantages of the single locus and multiple loci approaches.

Phylogenetics. Before comparing the relative merits of these different approaches, it is important to understand the overall phylogenetic method. Phylogenetics compares the similarities and differences between homologous sequences of genetic material,

which are sequences derived from a common ancestor (Scotland 2010). Closely related individuals, populations, or species should have fewer differences in the homologous sequence when compared to the genes of distantly related species (Lemey, Salemi & Vandamme 2009). These differences in the genetic sequence arise from the actions of several evolutionary mechanisms: mutation, natural selection, genetic drift, and gene flow (Hartl 1981). Genomic differences arising from these mechanisms are often the basis for phylogenetic analysis (Davis & Nixon 1992). In the presence of these processes, frequency of genetic alleles¹ will vary and a population will experience evolutionary change (Nei, Maruyama & Chakraborty 1975).

Mutations, or changes in genomic sequence which often occur spontaneously, are propagated or eliminated by the action of natural selection. If a mutation is deleterious to a species, natural selection causes it to be eliminated from the population. If the mutation is favorable, natural selection will allow it to become established in a population. However, a harmful mutation may propagate by the action of genetic drift. Genetic drift is the changing of allelic frequencies due to random occurrences. Effects of genetic drift are more marked in small populations, since deleterious alleles can become more easily fixed within a smaller population (Frankham 2005). Genetic drift and natural selection are generally considered to increase genetic differences between populations, eventually leading to speciation².

¹ Alleles are different forms of a single gene. Different alleles may create different traits in the organism in which they are carried.

² Speciation is the evolutionary process by which new species are formed.

In contrast, gene flow is generally considered to decrease the occurrence of speciation (Via 1999, Porter & Johnson 2007). Gene flow is the transfer of genetic alleles between populations of a species. Isolated populations experience decreased gene flow, because fewer individuals immigrate to or emigrate from the population to exchange genes. Over time, gene flow may cease and the isolated population could become reproductively isolated from the rest of their species. The absence of gene flow is considered to be a major mechanism of evolution. Together, these four major processes change the allele frequencies of a population, altering the relative relatedness of populations and species. Studying this evolutionary relatedness in the context of genetic data is one of the major applications of phylogenetics.

Phylogenetic Trees. The phylogenetic tree is a major tool of phylogenetic analysis. One of the most basic methods of tree-making uses a single homologous sequence – a single locus tree, and compares this sequence across members of a group, within or between populations, or between closely related species. These single locus trees can then be used to determine the overall evolutionary relatedness between members of the sample group. However, an analysis that stops with examination of a single homologous sequence would be extremely limited in scope. Limiting analysis to a single locus tree will only represent the events occurring at that gene locus, and may not necessarily represent the entire organism or species.

Analysis of multiple genetic loci is vital for a more complete understanding of evolutionary relationships, especially when considering that differing homologous sequences are subjected to differing evolutionary pressures (Brito & Edwards 2009). Because each homologous sequence changes differently, depending on evolutionary pressures exerted on that

particular locus, analysis of individual sequences will create different trees for the same group of organisms (Avice 2000). For example, a gene for eye color will be selected upon very differently than a gene for limb structure, generating different phylogenetic trees. By combining, or concatenating, multiple loci into an overall species tree – rather than a single locus tree, the most accurate representation of evolutionary relationships can be determined.

Generally, phylogenetic trees are constructed using a cladistic approach, where it is assumed that members of the tree share a common evolutionary history (NCBI 2004). The cladistic approach groups members of the tree by shared common ancestry, with members of the tree gradually diverging into individual groupings, or clades. Phylogenetic trees commonly take two forms: cladograms or phylograms. Cladograms only show the order of the branching changes of the homologous sequence, whereas in phylograms, the length of each branch of the tree corresponds to the number of changes that have occurred in the sequence (Hall 2004, Lemey et al. 2009).

Determining Accuracy of the Phylogenetic Diagram. Phylogenetic tree diagrams can also vary according to the statistical analysis used to generate the tree. Differences in genomic sequences can vary as a result of a number of processes, making analyses of sequence changes complex. Components of the sequence cannot always be assumed to change with equal likelihood. For example, genetic changes that result in the production of a similarly functioning protein would seem more likely than changes that completely negate a protein's function.

Additionally, multiple changes may happen at a site, with no way of knowing the total number of mutation occurrences. Changes may also occur that later revert back to the original sequence, causing organisms to

seem more evolutionarily related than they actually are (Hall 2004, Lemey et al. 2009). When multiple changes occur at a nucleotide site, so that the sequence is no longer informative about true evolutionary relationships, it is called substitution saturation (Lemey et al. 2009).

Substitution rates of nucleotide sites are modeled by several mathematical formulas, with each model representing a different relative rate of change. Models are chosen for a specific data set using statistical selection software (Posada 2008). Among the most popular are the MODELTEST and jMODELTEST. Model tests analyze the nucleotide sequences in the data set and select the model of nucleotide substitution that best fits the existing data.

The simplest model of nucleotide substitution is the Jukes-Cantor model, commonly called JC69 (Jukes & Cantor 1969). JC69 assumes equal nucleotide base frequencies and equal mutation rates for each adenine, thymine, cytosine, or guanine³ in the genetic code. Models become more complex as other assumptions are made about the base sequence and substitution rate. Felsenstein (1981) created a model (F81) which assumes unequal nucleotide base frequencies. The Kimura model (K80) assigns different likelihoods to transitions between the purines – adenine and guanine, and pyrimidines⁴ – cytosine and thymine (Kimura 1980). Subsequent models, including HKY85, TN93, and GTR, continued to vary and combine assumptions about base sequence and substitution rate (Tavare 1986, Tamura & Nei 1993).

After the designation of a nucleotide substitution model, sequence data is used to

construct the phylogenetic tree. Several different methods have been developed to construct trees (Lemey et al. 2009, Rosenberg & Kumar 2001). Among these methods are the Maximum Likelihood (ML) and Bayesian analyses. Both are considered to be “discrete character” methods, where compared homologous sequences are aligned – each position is considered to be a “character” and the nucleotide in that position is a “state” (Lemey et al. 2009). Character-states are analyzed independently to determine relatedness between samples.

