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January 14, 2011

The Honorable Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 – 1st Street, NE, Mail Code PJ-12.3
Washington, DC 20426

filed electronically

Ref: P-606-027, Kilarc Cow Creek License Surrender

Re: Updated Summary of the Kilarc Proposal put forth by Davis Hydro

Dear Ms. Bose:

The enclosed document puts in one place the entire proposed Alternative as of the end of 2010. It emphasizes working within the FERC process.

Respectfully submitted,

Richard D. Ely
Davis Hydro, LLC

cc: P-606 Service List

CERTIFICATE OF SERVICE

I hereby certify that I have on this day served the foregoing document by first class mail postage prepaid or email upon each person designated on the official service list compiled by the Secretary of the Commission in this proceeding.

Dated at Fair Oaks, CA this 14th day of January 2011.

Kelly W. Sackheim

Kelly W. Sackheim, Principal
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Fair Oaks, CA 95628

The Kilarc Project

An Anadromous Fish Enhancement Project

For the Old Cow Creek

Utilizing the Resources

of

The Cow Creek Community,

The Kilarc Hydropower Facility,

and

The Kilarc Foundation

Draft Summary 1
January, 2011

Compiled by

Davis Hydro, LLC
Richard Ely, Principal
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Forward

This document contains a summary of the Davis Hydro proposal for work at the Old Cow Creek, where it is the intent of the author, his company, partners, and friends to create a public-private partnership to help the fish, support the interests of the local community and to generate green power. From previous discussions with project stakeholders, we have become aware of a persistent series of misconceptions as to Davis Hydro's intent and motivation which have generated undue concern. Hopefully, this work addresses these misconceptions and should provide a fuller description of the structure and content of our proposal as it has grown.

To provide background, while initially I had felt that along with habitat, genetics would define the major components of our proposed solution to current problems, it has become clear that the new science of Conservation Genetics (Frankham et al 2010) is rapidly being supplemented, if not overtaken, by the even newer and more applicable science of "Conservation Epigenetics" which is growing out of the science of genomics. Epigenetics is a broad term for the study of the mechanism's control of the expression of genes. The "expression" of genes is controlled by the environment of the cell, and that environment is controlled by the environment of the fish. Genes are not generally directly affected by environment. In contrast, the epigenome, regulator of genome expression, is directly and profoundly influenced by the micro and therefore macro environment. If we are to look at how the environment affects our fish, then the functional path through the epigenome must be understood. I envisage that epigenetics will be the handmaiden of habit restoration in this recovery effort.

The degree and depth of needed understanding is unknown. However, at this point, like genetics, it may only be necessary to understand the function of the epigenome, just as it is only necessary to understand the function of the gene to do genetics. A grasp of the underlying chemistry is necessary to make sense of the chemical engine, but a mastery of the chemical structures and pathways is not necessary to "do" genetics. Likewise, in epigenetics, the chemistry provides a core mechanism of the science, but understanding that chemistry is not necessary to use epigenetics to our great advantage. How we use and modify natural genetic processes is to be soon eclipsed by epigenetics in life forms as they develop; examples may range from inhibiting the expression of an undesired gene to the control of genetic diseases in human and animal health. Specifically, we will learn how to harness and modify the "epi" mechanism, as in genetics, to help these fish, and to understand anadromy. Since epigenetics is likely to be the mechanism that controls anadromy and geoadaptation, its manipulation is central to our efforts.

One can always say, "hands off!", and trust that the fish will figure out how to best come back once the habitat has been improved. The implication being that further interference, after the genetic devastation caused by hatcheries, is equally unlikely to help. This approach has obvious attractions. It is "risk free" for any practitioner. Do away with man and in a few thousand years it is likely the effects of our pollution, dams, and genetic interference will be hard to discern. Unfortunately, unless we also do away with humans, the "Hands off – let mother nature do it" approach is certain to have profound negative consequences given the deterioration of the current

environment. Abandonment of our efforts is likely to prove a very slow and inefficient solution, given the other problems that presently interfere with natural recovery.

If we are serious about stemming the loss of fish stocks, we need to re-establish the genetic viability of both these species and their ecosystem as quickly as possible. Time is of the essence if the current rate of damage to these fish and all of our species - so clearly described by E.O. White - is to be minimized. His admonitions apply to most all species and now, with a clearer lens, to all epigenetic varieties. Minimization of our present and future damage requires us not to reproduce a rough semblance of a past ecosystem, but rather to aim higher and seek to steer the ecosystem to as close to a permanent favorable condition as possible given man's presence.

With the gathering clarity of modern science, we recognize that we are not addressing only a single behavior, or a single species. In fact, in our efforts described here, we are not addressing this fish as a goal, but rather these Fish as a symbol of how their environment could be reborn from what we have now ruined. The decline of these fish and their desired behavior are a visual indicator of our environment's ongoing destruction. It was put directly to me recently by senior FERC staff, "it is not about the fish." It is all about what we are doing to our entire planet. With this reason, this mandate, we address these fish as our environment. Delay is expected and set-backs are required for learning, failure is not an option. In fixing their world, we "fix" the world of many millions of other species that are not so iconic, and have no public voice. Hopefully, what we are doing here will be right and will be duplicated.

I am indebted to a number of colleagues for their help in the preparation of this document; to Kelly Sackheim a partner in KC Hydro and a strong supporter of community collaboration and working within the FERC process from the outset**;** to the fish biologists who have given me their time and council**;** and to the students and scientists in epigenetics who have guided my thinking and helped modulate my angst with understanding. I am also grateful to those passionate activists that have championed the interests of the fish and for continually challenging me and propelling me into this fascinating area of research. I hope that this summary will allay their fears and enlist their passion in support of this project. Finally, I am deeply in debt to Roan Harvey for her efforts at my poor English, and constraining my didactic.

This summary continues to evolve daily as I learn, so I have had to stop and "just get it out" as a snapshot of an education. The first draft was felt by various parties to be too technical and too long, which I fear resulted from my personal exuberance for the possibilities my research has uncovered thus far. This outline of the Kilarc Project is written and circulated to solicit comments and ideas to make it better. It is written in sections, primarily to facilitate updating. Let it be a starting point for a long fight to save what we can. All errors of content and writing style remain mine, and all comments on improvements - no matter how delivered, welcome.

Richard Ely

January 2011
Davis, California

Glossary

An informal explanation of the words used as they pertain to these fish in this summary.

Agencies Refers here to fish resource-oriented agencies such as NMFS and CDFG and to a less extent the California State Water Resources Control Board, and the national Fish and Wildlife Service. Also included here, by reference, are interveners to the extent they are interested in the fish and their environment.

Allele *noun* (allelic *adjective*) A particular combination of genes. It is also used to describe the resulting phenotype from those genes.

Anadromy *n.* (mous *adj.*) Fish that go to the sea and return to fresh water to spawn – often, but not always, to their natal site to breed.

Canal The "canal" refers to the existing 3-plus-mile headrace for the Kilarc Powerhouse, a component of FERC Project P-606 in 2010.

Conservation Genetics The exercise of genetic management usually of interbreeding multiple populations to produce a desired genetic mix in the offspring.

Conservation Epigenetics The science of creating and managing the epigenome to produce desired phenotypes and behavior in a resulting population.

Epiallele *n.* (elic *a.*) A phenotype expressing a specific pattern of characteristics from a given genome.

Epigenome *n.* (mic *a.*) The quasi stable (plastic) set of regulators that control gene expression in response to the cellular environment.

Fish Generally in this paper we are referring to Salmonids, focusing on rainbow trout.

Genetic Pertaining to the patterns of possible phenotypes encoded in genes.

Headrace The headrace is the open canal that connects a diversion to the typically pressurized penstock of a hydroelectric facility.

O. mykiss Often called rainbow trout, can express various environmental coping strategies, including anadromy. Called a steelhead upon successful return.

Phenotype The physical individual organism or organisms that result from a particular combination of genes and epigenomes.

Redd A spawning bed created by the female fish in which she lays her eggs.

Table of Contents

The Kilarc Project

Introduction

This document is a synthesis of the proposed efforts Davis Hydro (DH) and the Kilarc Foundation (Foundation) will undertake to support fish stocks, primarily of *O. mykiss* in the upper Sacramento River. Davis Hydro desires to operate the Kilarc development of the current FERC Project 606 (P-606) and will dedicate around 30% of its profits under a FERC license condition to the Foundation as an operating income. The Foundation will exist independently of Davis Hydro, but will be given these resources by DH along with other appropriate assistance to independently advance work on fish resources over the medium- and long-term. The Foundation is described and the work the Foundation might undertake is described in Appendix 1. Should the future directors of the Foundation wish, DH would supply staff, facilities, and services.

Project Summary

The Kilarc Project will serve dual purposes in the operation of the Kilarc development of P-606 jointly as a source of green electricity and a source of funding for the Kilarc Foundation, adhering to FERC procedures and federal and state regulations. Davis Hydro expects to operate the site as it is now, except that the Kilarc canal will become a multipurpose headrace, research, public outreach, and education facility. The old transformer building by the powerhouse will become a research field station equipped with bench space, offices, living facilities, and various labs. It is our belief that this proposal delivers considerable and adequate assistance to fish resources while supplying greatly enhanced services to the Old Cow community. This proposal will also save PG&E considerable cost. Finally and importantly, this proposal establishes structures and funding for a long-term positive relationship between the community and fish enhancement activities.

The major component of the Kilarc Project is anadromous fish restoration in the upper Sacramento River. It is the intention of Davis Hydro, and hopefully that of the Foundation, to consider and address a broad and evolving list of activities as the funding and science develop. The following section proposes some ideas on the sort of work that may be undertaken as funding and community relations dictate. These ideas are discussed here not in an effort to proscribe a particular off-project direction for the Foundation, but rather to engender discussion and elicit further ideas from stakeholders, and include:

- Habitat enhancements,
- Genetics and epigenetics,
- Geospecific propagation of anadromy, and
- Research.

Habitat Enhancements

Habitat destruction and watershed modifications have been instrumental in decimating fish populations, and all parties are in agreement on the need for habitat improvements. With the agreement of stakeholders, either DH or the Foundation could potentially contribute to the following, discussed in no particular order:

1. Water temperature improvement,
2. Lateral tree cover
3. Ranch practices
4. Diversion screens
5. Diversion volume reducing total flow

H-1. Water Temperature

Many of the tributaries to the upper Sacramento River are very warm in the summer in contrast to its central parts. The presence of large upstream dams, diversions, and field run-off create temperature regimes that are a severe challenge to both the salmon and the steelhead (Thompson). This challenging high temperature of some of the tributaries to the Sacramento is exacerbated by the contrast of an unnatural very cold central stem of the river from Shasta and the warm lower branches of the tributaries such as the Cow.

The Kilarc hydro power plant has a small direct effect of cooling the waters in the Old Cow and the hydropower that can be generated by the continued operation of this facility can be used to generate revenue that the Foundation can use to reduce temperature stress.

H-2. Lateral Tree Cover

Lateral vegetation provides a number of benefits for the tributaries. It provides habitat for insects, shelter for fish from predators, as well as wood and leaf debris used by primary producers within the stream. The overhanging bushes and trees keep the sun off the stream, and cool the air above it. Finally, the longer woody debris generated by this vegetation provides complexity in the environment that is useful in providing a spectrum of micro habitats for both spawning and rearing, and some protection at all stages from predation by birds.

The importance of this cover, food, and material source as well as habitat for insects on which the fish prey cannot be overstated and therefore one of the suggested work areas proposed is a series of joint projects to increase this vegetation including:

- The provision of funding to hand plant brush along the Creeks starting with the Cow and working up and down stream. We would endeavor to involve the local community, for example by creating summer jobs for local young people.
- Similarly, utilizing local labor and youth participation could further the creek-side planting along neighboring ranch waters, while increasing community awareness and connecting young people and their families to the health of the river.

- Using parts of the canal as a nursery to grow large numbers of plant seedlings for transplanting to the lower Cow. About 0.5 miles[1] of the canal can be used for this purpose and the roots, especially on the uphill side, may provide habitat to the emergent fry for their first year. This could be coordinated with spawning and research projects and other work going on along the canal.

A key feature of a natural creek is the complexity of the stream, which provides many benefits for fish. We would hope to scale up work with bordering landowners to increase complexity especially along stretches of the Cow and South Cow where it is lacking, having sought streambed permissions and permits from appropriate agencies and solicited the cooperation of local ranches and local people. Davis Hydro could coordinate supply of materials and the Foundation could contract local firms to supply and maintain tree root balls, large boulders, and other stream impediments where appropriate and subject to availability of local materials and permissions.

H-3. Ranch Practices

The Kilarc Foundation will have at least one, and potentially several, Board members recruited from the local community. Since ranches predominate along non-public stretches of the Creeks, having active ranchers as Foundation directors along with fish resource representatives should increase their confidence in the project. The following sections outline why we feel their input is so vital.

3.1 Irrigation Field Runoff

Water leaking off the fields in the summer is hot relative to the Creek. Today, most habitat in this area is temperature-limited so that leakage of irrigation water back into the Creeks destroys fish habitat. In addition, water run-off picks up chemicals from the fields, including fertilizers, animal drugs, and animal wastes, virtually all of which are toxic to fish. These issues can easily be addressed through a straightforward, collaborative effort by ditch owners, Davis Hydro staff, and the Foundation.

3.2 Fencing and Ranch Facilities Location

It is currently common to see ranch animals standing in parts of the Creek, which is devastating to the structure of the spawning beds and juvenile habitat, and a source of direct pollution from wastes. If facilities such as feedlots and holding pens can be moved away from the Creeks in collaboration with local ranchers, natural soil processes can better absorb waste.

H-4. Diversion Screen Support

The irrigation diversion screens in and around the Cow Creek vary significantly in design, deployment, and the quality of maintenance. The reasons for such variance are many and even within any one screen over time DH would propose that, under the direction of the owners, Davis Hydro and the Foundation can facilitate diversion support services, including design, operation, and maintenance services, that meet the irrigation needs of water rights holders and address the concerns of resource agencies.

[1] The canal, especially the downhill side, cannot have large trees or bushes on it because of destabilizing effects such as piping.

Diversion design: Various diversions could be designed and built to pass fish up and down stream as efficiently as possible. Often the diversion is only a few feet high and an upstream fish passage – possibly a preformed one – could be maintained. For downstream passage, screens are suggested. Our preference is for exploring where possible out-of-channel screens with natural returns designed to minimize injury and post screening predation.

Diversion Operation: The day-to-day maintenance of a diversion is required as screens need cleaning and wear out, floods destroy physical facilities, brushes and gates wear out, and any moving equipment jams with stream debris, etc. This work is similar to maintenance of a hydro facility and there are efficiencies to be gained by using the same staff for both.

Diversion Maintenance: Diversions on the tributaries vary in all characteristics. What is common is that they need maintenance to be effective. By dedicating a project to their maintenance, the diversion could be more assured of correct operation at all times for the benefit both of the water users and the fish.

H-5. Diversion Flow Management

As discussed earlier, one of the greatest environmental problems in many of the tributaries of the Sacramento is water temperatures (Thompson) which creates an environment inhospitable to fish. As diversions of cool creek water into the fields contribute to this problem, we propose work with diverters to reduce the amount of water they use to just what is needed, ensuring more water will be left in the stream and reducing the average stream temperature in the summer months. The best model might include Davis Hydro staff being available where necessary to complete this task under the direction and with funding from the Foundation.

In Summary

Part of the Kilarc Project is fostering a cooperative nexus between the hydro operations staff and the community. Under the funding and sponsorship umbrella of the Foundation, with labor and facilities supplied by DH, it may be possible to work with the community to help operate their diversions to meet all the water needs of the ranchers and provide protection to the fish resources in several ways. Foundation/DH actions might include irrigation ditch management to eliminate Creek surface runoff, diversion-design to promote upstream passage, leakage management to reduce water loss, diversion maintenance, and/or fish return facility[2] maintenance. All of the actions proposed above have the potential to improve fish resources, and can be undertaken as integral hydropower operations. Most can be undertaken in the summer and can be completed by non-professional contract staff. Finally, a spectrum of other habitat enhancement project activities are “off project” and are discussed in Appendix 2.

[2] Fish return facilities are in-ditch, off-stream-channel, in-diversion return screens and channels for returning seaward moving fish to the creek from the ditch. These facilities have the benefits of easy maintenance and simplicity. They have the drawback that they remove a small amount of water from the streambed below the diversion to above the fish return.