Maximum Likelihood examines different possible tree formations and searches for the most likely tree, according to a particular evolutionary model. Likelihood of possible trees is calculated, according to an algorithm, and the most likely tree is selected. A ML generated tree can be supported by the use of bootstrap resampling. Bootstrapping takes a subsample of character-states and creates a tree based upon this subsample. The bootstrapping process is replicated numerous times, providing support for the final chosen tree. In contrast, a Bayesian analysis does not search for a single best tree. Bayesian analysis targets a distribution of possible trees by using prior probabilities. After analyzing possible tree formations, a consensus tree is created based on the highest posterior probabilities of each branch or node. (Hall 2004, Lemey et al. 2009).

Freshwater Sculpin. Structuring evolutionary processes into a phylogenetic tree has applications across a number of biological fields, including: molecular biology, evolution and development, epidemiology, ecology and conservation biology (NCBI 2004). A particularly engaging application of phylogenetic methods is the use of trees to delineate the distribution and genetic variation of cryptic species. Cryptic species, by definition, are notoriously difficult to classify, usually because of ambiguous morphological features. In some cases, understanding the

³ See purines and pyrimidines in 4.

⁴ Purines and pyrimidines are two groups of nitrogenous bases that are part of the variable components of DNA. Adenine and guanine are purines, while cytosine and thymine are pyrimidines.

distribution and improving classification of these species can lead to insight about important historical evolutionary and geographic processes, as well as potential human environmental impacts.

One such cryptic group of species, freshwater sculpin (genus *Cottus*), are an ideal candidate for study of species variation and distribution. Sculpin exist in a variety of habitats, with many freshwater sculpin species inhabiting various inland rivers and streams, freshwater lakes, and brackish coastal waters (McGinnis 1984, Moyle 2002). Freshwater sculpin have value as a potential *indicator species*, a species that characterizes certain environmental conditions in a particular ecosystem. Indicator species can provide valuable information about a wide range of factors contributing to species distribution, including geographic, environmental and anthropogenic effects (Lindenmayer, Margules & Botkin 1990, Noss 1990).

Utilization of indicator species is an especially pertinent strategy in California, which is the site of one of the most complex water storage and transport systems in the world (McClurg 2000). California's water system necessarily impacts natural environmental conditions, with implications that are difficult to measure fully. Discerning the value of freshwater sculpin as an indicator species in California waterways would offer more headway in measuring these effects. *Understanding these environmental impacts is vital to maintaining a water system that is both efficient and sustainable.*

Distribution of freshwater sculpin species is poorly understood at this point in time, with recent genetic studies conflicting with earlier morphological definitions -- which were ambiguous enough to begin with (Baumsteiger unpublished, Kinziger, Wood & Neely 2005, Moyle 2002). To date, there are no studies using nuclear DNA markers to analyze California freshwater sculpin. By

constructing phylogenetic trees using the nuclear DNA of freshwater sculpin, new and valuable information about the ecosystems of California waterways may become available. Understanding the evolutionary progress of this genus in California will illuminate the factors -- man-made or natural -- contributing to its distribution in California waters.

Method. Eighteen freshwater sculpin DNA samples were used to conduct the study. Samples were either collected directly from the field or provided from established museum collections. Species and locations included 2 prickly sculpin (*Cottus asper*) from the San Joaquin River, 2 riffle (*C. gulosus*) sculpin from the Sacramento River, 2 prickly sculpin from the Smith River, 2 riffle sculpin from the Kings River, 1 rough sculpin (*C. asperrimus*), 1 riffle sculpin from Washington, 1 reticulate sculpin (*C. perplexus*), 2 riffle sculpin from the Russian River, 2 prickly sculpin from Clear Lake, 1 coastrange sculpin (*C. aleuticus*), 1 mottled sculpin (*C. bairdi*), and 1 margined sculpin (*C. marginatus*) (see Figure 9). All individuals came from California waters, except for the Washington riffle sculpin, mottled sculpin, margined sculpin, and reticulate sculpin samples.

Ten previously identified nuclear markers were developed from a 454 sequencing run of prickly sculpin DNA (Baumsteiger unpublished data). Using the software MSATCOMMANDER (Faircloth 2008), markers were selected for: conservation across all sample species, sequence variability between species, repeatability, and an overall length of between 400 and 500 base pairs. Each marker was optimized for a polymerase chain reaction (PCR) to amplify the desired DNA. Once amplified, the DNA was analyzed through gel electrophoresis⁵ to compare amplification. Amplified products were

⁵ Gel electrophoresis is a method of separating DNA fragments in order to analyze them.

further purified with ExoSap⁶ and submitted for sequencing on an ABI 3730 Sequencer at UCLA's Genome Core facility.

Sequences were compared and aligned in several programs. First, sequences were aligned by forward and reverse alignment of each sample, to ensure that complete and readable sequence was present for analysis in SEQUENCHER (Gene Codes Corp., Ann Arbor, MI). After forming a contiguous sequence for each sample, sequences were then aligned according to nuclear marker and trimmed to uniform length with MUSCLE (Edgar 2004) or MEGA (Kumar, Dudley, Nei & Tamura 2008). Alignment by nuclear marker confirmed that the markers chosen were homologous sequences for each of the freshwater sculpin samples.

Once each marker was aligned for all 18 individual samples, JMODELTEST (Posada 2008) was used to determine the best nuclear substitution models for each locus. All ten loci were then concatenated at each sample to create one continuous nuclear sequence using FASconCAT (Kuck and Meusemann 2010).

The concatenated homologous sequence, created from these 10 markers was used to create the multi-locus phylogenetic species tree. Single-gene trees were generated from each of the nuclear markers as well. Both approaches used Maximum Likelihood analysis in PHYML (Guindon & Gascuel 2003) and Bayesian analysis in MRBAYES (Huelsenbeck & Ronquist 2001) to generate the single gene tree and the multi-locus species tree. For all trees, the mottled sculpin (*C. bairdi*) was used as an outgroup⁷ for tree

rooting based on previous phylogenetic analyses (Kinziger and Wood 2005).

Results. After completion of the JMODELTEST for each marker, JC69 was the model chosen for markers 502, 505, 507, 518, and 520, with HKY chosen for markers 508 and 514, F81 chosen for marker 510 and K80 for marker 516. Finally, TN93 was used for marker 517 and the overall concatenated sequence. If usable sequence could not be generated for a sample, that sample was omitted from the single gene tree. The majority of the markers did not show major differences between Bayesian and Maximum Likelihood analyses.

Only two of the ten nuclear markers generated trees with major differences when created in PHYML compared to trees created in MRBAYES (shown in Figure 1, next page). For all trees, support values for branch separation were generated as measureable evidence for proposed relationships. In Maximum Likelihood trees, branch value bootstraps closer to 100 indicate greater support for a given separation. In Bayesian trees, branch value probabilities approaching 1.0 indicate strongly supported separations.

Several trends emerged when comparing the single gene trees. All ten trees showed recent common ancestry between riffle and prickly sculpin. Nine trees showed the coast-range sculpin as the most distantly related species, other than the root defining mottled sculpin. Margined, reticulate, Washington riffle, and rough sculpin were also frequently shown to have more distant ancestry to the prickly and California riffle groups. Seven trees depicted prickly sculpin in a distinct clade, while five trees showed the California riffle in a distinct clade. None of the 10 trees grouped the Washington riffle with California riffle (shown in Figures 2 and 3).

⁶ ExoSap is a common procedure used to sequence PCR products for more accurate sequencing.

⁷ In this study, the mottled sculpin was used as an outgroup to provide perspective when comparing the relatedness of the different sculpin species. It is known that the mottled sculpin is distantly related to the samples in the study; however, it is still closely enough related to allow genetic comparisons.

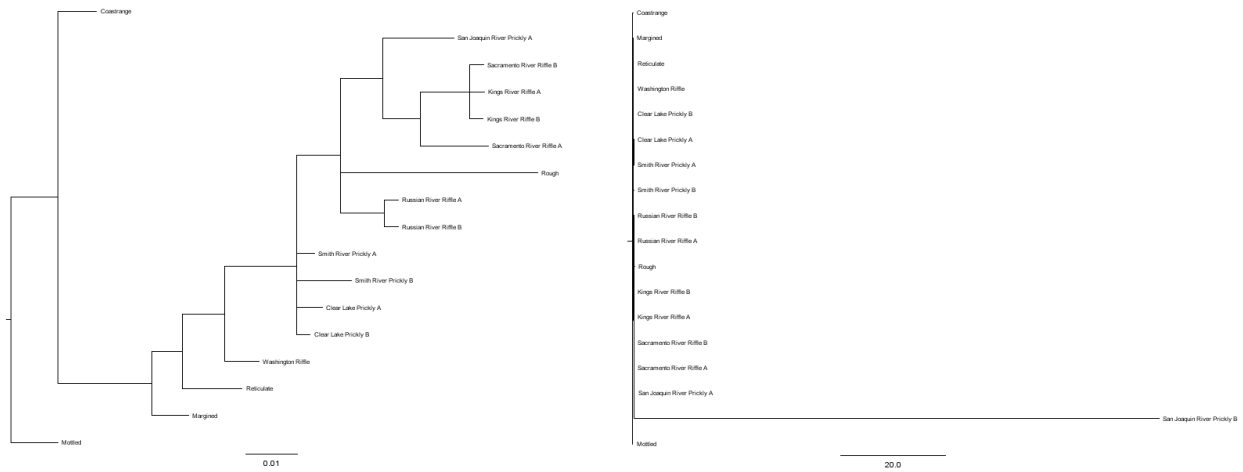


Figure 1: Marker 507 generated extremely different trees in Bayesian analysis (left) and in Maximum Likelihood (right)



riffle sculpin



prickly sculpin

Marker	Length (bp)	Samples Omitted	Evolutionary Model
502	417	None	JC69
505	475	None	JC69
507	493	San Joaquin River Prickly B	JC69
508	474	Clear Lake Prickly A	HKY
510	489	None	F81
514	486	Kings River Riffle A and B, Russian River Riffle A	HKY
516	447	None	K80
517	433	None	TN93
518	436	None	JC69
520	435	None	JC69
All	4585	None	TN93

Summary of results for genetic markers

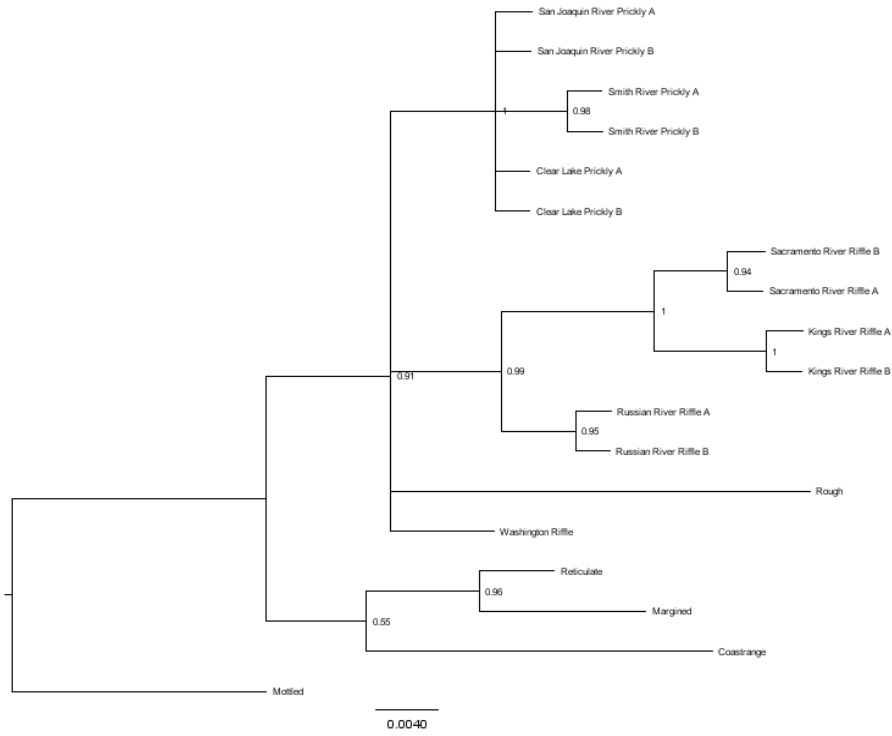


Figure 2: Single gene tree for marker 510, created with Bayesian analysis.