Genetics and Epigenetics

To complement habitat improvements, we propose to work to enhance the intrinsic resilience of the fish themselves. Appendix 3 to this report discusses the key genetic and epigenetic issues that could guide anadromy restoration. There is a limited genetic component to anadromy as only some species migrate. Science is now clarifying both the genetic and epigenetic taxonomy of anadromy[3] and other features of these fish. It turns out that the behavior variability that is observed in *O. mykiss* can be explained not by genetics[4] (Clemento et al, Olsen et al, McPhee et al), but by epigenetics (Pavlov et al 1999, Pavlov 2008). While genetic differences are seen between differing populations of fish, it has not been shown that there is an anadromous genotype and a non-anadromous genotype that is consistent across geographic populations. Rather, as shown by Clemento, McPhee, Olsen, Pavlov, and others, that for a studied populations, the probability of anadromy is more associated with local environment than any genetic differences[5].

Epigenetics opens a significant window of opportunity to aid fish stock recovery. Unlike genetics, changes in the epigenome occur within a generation, and these can be passed, in diminishing intensity on to successive generations. Repetition of the associated stimuli strengthens the anadromous behavior; other coping strategies compete and diminish its probability and chance of success. This rapid adaptation is extremely significant as it means that coping skills learned in response to environmental pressures are passed on to progeny far faster and more flexibly that any genetic encoding. The epigenome is likely to be the primary encoding mechanism for anadromy and, if we maintain the environment correctly at time of imprinting, we may be better able to ensure Cow Creek fish are programmed for anadromy.

We recognize fully that, as epigenetic management science is still in its infancy, current available research can only suggest, rather than stipulate exactly which approaches are likely to be successful. This is an opportunity for Cow Creek and all anadromous management programs to benefit from and contribute to ongoing research in this field.

Programming

The epigenome is continually updated so that subsequent generations of fish that are anadromous reinforce the imprinting, and their offspring are more likely to exhibit this behavior than fish whose ancestors did not migrate. The converse is also true. Fish that do not migrate, lose the epiallelic encoding for anadromy. Reprogramming this epigenome, or teaching the Cow Creek fish to migrate, is a new complex art and likely to prove challenging.

That said, it is possible to cross breed local fish populations with exogenous healthy fish populations imprinted with patterns that enable and possibly encourage anadromy. To be a statistically successful outbreeding effort, these imported fish will have to be from similar temperature and disease profile populations have compatible base genetics (Frankham *et al*) to

[3] The concept of epigenome imprinting of anadromy is now sufficiently robust that it has permeated to Master's Level research (Garrett).
[4] Olsen *et al.* found no genetic difference between sympatric steelhead and resident *O. mykiss*.
[5] It may likely eliminate applicability of the Endangered Species Act since no genetic changes are at issue.

enable breeding of new, genetically robust, populations that also carry the epigenetic code that will compel them to migrate.

Homing

The epigenome is also the most likely location of the geospecific "homing" tendency of anadromous fish and carries the geo-specific "smell" of an area that guides an anadromous fish to their natal spawning ground[6]. The anadromy and "smell" imprinting of the epigenome, interacting with the environment, expresses signals that tell the fish when and where to migrate and how to survive difficulties such as artificial variations in temperature. This composite "information packet" is passed on to offspring, enabling the descendants of an anadromous fish from one area to return to that area. The urge to do so is literally encoded into every cell in its body[7]. If the temperature, chemical, light, and other environmental signals are right, the anadromy will be successful. If, however, fish are outbred with anadromous fish from other areas their progeny will be unlikely to hold a complete set of local environmental codes. As a consequence, they will be less able to recognize local environmental signals, and the likelihood of successful migration is dramatically reduced. An area of proposed research addresses the difficult task (Frankham p.381) of taking anadromous fish from one area and having them survive in another. Losses are very high and the risks of disease and outbreeding depression are prevalent. Thus, we need to find not only genetically compatible anadromous fish coded for anadromy, but due to epigenetic inheritance, also their epigenome must match similar environmental conditions to what the juveniles will pick up from their new environment.

In the upper Old Cow Creek, the "anadromous behavior" imprinting has been attenuated over time through inbreeding of fish that are resident-adapted survivors, weakening their migratory predilection and possibly capacity[8]. Separately, the "Old Cow is home" coding has been diluted through hatchery breeding and insemination of the Cow Creek area (CDFG). With this in mind, we will need to introduce new stocks of genetically compatible anadromous fish capable of breeding with Cow Creek's existing fish population, but whose epigenome also codes for anadromy triggered from environmental conditions found by their offspring in their new environment. While challenging, and known to be difficult this is far from impossible[9].

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[6] This "smell" response is a macro version of the epigenetic response of every cell beyond stem cells. Since every non-gamete cell in our bodies carries the same genome, it is the environment that induces it to develop certain structures and to take on certain behaviors. The epigenetic behavior of our anadromous fish is the aggregate manifestation version of this micro-encoded behavior. The balance between permanent genetic encoding and transient epigenetic encoding is clearest at the cellular level. When E.O. Wilson (Wilson) identified the genetic encoding of aspects of behavior in animals in his seminal work on Sociobiology, he did not then extend it to the cell, yet as it now turns out, it is at the cellular level where the epigenome exists and response to stimuli allows expression of the genes.

[7] Most important of course is imprinting onto the gametes for as in genetics, parts of the epigenome are transferred along with the genome to the offspring.

[8] Because of the difficulty of any upstream return in most years, the surviving fish that are the current source fish in the area will have only resident adapted fish left. Any with anadromous tendencies would have left and been statistically unlikely to return in significant numbers. The planting of hatchery fish in Buckhorn Lake would only exacerbate the limited genetic pool in the upper Old Cow area due to isolation.

[9] Frankham *et al* discuss at some length the difficulties of outbreeding. The further requirement of outbreeding so as to inject anadromy as well as a diverse genetic mix will challenge the search for suitable source population.

Someday, an understanding of the functioning and structure of the *O. mykiss* epigenome, and particularly how desired behaviors are encoded, will facilitate our assistance to these fish to re-establish this behavior. For now, as practitioners, we can start by researching how to expose fish to various encoding regimes at different life stages. We can husband fish that are genetically compatible and study methods for epigenome-encoding needed features of anadromy on their successful progeny. The multigenerational aspect of the epigenome opens some doors of opportunity such as to how to retrigger and rebuild the anadromous epiallele. Rebuilding anadromous populations is difficult to do on the genetic time structure (by competition and selection). Using the Kilarc Project facilities, we can study and we can heuristically use what we learn to help the fish far more rapidly than otherwise.

Geospecific Propagation

Conservation genetics suggests that fish living in one area are the survivors of all the environmental elements in that area. For this reason, we must implant fish in specific areas with the proper prior encoding not only for anadromy, but also for geospecificity. We want to bring the anadromous epialleles and the epigenetic survival coding of environment and behavior useful for survival in geographic locations of the upper Sacramento to promote rapid widespread dissemination of anadromous behavior. We hope to address this geospecificity/anadromy imprinting and timing science to foster anadromous fish populations at each and every different outbreeding location we can in the upper Sacramento River. Just as the "anadromous behavior" is encoded on the epigenome, so too the "home" location encoded on the epigenome from the environment of the fish. Understanding that the geospecificity of "home" is heritable through the epigenome potentially provides a solution. Research is needed to learn how to use, extract, or simulate the remote micro environments for our target populations, and properly expose fish.

Research

It is intended that the underlying research needed to support the above goals will be supported or carried out by the Foundation as described in Appendix 1. Davis Hydro is also keen to support this work by ensuring the availability of necessary facilities, human resources and through the supply of contract labor to support related activities. Further, Davis Hydro will undertake, as part of the public community access mission, an education element on the canal. DH will help support production, research, demonstration, and education work in the canal (Appendix 4), the Kilarc Lab (Appendix 5) with its nearby Cow Creek research area, and maintenance of the historic powerhouse (Appendix 6) improvements and other public outreach activities.

The research facilities at the Kilarc Project are intended and enabled as support for the anadromous fish resource improvements.[10] Most of the Kilarc Project research facilities will be maintained by DH and integrated into the generation facilities. Davis Hydro will independently undertake research to further understanding in their own areas of interest, and the facilities will be made available to groups recommended by the Foundation as space permits. Extraordinary

[10] Research is not normally recognized as a valuable component in FERC licensing. In this case, however, we are now fighting a losing battle to maintain *O. mykiss*, and our efforts would be incomplete if we did not explore how to stem and remediate this disaster. Since the key element we are addressing has just been identified as an epiallelic-encoded survival strategy, it is incumbent to explore how to use and extend this science as it develops.

efforts such as significant bed and canal modifications for research purposes will be charged to the Foundation as expenses[11]. Exactly how resources will be shared and allocated will be subject to discussion with all stakeholders and, we trust, will be facilitated by the extension of goodwill from all parties as all have an interest in and a desire for the success of the Kilarc Project.