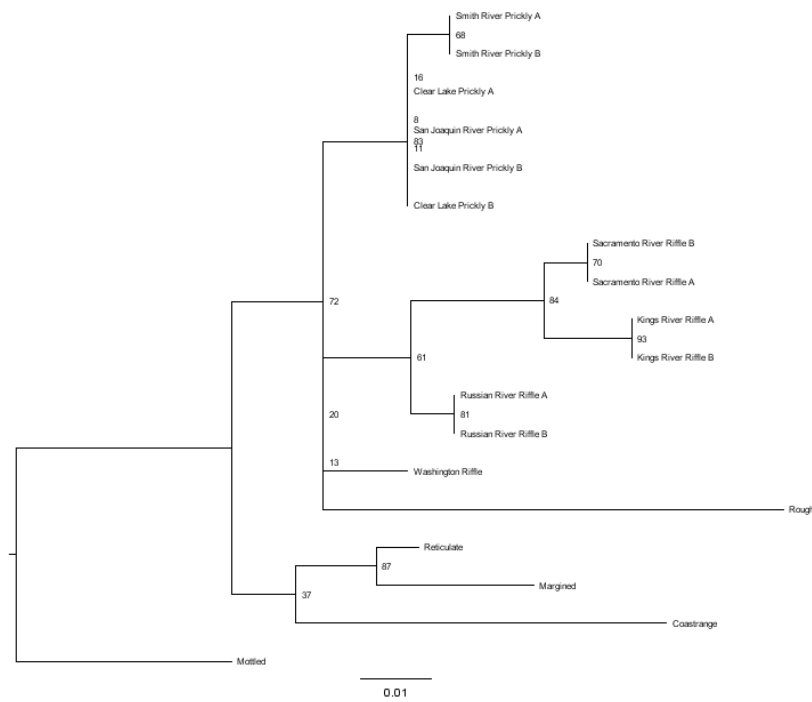


Figure 3: Single gene tree for marker 510, created with Maximum Likelihood.

Within proposed riffle sculpin collected in California, the Russian River samples were observed to form their own clade in eight of the single gene trees (Figures 2 and 3). Riffle from the Sacramento River and the Kings River were also observed to diverge into separate clades frequently (Figure 4) – in five of the ten trees. However, support values for

this separation varied greatly. Similarly, within the prickly sculpin, Clear Lake prickly formed a separate clade in four trees with strong support values for the separation (Figure 5). However, in three trees the Clear Lake samples did not group together, making conclusions difficult (Figure 6).

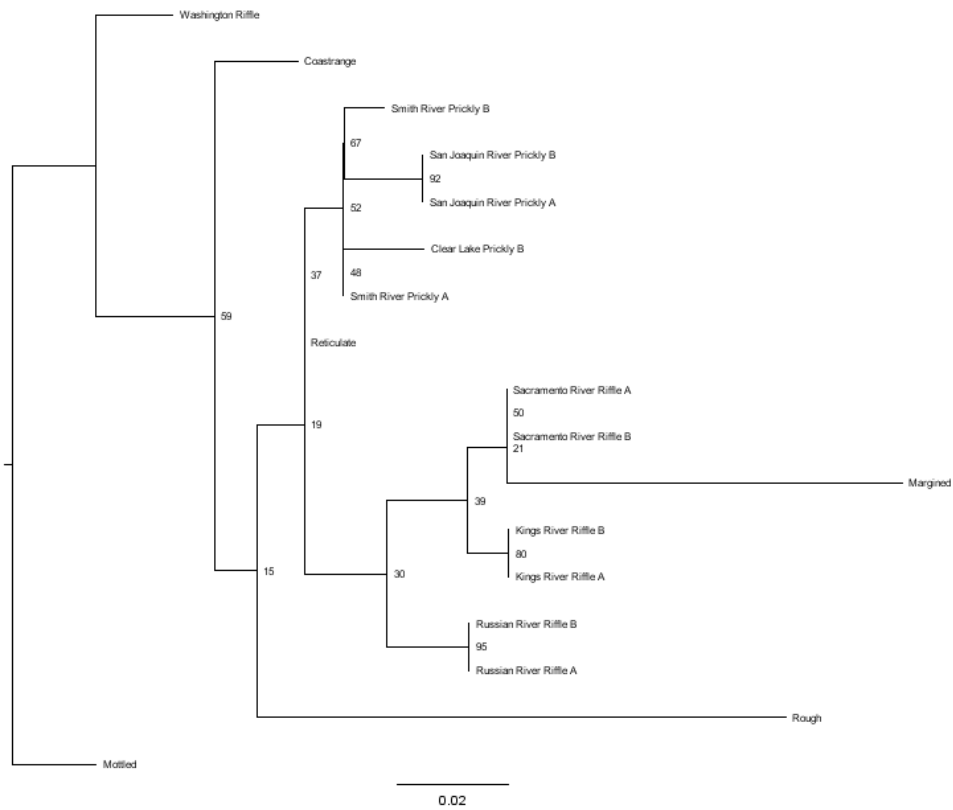


Figure 4: Single gene tree for marker 508, created with Maximum Likelihood.

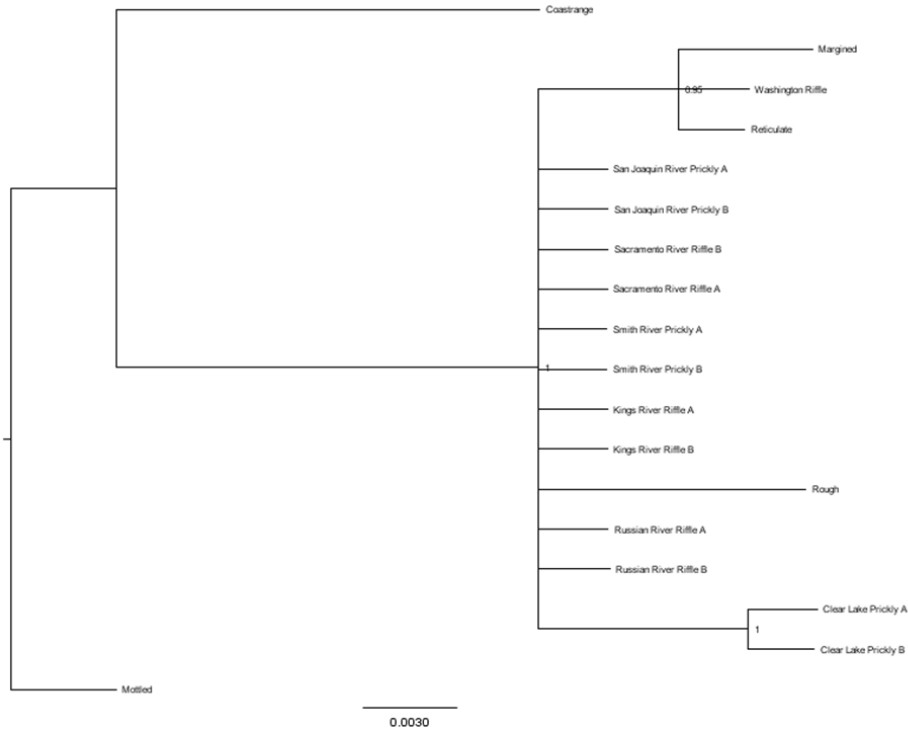


Figure 5: Single gene tree for marker 516, created with Bayesian analysis.

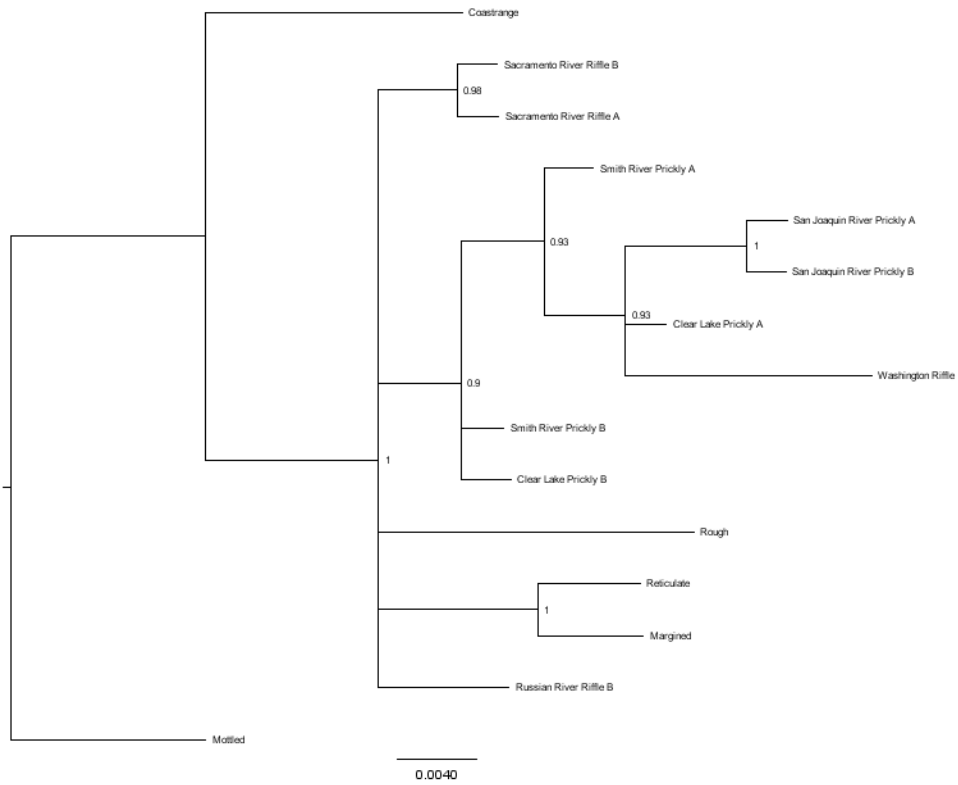


Figure 6: Single gene tree for marker 514, created with Bayesian analysis.

Identical multi-locus trees were generated by the Bayesian and Maximum Likelihood methods (shown in Figure 7 and 8). Support values for both trees were strong.

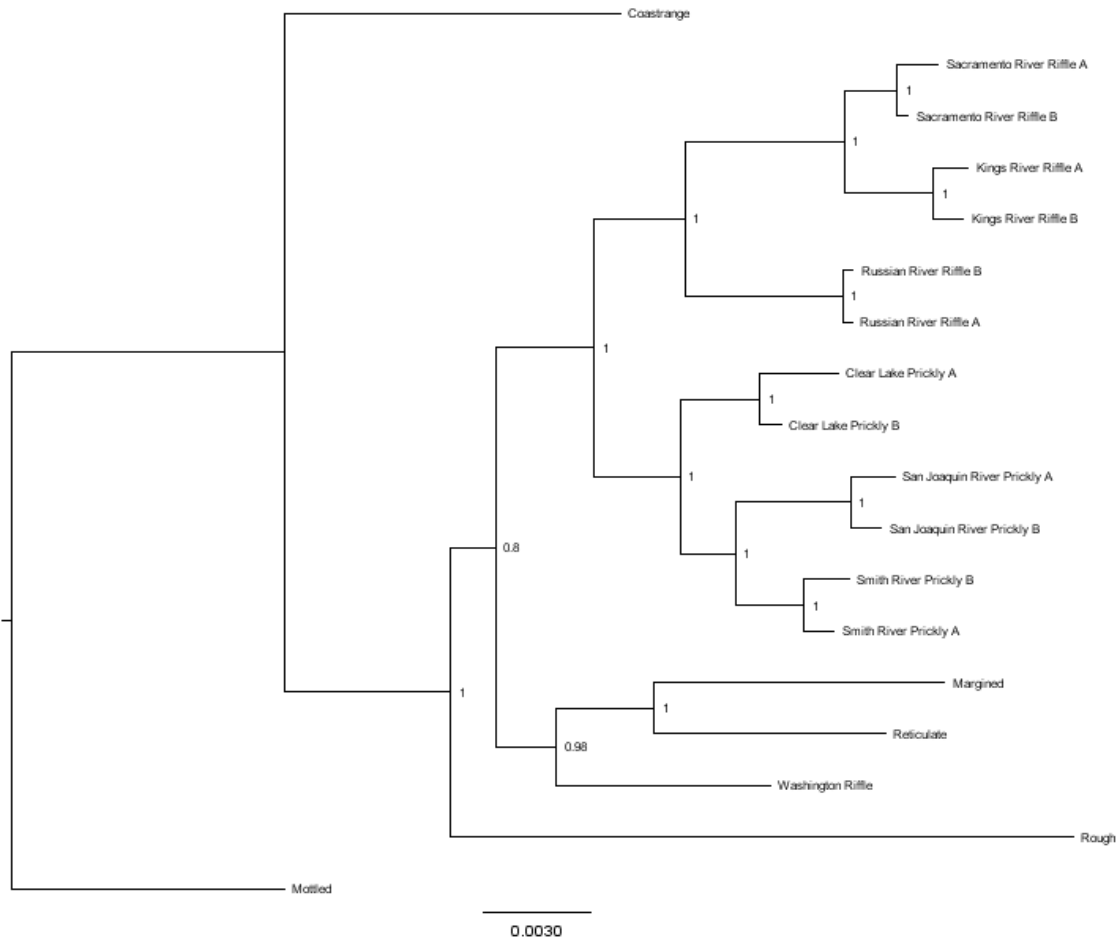


Figure 7: Multi-gene tree, generated with partitioning and Bayesian analysis.