Project Methodology Discussion

Natural Recovery

Without our intervention, it is unlikely that Cow Creek fish stock replenishment will be solely, or perhaps even principally, from local stocks. Their genetic diversity has been weakened, and resident-adaptation reinforced through inbreeding (Araki, CDFG). In the long run, without our acceleration, we are likely to see in-migration of alleles that may have a stronger straying and anadromous tendency than the populations we see locally now. Local stocks will need a mix of outbreeding and subsequently geospecific adaptation encoding necessary for survival. The descendents of these epialleles will eventually reestablish the fish here, and may then statistically develop anadromy as a survival strategy. Without our assistance, the re-establishment of anadromy likely will take many years.

An Alternative Proactive Plan

The scenarios[12] described here outline a current vision of how we would like to proceed. Knowing, as we now do, the challenge faced by these fish, after some study of the literature, and given the limited and declining genetic resources available, our first goal will be to work with agencies to build a strong less-inbred population derived from local California fish. To shorten natural re-establishment time, we will support, and sponsor, carefully orchestrated speeded-up outbreeding activities to re-establish a base population as locally adapted and as genetically diverse as is possible. On this new "local" genotype evolving genetic population base, we will then, over the long term, endeavor to impress anadromy.

The new generations of fish will continue to be challenged unless we also address much needed habitat improvements (described above and in Appendix 2). If we reduce pollution, water temperature problems and managing diversions the anadromous fish might regain an independent existence. Until then, our job, under the direction of the Foundation, will be to assist in every way we can, to maintain a healthy local genetically diverse fish population. DH will work to improve the habitat, and finally assist in every way we learn how to instill and enhance the epigenetic tendency to be anadromous.

Davis Hydro will do its part independently. DH will create the wet and dry labs, the office/bunkhouse space. We will put in the communications and data collection backbone for

[11] The general expected guideline for the relationship between hydropower under DH or its assignee and research under the Foundation is that non-DH projects will be accommodated at only the marginal cost to the facility; these charges might be for the value of the lost power during bed modifications, use charges for earth moving equipment, cost of specialized bedding material, or the purchase of in-situ cameras, or consumables or equipment for chemical analysis.

[12] See Appendix 7 for much longer ideotypic scenarios.

research safety, and production efficiency. DH will provide tools, machines, manpower, and a large facility in which to do research work. DH will do or sponsor, or encourage research projects to help the fish, and we will work with the community to help them meet their water and irrigation needs while helping the fish. We will stand ready to work with the Foundation to help them meet their objectives. If permitted, at the same time, due to our own interests, we will proceed with fish enhancements and research from internal funds independent from and irrespective of Foundation activity. The independence of the Kilarc Foundation is important for many reasons. The Davis Hydro project will be able to operate independently of the decisions of the Foundation and equally important the Kilarc Foundation will be able to operate independently of whoever takes over the Kilarc Project in the future.

Execution – A Cooperative FERC/Agency Process

Implementation will fall under the direction of the FERC. The licensee, Davis Hydro, or its assignee, will provide services and money to the Foundation. The Foundation is expected to have as its directors, agents of the resource agencies and the community. Davis Hydro will serve as an expediter during the early phases of the project but is not expected to have any continuing management role in the Foundation. Assuming Davis Hydro can obtain the Kilarc site in operating condition, we would immediately seek to set in motion an organization of the administration of the Foundation to prepare it for operation, including reconstituting the board of the Kilarc Foundation to include primarily resource agency, community, and science professionals. Significant funding for the Foundation will follow the realization of profits after necessary site maintenance, upgrades and repairs.

Encapsulated in Appendix 7 are examples of how we can go forward within the Federal, and State laws and FERC procedures. These fanciful but illustrative development scenarios are presented as “strawman” paths for discussion and realization that we can do this if we want to.

Davis Hydro is willing to discuss any reasonable variant that is economically viable and in the best interest of fish stocks[13]. DH has described in this document the dilemma we all face in fish resource restoration. Nothing will be more difficult. We have argued that leaving it to natural processes under the current genetic, epigenetic and habitat conditions will not have any reasonable success in our generation. We can develop the tools to shorten this passage. After studying the exploding literature in this area, we expect that any plan we start on in the area of genetics or genomics will not be the same in five years. We embrace that. The science is simply moving too fast. The fish population and its genetic diversity are collapsing underneath us and the forces against success are too clearly arrayed against us. We therefore are not asking for the acceptance

[13] Execution is currently dependent on agency decisions on whether they can accept an aggressive partner in anadromous fish enhancement. After some study of the underlying genetics and genomics, we are convinced that we are addressing important parts of the problem. We have become aware of some of the needed study, and implementation difficulties if restoration of this resource is to proceed successfully. We have tried to outline them here. We are continuing to study the application of the emerging sciences of restoration genetics and the new field of restoration epigenetics. We need to apply this new science to this fish if we are to be successful. Our job is to help them as much as possible in part by fording geographic distances seeking compatible alleles with the desired traits for implanting. As we do so - as we work in a field that does not yet exist - we will be putting the agencies and ourselves in the forefront of aggressive natural resource restoration. Learning will be difficult and full of setbacks, but failure is not an option.

of any blueprint, or even elements, other than the being allowed to work as major actors going forward in the recognition that if we do nothing the fate of the fish is clearer than if we act.

Next Steps

Davis Hydro advocates the plans put forth and outlined here as good for the fish in the short and long term. We hope this document conveys the depth of our commitment to the replenishment of fish stocks, the interests of the local community and the provision of green energy (A listing of Davis Hydro FERC filings[14] is included in Appendix 9. In order to help us realize this vision, we request some of the following steps be considered:

1. Review this Summary of the Kilarc Project

We invite comparison with and consideration of alternative[15] proposals. We are more than confident that this proposal provides greater depth of understanding of the problems faced, and goes further to involve the community in delivering more diverse healthy anadromous fish than any other current proposal. We believe that community trust and cooperation will be essential components of future environmental efforts and believe the project has the potential to deliver responsible green power and fish resource enhancement on a scale that is unmatched by any other private program in the area.

2. Critique this document

We would warmly invite stakeholder input into this proposal in an effort to strengthen and improve it. Most of what is presented here has been discussed in numerous previous editions most of which are cited in the annotated bibliography in Appendix 9. In particular, we would invite input in two areas:

1. How can the proposal be modified to meet the best interests of the fish?
This alternative is unlike a typical compliance/mitigation set of license articles and conditions. The approach suggested provides for collaboration with and funds a non-profit Foundation to deliver responsible green power and fish resource enhancement on a scale that is unmatched by any other private program in the area.

2. Ask, what is best for the fish?
Normally, “Adaptive Management Plans,” and their variants are anathema to FERC and hydro developers alike. Such is not the case here. We know that time and existing science are neither on our side, nor on the side of the fish. We will passionately and flexibly pursue the objectives stated here and hope to contribute to advancement of scientific understanding as we do so. To prevaricate or to do nothing, in the face of urgent and ongoing genetic and epigenetic collapse is not an option. In that light, is what we propose here a workable solution?

[14] This annotated bibliography is informal, and contains hyperlinks to most all of the source studies and opinions used by DH in developing this project.
[15] Appendix 8 to this summary again briefly compares alternatives. Much more discussion is contained in recent FERC Filings responding to NOAA and CDFG filings. These documents speak for themselves and are only touched on in Appendix 8 for brevity.

3. How can the proposal be modified to meet the best interests of the local community? In this instance, what is best for the community cannot be separated from what is best for the fish. If the community is negatively impacted– more threatened by fire – reduced in size, or has part of its livelihood and recreation destroyed by removing its *raison d'etre*, anger against the fish resource agencies and the fish themselves will be damaging and long lasting. In our investigations, in talks with ranchers and people bordering the Creeks – we are encouraged that all stakeholders clearly want to help restore the fish, but most express less willingness to work in partnership with the fish resource regulatory agencies. We believe that the support of the local community will be a vital component of resource enhancement efforts and should be included in the calculus of evaluating alternatives. The project structure described here has as its backbone efforts to increase fish stocks through funded community involvement, and extensive outreach and education.

Let us take a decision to save these fish and act as a community as a matter of urgency. All actions suggested in this paper will lead to uncertain results. Likewise, if the actions in this paper are not taken, the results will also be unknown, but it is likely that they will not be much different from the present conditions for many years. This, of course has yet to be shown. All parties agree that, whatever action is taken, the status quo should not responsibly be allowed to continue for long.

Davis, CA December 2010

Appendix 1 The Kilarc Foundation

Introduction

The Kilarc Foundation was founded in early 2010 as an independent institution to address anadromous fish restoration in the Upper Sacramento River utilizing funds generated through the operation of the Kilarc Hydroelectric Project. As a corporation[16], it is chartered and exists independently of Davis Hydro and the Kilarc Project. The Kilarc Foundation (herein referred to as the Foundation) provides a vehicle to complement and enhance the operation of the hydropower project in a way that can meet long-term environmental goals independent of any current actors.

Through the Kilarc Foundation, Davis Hydro will address problems affecting fish stocks in the vicinity, in order to create a population of healthy *O. mykiss* with the expression of anadromous behavior. Eventually, we hope to provide the Foundation resources to disseminate these micro-populations as outbreeding sources of throughout the small streams in the Sacramento Valley.

Programmatic Separation

The Kilarc Foundation operates independently from Davis Hydro and as a result can undertake projects far from the Kilarc Project boundaries. The Foundation hopes to work with a range of other agencies, conservation, and research entities, both private and not-for-profit, to accomplish its fish resource enhancement objectives. The Foundation can also undertake projects in furtherance of its objectives without approval of DH, FERC, or the complete agreement of any agency including members of its board. Today, we are in a world that does not easily fit into the legal or regulatory patterns of the past, and using an independent foundation with a dedicated purpose will provide flexibility to partner with both private and non-profit entities to fund conservation projects. In summary, the benefit from this separation is that the Foundation in pursuit of its objectives is not constrained by the limitations put on any of its constituents.

Community Connection

The Foundation as an independent agent can be tightly connected to the community. The Foundation can rechannel some of the current animus towards state and federal regulatory agencies currently being exhibited into understanding and acting on projects needed to improve local habitat. The Foundation can undertake fish enhancement project work with or without the use of the Kilarc Project framework or if conditions change any projects on the Kilarc Canal or Kilarc hydropower facilities directly. The Foundation will last into the indefinite future with a tethered source of funding and community connection as an independent agent of environmental enhancement, research, and education.

[16] The Kilarc Foundation was established as a Vermont Non-Profit corporation. Its incorporation papers, bylaws and other documents are available on request or on the Davis Hydro Web Site. It is there because we will be doing work on anadromy on some of our New England Projects in that state and New Hampshire. Should the Foundation become funded by the Kilarc Project, it would be appropriate to have it become a California Corporation with an appropriate local Board.

Foundation Project Choice

The Foundation is chartered to support *O. mykiss* and to support the increase in anadromous Salmonids generally. It is the intent of the Foundation to support anadromous fish resource enhancement projects. It is intended that projects will be local to the funding sources, and the directors of the Foundation will be drawn from local agencies, and local community groups. The current directors will direct the projects of the Foundation toward the support of projects in the area of the funding of the Foundation that, by intent, will be its namesake, the Kilarc Project. Should the Kilarc Project not succeed, the resources of the Foundation will be directed to help anadromous fish wherever its funding is available.

It is expected that the Foundation will be flexible in the pursuit of projects and research that balance short and long term resource gains as the science and income develop. It is hoped that the Foundation will be free to support long term projects, projects outside of regulatory structures, community projects, and will work to attract grants and other funding sources to complement that garnered from the hydropower from the Kilarc Project.

Appendix 2 Off-Project Activities

Administration

Generally FERC-licensed project regulation is contained within FERC-designated project boundaries. There are more exceptions to this as time passes in response to a recognition that environmental effects often extend far beyond project boundaries, generally handled with codified agreements among parties addressed in license conditions. The Foundation will undertake management and funding of virtually all off-project activities. In this case, most of the environmental proactive work outside of the labs and the canal will be done by the Foundation, with only a small amount work undertaken within the formal FERC project boundary.

It may employ Davis Hydro operators or maintenance staff as required, and may conduct projects and research within the Project Boundaries. The following sections describe some of these contemplated activities:

The Old Cow Bypass Reach – New Uses

The Old Cow Research and Production area is in the reach above the powerhouse and currently has an intermittent small population of trout, most likely descendents of resident fish present upstream. There is some habitat in the lower part of this reach, especially in the first mile or so upstream from the road bridge next to the powerhouse. This immediate area could make an excellent research area as it will have data coverage and is very close to the Kilarc Research Lab, and is easily accessible year-around.

Adjoining this area are several ponds and work areas that are fed from various leakages, and overflows from the Kilarc Canal. Davis Hydro has an understanding with the current land owners that these might be made available as experimental stock ponds, though details have yet to be worked out. While the exact projects to be undertaken here are unknown, the following are currently smaller projects of interest to DH staff that could be conveyed to the Foundation at the appropriate time:

- Fish counting and biometric identification and metrology – in particular the measurement of small fish and differentiation of small fish from debris in counters
- Informal Screening – in particular flood survival and maintenance of informal screens, fry screens, and screens with integrated counting technology.
- Redd formation in “difficult” unsorted gravels such as those of the upper reaches[17] that appear on the surface as ideal for fish spawning, but when dug, reveal a dense, nearly impermeable gravel matrix[18] fairly unsuitable for spawning.

The Old Cow can provide a spectrum of field opportunities to investigate the best ways to turn poor spawning conditions into good ones. This area could also be used to field test screens. The difficulty of a natural fish population migrating up this far can be turned to an advantage.

[17] See discussion of ongoing gravel study in footnote 31.
[18] These gravels are derived to a great extent from the adjoining incised banks which is why sorting is so poor.

Without natural migration, the area becomes available to study and test technologies that cannot be responsibly tested in a stream with a more reasonable probability of migrating fish.

Stream Diversion Screen Technology

New fish screens are in use around the world. They each have good and bad features. The simple question of whether some of these screens will work efficiently in quiet water can be answered in the canal screen testing areas of the Kilarc headrace.

The test setups can be used to evaluate maintenance needs and efficacy in real streams – real diversions. A starting show, test, and tell area in the Old Cow could be a walk up demonstration area for a myriad of screens in various states of testing and development.
Using the sections of the Old Cow as a test area – just upstream of the Powerhouse, for example, allows the public to come and see if and how these new screens work and what it takes to keep them maintained. Coanda[19], flat plate, and similar screens can be compared and improved upon to see if they can both be effective and withstand real stream conditions. Several of these designs may be useful for returning juvenile fish to the Creeks from diversion ditches.

A side purpose of these tests is a show, test, and tell objective aimed at local diverters to show how these screens can work to keep their diversions free not only of fish but also debris that is a constant headache of splitting boxes and orifices used in flood irrigation. Familiarity with low cost and reasonably low maintenance screens provides a mechanism by which the community can see how they can help save the fish independent of any regulation.

Pumping and Temporary Diversions

One of the problems in the whole of the upper Sacramento River is the large number of irrigation diversions scattered along the sides of the main stem of the Sacramento and many of its tributaries. In talking to ranchers and farmers who divert water, we have come to realize that a great many would like to be responsible and protect the fish, but are unwilling, and usually unable to install screens that would meet agency approval. This reticence can be for many reasons: the diversion is illegal, too small, intermittent, or commonly a lack of money. The diversion's owners may not have the ability to maintain a diversion, for reasons of ownership, law, health, organization, tenure, or responsibility.

Most irrigation pumps are essentially unscreened from the perspective of a 10 mm fish migrating downstream. These pumps deliver small fish into the irrigation water from the lift pump at an elevation at or near the top of the riverbank at steady rate. An area to be explored is: can a simple – perhaps portable screen be built easily and economically given various geometries of irrigation water lift outfalls? Perhaps a portable modular system could be designed and tested that is operated and maintained at no cost or involvement of the farmer. Approved diversion screens are expensive, and as with most conservation measures not in the interest of the person leasing the land. Approved diversions are generally massive concrete structures that have up and downstream passage built in and can require extensive maintenance. Can we look at ways around this?

[19] See for example, http://www.usbr.gov/pmts/hydraulics_lab/pubs/PAP/PAP-0841.pdf

A project might be to build along the upper sections of the Old Cow a series of demonstration diversions that have upstream and down stream features to show people informally how they can modify their diversion to be varying degrees of fish friendly. The temporal features of the diversion screens would be compatible with other projects going on in the Creeks such as screen testing, fish counting, anadromy triggering, etc. The fish diversions in the irrigation water would allow for surviving fish to be channeled back into the Sacramento River or into nearby creeks. Since each unscreened diversion is unique, the project can show various types of screens and diversions with varying degrees of construction and maintenance involvement. Each would have some analysis of what fish this would be effective for, costs, and maintenance issues.