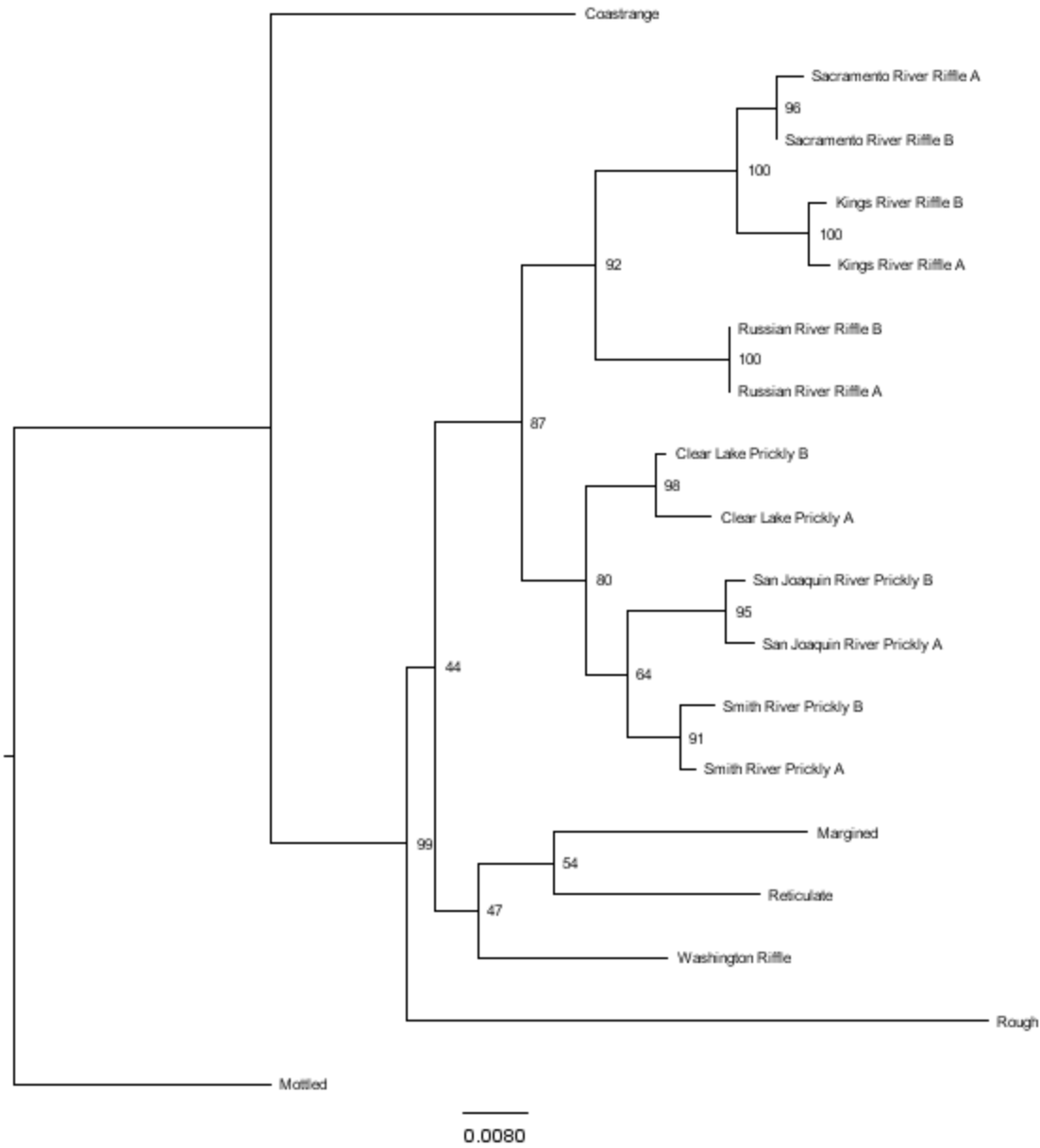


Figure 8: Multi-gene tree, generated with Maximum Likelihood.

The multi-loci tree showed many of the same trends depicted in the single gene trees. Coastrange, rough, Washington riffle, reticulate, and margined sculpin have more distant ancestry to the riffle and prickly sculpin. Riffle – (except for the Washington riffle), and prickly each formed their own clade. Within the riffle clade, Russian River

riffle were more distant from the Kings and Sacramento River riffle. In the prickly clade, Clear Lake prickly were more distant from the San Joaquin and Smith River prickly.

Discussion. The multi-locus tree appears to provide a better representation of the evolutionary relationships of 7 species of Eastern Pacific *Cottus* than the single-locus

trees. Trends found scattered through groupings of the single gene trees are clearly represented in the concatenated species tree with extremely strong support values for the branching. Many of the genetic relationships shown are strongly supported by their presence in both the single and the multi-locus tree. However, the multi-locus trees provide clearer depictions of the relationships. Furthermore, our findings do not align with current morphological species classifications.

Freshwater sculpin are highly suspected of cryptic speciation (Moyle 2002). This species ambiguity is illustrated by our genetic analyses of Californian sculpin, which show complex and unexpected speciation patterns. Existing classifications of sculpin, such as riffle or prickly, do not seem to convey the full variation present in each species in the state. Many of these discrepancies can be tied to California's phylogeography. Principally, phylogeography seeks to understand how historical processes of changing allele frequencies have left behind evolutionary implications on geographic species distribution (Avice 2000). Within California, this phylogeography is highly complex and subject to strong anthropogenic influences, causing additional ambiguity.

Lastly, because of confusing morphology, it is possible that some identification of samples may be erroneous – as may be the case in several of the riffle sculpin. Confusion of species definitions is not limited to morphological discrepancies, however, as previous species definitions of sculpin (Kinziger et al. 2005) conflict with initial phylogenetic trees generated in this study.