The projects might have four different parts.

Human Engineering: The question how to best approach legal and illegal diverters and get them to cooperate in saving the small fish.

The Diversion Process: It is clear that nearly all the pumping irrigators in Northern California are illegal if they use Sacramento River water since there are “listed species” in the water. That said, when an enforcement action is not imminent, we seek to motivate cooperation of these diverters outside of the regulatory process.

Focusing on the pump and diversion physics: Can the diversion be designed better to reduce entrainment? Can the pump be better designed to do less damage to small fish? It is clear that not all small fish are killed by being pumped up 20 or more feet to be dropped onto an irrigation canal. This is clear from observation. It is also well-documented that larger slower-moving turbines or pumps have only a small morbidity and delayed mortality impact on some fish. The smaller the fish are, the better they do. A research and pragmatic anadromous fish protection question then is, “where and how can equipment be changed at low cost to protect the fish?”

The constant flow rate of pumped water makes some screening such as the Coanda practical and simple to assure optimal filtration. The small fish are screened and returned to the river via a pipe from the top of the riverbank. The constant flow, and the controlled conditions of the bank, make this process simple. It is conceivable that the return rate might be near 60 –80% based on fish mortality studies for similar larger hydro turbines.

The Return: One of the problems of nearly any fish screening and return process is determining how the fish can be reintroduced into the river without disorientation and resulting predation. A protected resting period is needed on re-entry to minimize predation by fish waiting at the outfall. This outlet resting function on active riverbeds is a worthy research question in its own right. What is needed is an acceptable return structure that is both economical and compatible with the unstable dynamics of riverbanks.

Research and Conservation Grants

Possible projects might include a revolving matching conservation easement fund. It may be efficient for the Foundation as a non-profit to put up matching monies for conservation

easements. Under the charter of the Foundation, these would have to be for fish enhancement activities along designated stretches of the creeks. Matching money for conservation improvements generally can be made available at the direction of the board of the Foundation.

Likewise as a non-profit, the Foundation could channel research monies more broadly for studies on anadromous fish resource sciences in new areas as they develop. Currently, we are witnessing a transition of understanding of the needed science and practice from genetics to epigenetics, since epigenetics is filling in explanations of the observed behavior unexplained by genetics. Who knows how that will develop? What is clear is that much research is needed in this field. How much can be done by or with the Foundation will have to be explored. It is the current intent of creating and using the facilities of the Kilarc Project partly as a research facility, and these facilities and the Foundation money might be useful in attracting more dollars to the area for the direct and indirect benefit of the species.

Anadromy Imprinting & Expression

This is fundamental, but very difficult field research. It is important because if we do not understand how to imprint and reinforce anadromy, and if possible, to trigger the anadromous behavior, we will be very constrained and much less effective in any restoration activities.

The work to observe environmental triggers is difficult in that it requires open field studies not only of the detailed environmental conditions seen by the fish, but also the behavior of the fish. We need to integrate the screening facilities contemplated in the above activities with close environmental monitoring to see when and what triggers the fish to move downstream.

A key area for research may be epigenetics. The temporal calculus of encoding parts of the non-inherited parts of the anadromy epigenome is undefined. Matching funds for epigenetic imprinting research with university faculty and students is suggested as a needed goal. It is unknown when, and how a fish acquires the tendency to migrate, and thus how most effectively motivate such tendency. The literature and our own writing divides *O. mykiss* into “resident” or “anadromous” based on behavior. It remains unknown under what conditions they acquire – if they do so, the behavior, rather than simply exercise an innate ability to migrate to sea and return. It seems possible, if not logical that the behavior is encoded to varying degrees and it is environmentally triggered. If so when? Can it be reinforced? Is the behavior passed on generation to generation like other epigenetic traits between generations, or is it embedded in the genes and passed on as any other genetic trait? The difference is profound not only in terms of the applicability of the ESA, but more important in what we can do to reestablish populations of anadromous fish.

We may be able to set up field lab conditions to test this. Exposing fish at different times of development to different stresses and see exactly what timing and conditions predict anadromy. This is valuable because once we understand the triggers or even the correlates of anadromy we can use that information to more efficiently induce or introduce that behavior in a new population.

Appendix 3 Genetics and Epigenetics

Current practice of anadromous fish conservation deals with habitat, passage, predation[20], and genetics. Genetics are likely to be of partial importance in the battle to reestablish anadromy in *O. mykiss*. What will be important - after, and independent of habitat improvements is the epigenetics of the species. Specifically, how can the emerging science of epigenetics be used to reestablish a healthy set of diverse populations of geo-specifically imprinted phenotypes that will exhibit the desired anadromous behavior in all the different sub-populations that will be necessary in the upper Sacramento?

The previous species-level-thinking model of Salmonid anadromy is that there are various sub-populations of genetically slightly different fish that have varying phenotypic tendencies toward anadromy (and other behaviors) in response to various environmental factors. This has been accepted dogma for many years. The difficulty with the theory is that in many populations there is little or no genetic difference between the anadromous and resident ecotypes. In addition, in some populations, there are genetic differences between groups of predominantly migratory and resident fish population on the same river, but it is not clear that these differences have anything to do with anadromy. They might be coincidental rather than in any way causal.

An updated and quite different thinking is that certain patterns of imprinting of a quasi-plastic *O. mykiss* epigenome by its environment will increase the tendency for a plastic phenotypic anadromous response to the environment of the upper Sacramento River tributaries. In short, the genetic expression of anadromy and many other phenotypic features of the genes are controlled by the epigenome. This epigenome can be effective over multiple generations. In some animals, the environmental effects on a gamete genome can be traced through several – sometimes tens of generations. The important point here is that the genome (and thus the species, however subsetted) is the same; it is the genetic expression that varies due to the regulation of gene expression by the epigenome.

This regulation of gene expression is controlled by a DNA methylation pattern. If this anadromous signature process on the epigenome can be artificially established or instilled though outbreeding, and propagated across generations, it might naturally propagate in sufficient numbers to generate a population of anadromous fish where none were there previously. If a robust anadromous epiallele attains a sufficient population that is stable and broad enough across a healthy diverse genetic base, we may be able to address and possibly, reverse the collapse of the genetic and epigenomic diversity and the deterioration of population health currently underway. This mechanism, phenotypic plasticity, appears to be present across a range of genetically different fish, so that the establishment of the anadromous response is related to the robustness of the population not necessarily to the exact composition of the genotypes[21].

Davis Hydro is presently involved in discussing methods for restoring the anadromous epiallele of *O. mykiss*. To do this, work focuses on understanding the evolving applicability of

[20] In this summary paper we only briefly address fish passage and predation with reference to screen technology.
[21] Since there is no role here for the "endangered species" in the sense of genetics, it will be an interesting question whether the intent of the law can be extended to epigenetics which is both inherited and environmentally imprinted.

epigenetics rather than genetics as applied to these fish. Most of the features of this field are being aggressively researched in humans and then extended to other animals because the nutrition and nurturing environment of the human genome create dramatic epigenetic effects on the phenotype whose effects can be easily measured in later generations. Similar effects are predicted in fish. These epigenetic effects are heritable and affect the descendant phenotypes for generations not unlike what possibly happens in humans. In fish, it is not easy to differentiate any epigenomic patterns at present along the genome that predict anadromy as the existing tools are too crude (Blouin).

The environmental effects on the structure and function of the phenotype are primarily within the span from gametogenesis in the parent to death of the individual. The intergenerational epigenetic effects decay, can be overprinted, and are reversible over a number of generations. The rate of decay is unknown. We know they are not limited to the life of the genome in humans. Reversal of epigenetic effects is inevitable and attenuated through the generations. In humans, as in fish, repairing, or modifying the encoding epigenome within a generation is the way the epigenome becomes encoded in cells including the gametes. During gametogenesis, this encoding is passed on, generation to generation, in some cases this is detectable in phenotypes for many generations. Thus, anadromy[22] is encoded, and amplified or diminished with the degree of repetition at or before the time of gamete formation. The "resident ecotype" is genetically similar to any other *O. mykiss* but without a strongly imprinted anadromy vector in its epigenome.