A number of Riffle sculpin classifications are called into question by our latest findings, though this is not entirely surprising given the life history requirements of these fish. Riffle sculpin need cold, clean, highly oxygenated water to exist and given the current distribution of riffle sculpin along the west coast, gene flow between populations would

be highly unlikely (Moyle 2002). For example, the sample from Washington, called “Washington riffle” may be wrongly classified. The Washington “riffle” did not group with the other riffle species, indicating that it is not the same species as these other fish. Some genetic variation would be expected between the proposed Washington riffle and the California riffle because of geographic distance (Hutchison & Templeton 1999); however, the observed distance between Washington and California riffle is too great to be completely accounted for by the geographic distance effects and the loss of gene flow.

Additional discrepancies exist in riffle sculpin in the Russian River, where preliminary results indicate that they too may not be a “true” riffle sculpin. The separation of the Russian River riffle may have a phylogeographic explanation. A coastal mountain range separates the Russian River riffle from the Kings and Sacramento River riffle. Geographic variation in the American Pacific Northwest has been linked to pronounced genetic variation between species in the area (Brunsfield et al. 2001).

Lastly, the margined sculpin sample also contradicts existing classifications of this species of sculpin. According to Kinziger, Wood, and Neely (2005), the margined sculpin shares a clade with riffle sculpin. However, in the trees generated by this study, the margined sculpin is in a more distantly related clade with the Washington riffle and reticulate sculpin.

Relationships among prickly sculpin also show additional complexity than would be initially assumed. Clear Lake prickly sculpin form a separate clade than the San Joaquin River and Smith River prickly. This separation, based in higher numbers of genetic differences, could indicate reproductive isolation between the Clear Lake prickly and the other prickly. Reproductive isolation has been shown to arise in fish over

a relatively short period of time (Hendry, Wenburg, Bentzen, Volk & Quinn 2000). Clear Lake prickly, collected from a lake environment after thousands of years in isolation from other species of prickly, appear

to have become reproductively isolated from the other prickly, certainly more so than the various species of prickly typically inhabiting river environments.

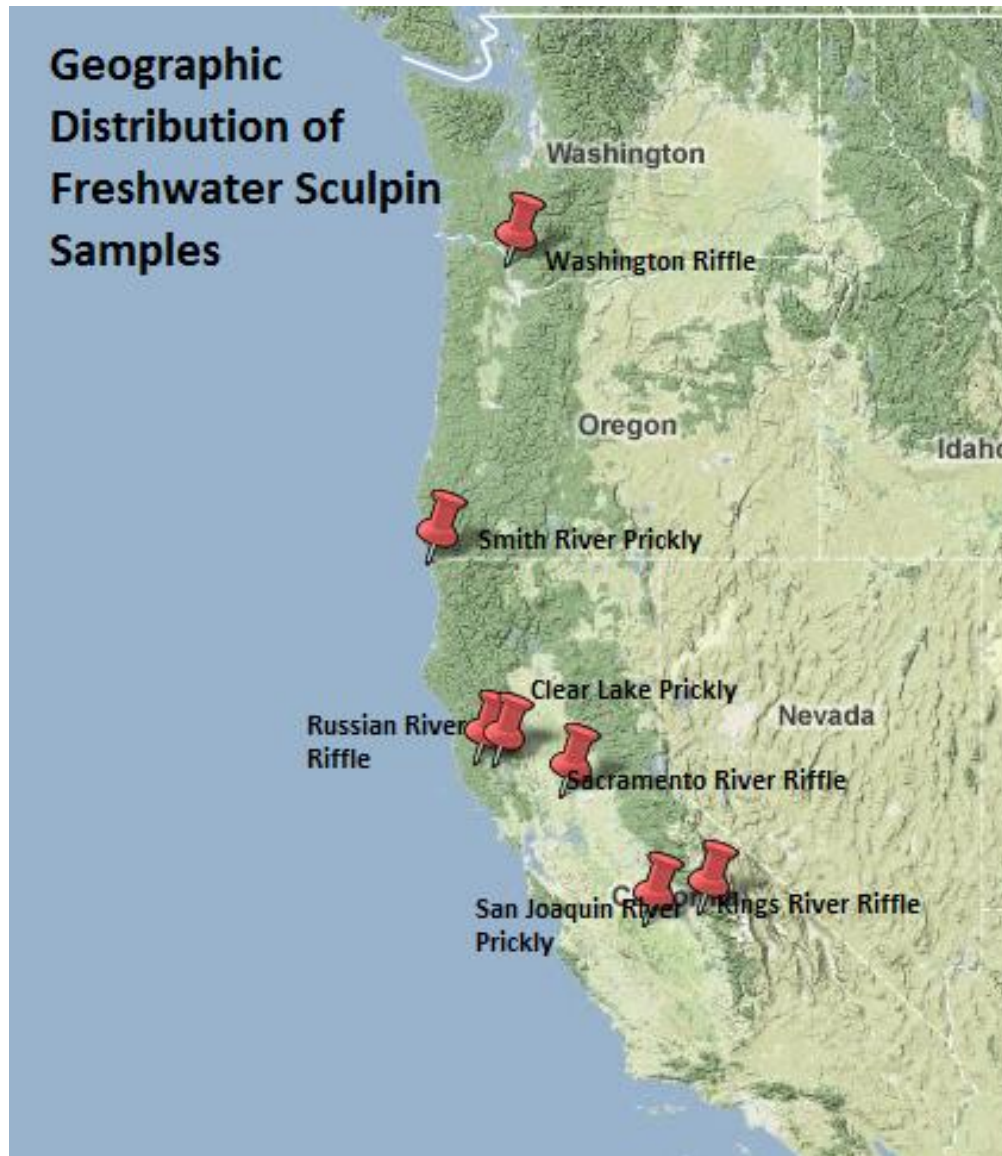


Figure 9: Geographic distribution of freshwater sculpin samples used in this study.

Future research, utilizing more samples from varied locations as well as different methods of analysis, may contribute to clarifying the convoluted species definitions of freshwater

sculpin. Sites and Marshall (2004) suggest using multiple strategies of analysis to empirically delineate species. Combining data from morphological classification with

genetic information from several sources – including mitochondrial, nuclear, and microsatellite analyses, may provide the clearest picture of freshwater sculpin speciation and distribution. The results of this study, generated through a multi-gene species

tree approach, may contribute to understanding the role of sculpin in California's waterways and their potential to demonstrate principles of phylogenetic and ecosystem complexity.