Given the similarity of the fish genome and its processes to the human, careful monitoring is suggested as the level of human research is currently at a very high level for possible medical interventions that would directly influence gene expression[23]in humans. Progress in this field will immediately be applicable to progress in understanding and managing fish behavior. We need to understand how to trigger, use, and amplify the encoding anadromy, and to suppress the behavior for residency in a population that has statistically lost its tendency to migrate.[24]

The reestablishment of a healthy anadromous population of steelhead will require major epigenetic work far beyond anything that has been contemplated to date. Specifically we are now aware of the dimensions of the tasks ahead to help this population. We are aware of the phenotypic plasticity of O. *mykiss* as well and the traditional conservation genetics we will have to use to re-establish this population. We make no pretense at understanding any more than anyone else exactly how to solve the non-environmental problems of the observed collapsed anadromous fish resources in the upper Sacramento. Simply put, the science is too new. But we are sure that the "genetic" solution involves a major contribution of epigenetic manipulation.

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[22] The macro phenotypic trait of anadromy is no different than any other behavioral trait, except that it has a political constituency, and thus becomes valued both for its sports value, but also as an iconic symbol of a macro habitat condition.

[23] The importance and universal applicability of research on how cells with fixed genes express themselves in real time cannot be underestimated. Results will be applicable to any genetic based disease such as various cancers, or in our case, behavior like ADD, or anadromy.

[24] In this paper we are focusing on anadromy, but this technique, once mastered may be even more useful for amplifying other traits that will help *O. mykiss* survive and prosper in a man-altered world. The ability to acquire a lifestyle to survive in the inverted temperature regimes downstream of dams, for example, may be equally or more valuable.

Upper Sacramento Restoration/Re-establishment Tasks

Genetic Basis

There are two major stages of restoration work that have to be undertaken, first is the classic restoration genetic efforts (Frankham *et al*). This is a necessary first step to provide a genetically stable population with enough diversity to provide for a healthy multi generation population with a wide range of genomes represented over several generations. This however, says nothing about anadromy, simply that there are enough different fish in an area to provide a healthy genetically diverse population on which epigenetic patterns can be imprinted. This is not a small step. It encompasses all the required work necessary to recover from genetic collapse due to hatchery operations and poor genetic tolerance to modern river temperature and chemical regimes.

Epigenetic Imprinting

As that traditional genetic restoration work progresses – hopefully under the leadership of the CDFG, there is an entirely separate additional work needed to infuse epiallelic imprinting of anadromy. We need to imprint anadromy on fish epigenomes so that they will trigger/express anadromy as a result of today's environmental conditions. A modern response sensitivity is needed that will trigger the appropriate behavior that will allow the fish to survive in the ecosystem we as humans have created for it. This work may be difficult, or it may not be, as these fish have shown remarkable adaptability around the world. The imprinting of anadromous behavior may take imprinting on both parents. It may take several generations of migration to imprint the anadromous epiallele with enough significant statistical reinforcement so that it can be reliably transferred intergenerationally. Once established in the stable population, it may last for several generations, declining over time. It may be sex-linked, thus requiring a higher degree of saturation before it is reliably expressed in a population, or it may have other unknown characteristics.

Once a healthy population of *O. mykiss* exists, its own straying tendencies will cause some of the variance in behaviors to lead to anadromy in some individuals. If these can return (obviously, not to the Kilarc canal directly) they will be stronger and may well be able to out-compete local *O. mykiss* at breeding. The difficulty of returning and breeding at Kilarc is the main reason it makes little sense to focus too much energy on establishing a wild resident breeding population there. Even if the returning fish could get up to the power house, and even if there were no competition from resident fish populations upstream, the generated population will be small and uncommonly accessible. This will inhibit the formation of a sufficiently genetically diverse and robust population on which the anadromous epiallele can be imprinted.

Geographic Diversity

Our field implementation approach is expected to be quite different from what has been used in the past. As we begin to define and acquire healthy alleles that have anadromous tendencies, we need to reinseminate them at early life stages, not only to the Cow, but also to all the small

tributaries of the northern Sacramento. We see that this is important so that whatever local genetic selection and local epigenetic imprinting that has been acquired can be passed down and mixed with stronger anadromous allelic imprinting from other – out-of-area, and hopefully non-familial related phenotypes.

The most effective way to do this is to choose some of the fish with the strongest anadromous tendencies from large genetically-diverse populations from similar climate, temperature, and chemical water regimes as we have here, but ones that have as weak inbreeding with Sacramento genotypes as possible. It is quite possible that these genotypes will not be from the West Coast of North America, but from northern Europe or Asia generally. What is desired is a diverse genetic community with a strong expression of anadromy; while at the same time we need fish whose epigenome is climatically adapted to regimes similar to the target areas here on the upper Sacrament River. Given these matches and assuming genetic compatibility, these fish hopefully will be able to interbreed profusely and not suffer from outbreeding depression or bring in any significant diseases to which the local geo-adapted fish have no immunity.

Propagation

Up to this point, we have outlined the environmental, genetic, and epigenetic work that has to be underway as part of any restoration effort. However, even having all these in place, there are several additional problems that have to be overcome:

The existing populations of resident-adapted fish living now in refugia in the upper area of the Sacramento will emit resident-adapted fish downstream into the indefinite future. This will put constant pressure on any imported anadromous epialleles. Further, assuming that there is significant inbreeding (CDFG), then they will contain many of the same genes as the fish downstream that are being interbred with foreign anadromous stock. How are these two factors to be evaluated? How is this to be managed? Do these fish contain useful location-specific attributes like disease resistance and other local-adaptation genes that will be an asset? This is unknown, and will have to be left to the work by the Foundation to discover.

A second problem is that the mission is the return of *O. mykiss* anadromy to the upper Sacramento River, not just some part of Cow Creek. Each different area of the River – each different creek, will have a different set of features that may or may not be important. Known ones to be considered include resistance to local diseases, local pollution, and local temperature patterns that are different depending on upstream releases and diversions. These are local adaptations. Conversely, each different area has a different “smell” so that anadromy imprinting on any fish that should migrate will be geo-specific on its return.

These factors mean that to successfully breed in anadromous tendencies from foreign stock, the best local alleles are probably different in every geographic area. This variety of local-adapted epialleles triggers the need for small population cross breeding, most likely done with parents taken from the target local areas. It might also be possible to raise numerous different outbred fry specific to different Creeks. It is possible that the headrace can be modified to keep different fry populations isolated. This will not be dramatic. Releasing pods of a few tens or hundreds of small fry into diverse Creeks up and down the Sacramento hoping that the different batches are

successful will be difficult to justify given that the measurement of the degree of success is difficult.

Summary and Impetus

Why is this element here? Why spend so much time with epigenetics, when clearly we first have to have a healthy stable diverse population on which to work. In summary, the answer is that it will be essential to understand, incorporate, and address in detail the difficulties of implementing an epigenetic imprinting on top of a base when that base population does not presently exist. Specifically, we have two missions that are not independent: first to have a healthy genome distribution and second, encasing that genotype in an epigenome that favors anadromy when triggered and when appropriate. The "when appropriate" is likewise not any historic pattern perhaps encoded in the underlying genome, but in modern signaling structure that addresses the modern world.

The first step will have to be the establishment of a healthy population of *O. mykiss* whether or not any in it are anadromous. This is essential; otherwise there is no population on which to have the anadromous epiallele develop. Restoring genomic diversity can only be the second step in a geographic area that is so challenged the existing population has collapsed.

We must proceed down these two roads because the only alternative is natural processes of straying and auto-stimulation of anadromy in fish that have a poor epigenetic predilection to support it. The work of the Foundation will have to be designed to supplement the natural processes, hopefully it will greatly speed up the reconstitution of robust healthy populations of the anadromous ecotype far faster than natural processes for reasons discussed elsewhere in this paper.

Appendix 4 The Kilarc Canal - Production, Research, and Education

Description

The Kilarc headrace, also called the Kilarc canal, is about 3 miles long. Roughly one third of its length is made of concrete channel and metal conduits. In these, there is no habitat possible and research is limited to fish kinesiology, and artificial fish passage micro-refuge design. Because the flow is regulated precisely, the canal is conducive to experiments on equipment that is applicable in conduits and other artificial structures. About a mile of the remainder of the canal, contains long uniform reaches that run along a north facing, forested slope. It is in these sections that different research and research/production studies can be constructed and conducted by varying local hydraulics from canal features such as boulders or boards, and tree cover from overhanging trees and brush.

Initial Projects

The following projects are of interest to Davis Hydro and are suggested for the Foundation to consider at this point. Currently, we are studying the science connecting anadromy and epigenetics. By the time we have funding for work, these ideas, expressed below, will be either greatly fleshed out or replaced as our understanding of the behavior increases.