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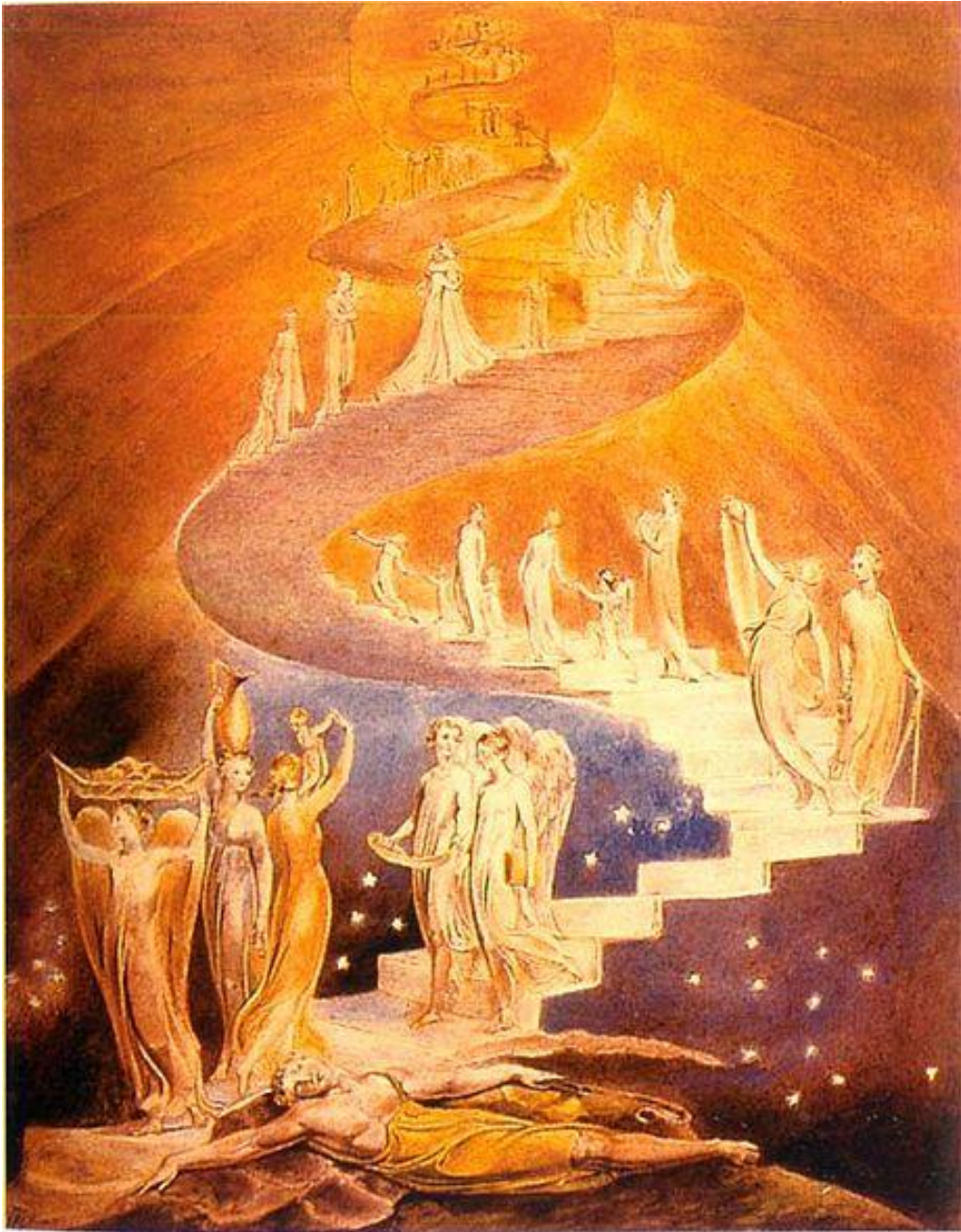
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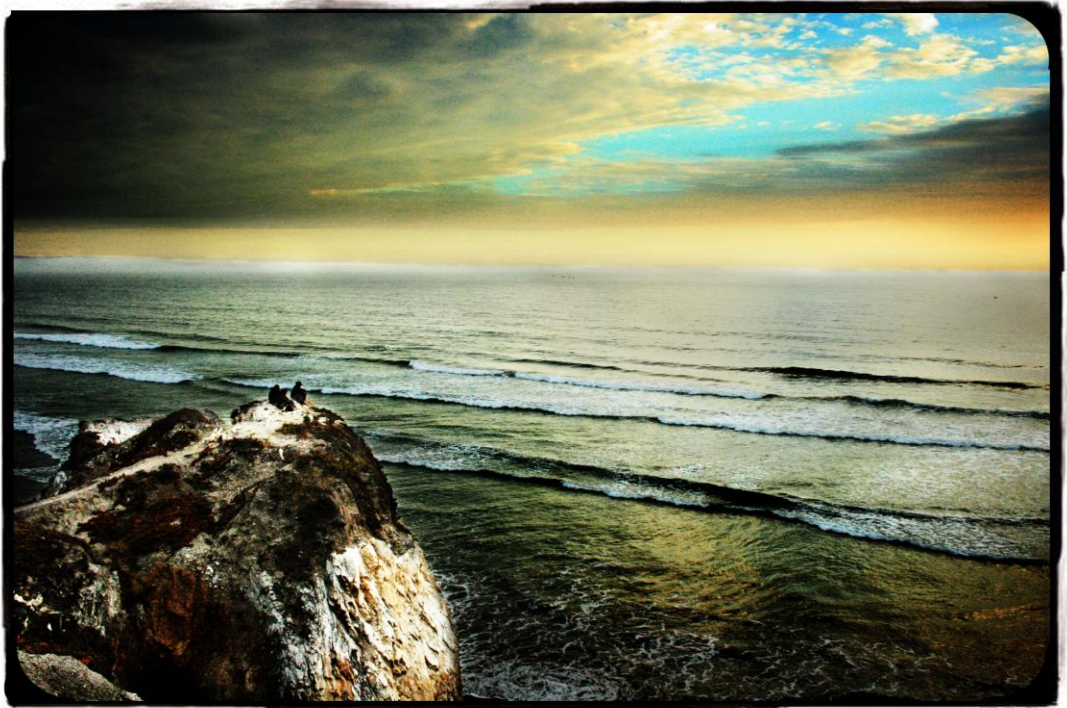
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Salt Pond – Eddie Campbell



Jacob's Ladder – William Blake



EAC

Confluences