Spawning beds – Experiments

Controlled and screened spawning grounds are expected to be part of the canal.[25] We are investigating the possibilities of using each of the production and research spawning beds differently to imprint different conditions on the fry in the gravel and perhaps during their first year of emergence. To do this properly the different groups will have to be segregated so that they can be can be imprinted differently. Clearly, this is a problem in a production facility, and clearly it is a problem in a public river or site open to vandalism. The open nature of the research station is part of the research mission.

The “problem” can be extended to research on screening and counting small eggs and fry. To the extent we can experiment with different groups of fry, we can investigate variability in identification and encoding various genotypes, alleles, and anadromous epialleles to be adapted to different target locations up and down the Sacramento River. One of the things learned from the hatchery study is we do not want large production from few parents. That triggers a research agenda on how to produce many geo-adapted fish from many, but specific parent population(s), on a production basis economically.

[25] We would also like to provide facilities for studying and perhaps breeding isolated populations of other species of interest such as red legged frogs to protect their genetic diversity. This discussion will go beyond the purpose of this paper.

Spawning beds matrix study areas

The facility will be modified to accommodate gravel beds of various sizes, hydraulics and covers to study fry development both in-gravel and during the emergence and first year of life. Davis Hydro intends to provide researchers with data links for doing in-gravel studies of trout egg development. The only limitation on this activity is winter ice sheets and the damage that these sheets will do to beds prepared for study the previous fall.

Video bandwidth is intended to be developed as an extension of the security system, and we intend to provide remote secure data gathering facilities linked to the new Lab near the powerhouse. The data facilities will be an adjunct to the SCADA backbone systems to be installed to control the site. The data links will allow for continuous sampling as necessary.

Due to the easy access and the outreach mission of the facility, it is likely that we will have live TV feeds to the public displays in the lab showing the developing eggs, alevin, or fry. A major commitment of Davis Hydro is to provide these facilities and connect people of all ages to the fish.

Micro Screens

There is a lot of discussion, regulation, interest in, and difficulties with small pore screens for the containment and channeling of small fish and fry in certain directions. The collaboration of Davis Hydro with the Kilarc Foundation and the cooperation of local landowners provide both laboratory scale and control coupled with field exposure in the Old Cow. In the canal, we can provision research areas with slowly varying flow; a myriad of screens and screen types will be built and tested. In the Old Cow near the powerhouse, field studies of the same screens can be tested and demonstrated in actual field conditions.

In the canal, we have partially controlled conditions – quite different than the open channel screens that might be field weather/flood tested and displayed down in the Old Cow. The screens to be tested here would be applicable in our conservation (epi)genetics, production facilities, and lateral vegetation microhabitat studies.

Fish Passage

In many cases, manmade conduit or lined channel has limited upstream migration. In this facility, specifically within the concrete flume sections of the headrace, with the data collection, in the summer, we can study the physical performance of fish in highly defined conditions[26]. Further, using the constrained geometry of the concrete channels, various types of hydraulic breaks can be installed and studied to see how fish of different sizes and types can use these hydraulic impediments to rest and pass upstream. Specifically, if a block – say a standard masonry concrete block is put in a concrete channel, it will provide shelter from the flow behind

[26] All canal activities, and this is no exception, will be vulnerable during and following winter cold snaps to the interaction of breaking ice sheets and any obstacles in the canal. Ice may limit canal activities in the winter. Any block might also stop an ice sheet or a small tree that has fallen in the stream and that tree held by the block will stop more debris causing quickly – and usually in the worst weather, a flooding condition. In the Kilarc canal, this is a constant problem, in that if there is any overflow, the supporting hill will be eroded quickly and the canal lost.

it that can be used by fish for resting while working upstream. It is expected that both the data link and the video links will be useful for this research.

Fish Kinesiology

The concrete channels provide long uniform channels to conduct studies of how well the fish are able to physically swim against long stretches of current. Due to the linear nature of the headrace, it provides a limited but low cost racetrack where fish released at one point can be tested for statistical passage at various distances against a range of currents. Different fish have differing abilities at different times in their lives to negotiate upstream against a flow. Because the flow in these concrete channels can be regulated by partitioning and controlled precisely, some of the concrete flumes make excellent places to study fish energetics.

Education

Since the end of the canal is accessible about 10 months of the year, it will have a public outreach and education component primarily maintained by Davis Hydro. The canal will have information placards in two kiosk (Mono Lake type) information huts describing various features of what is going on in the canal, and explaining how the works there help the fish. Other placards located at the canal and down at the power house will show the life cycle of the fish and what can be done by everyone to help them. Maintaining this type of information facilities is both expensive and frustrating; we recognize this DH responsibility in advance.

Another educational section of the canal might be used as a nursery for small brush stock for summer planting along the sides of the Cow.

Macro-invertebrates and Production

It has been suggested that if we can “section” off distinct reaches with different flora and fauna present, it may be possible to study local relationships between plant growth, macro invertebrates, and fry development. An objective of this area of research is to increase understanding of which vegetation is most effective in providing the best environment for fry development in adjoining spawning grounds.

Conclusion

It is not a purpose of this paper to know or specify research in this area, and we are sure that current ideas will be replaced or improved upon by fish biologists working for the Foundation. Exhibited here are ideas simply to show willingness and the breadth of possible projects for the canal when DH is working with the Foundation. Generally, DH is actively looking for partners who are interested in action plans to study the fish and testing ideas to help the fish. We are willing to consider cooperation and separate support in all variations of these projects, and hope that we can find partners who are equally intensely interested in helping this environment.

Appendix 5 The Labs

There are two buildings in the powerhouse area. The powerhouse is described in Appendix 6. The second building still standing is ideal for conversion to serve the hydro and the research. It was a transformer and switch building as originally constructed. It might be renamed the Kilarc Lab. We would like to refurbish the inside to accommodate the following facilities:

A Davis Hydro office. – The Office

The Kilarc Project office will probably only be one room with one or two desks and a series of monitors following the hydropower, along with local research and environmental monitoring. This station is expected to be visible through a glass wall by the public from the access hall. Since we propose no separation between the mission of the hydro and that of the whole facility, it makes sense to consolidate the functions in one room so that one person can monitor as much as possible. Typically, in most hydro operations, as in most fieldwork, there is a lot of remote equipment monitoring mechanical or biological processes with long periods of very boring monitoring. Since the hydro will have a SCADA system partially visible by the public, it will make great sense to extend this capability to research projects.

A museum-public access hall – The Hall

The small public access hall would look into the facility office where it could see readouts of the present hydropower and experiment data and conditions. It would also look into the lab where there would be displays showing the data collected at other times and perhaps an infra-red in-gravel video feed from experiments in the canal or up on the Old Cow. It might also have a display of historic pictures, live sound, data and video feeds depicting various parts of the facility and public access. We expect to have the canal security system tied in so that it captures the rapid movement of people catching fish and fish spawning for display on the monitors.

We also want to have live TV feed from the Pelton bucket areas of the turbines lit by strobe light so that:

a. we can see that the needle valve is focusing correctly and not blocked,
b. so that people can see how the turbines work, and
c. the SCADA system will have live feeds showing how much power is being generated,

Finally, other security camera video pick-ups will incidentally be triggered by wildlife as well as fishermen. We expect, based on our own encounters, to see cat, bear, fox, and eagle. Critical to the Foundation and DH mission is to engage the community in being a part of helping these fish thrive.

A Wet Lab

The Wet lab will be a space with Old Cow water continuously available for “lab bench” study elements, dissections, tag insertions and sample counting filter analysis, screening, and similar operations. The wet lab will include stone and stainless steel tanks, slabs and fish holding

facilities, possibly along with chutes to quickly return fish to the stream as warranted without harm.

The Dry Lab

The "Dry" Lab will have workbenches and desks for lab analysis of samples. It will have desks and cubicles all with DSL Internet data connectivity, refrigeration at 36º and –20ºF freezers, and shelves for sample storage.

Data and Experimental Support

Hardware and Infrastructure

Primary and Secondary Nets

Davis Hydro will construct redundant Ethernet backbone networks extending from the lab to the powerhouse, up to the forebay, up the canal to the diversion. These are necessary for operations and will be scrupulously maintained. They will have completely separate data paths. One will be designed as a modular Zigbee-based self-healing[27] mesh network. The second a tandem dual channel wireless based system with one router on the tower at the outlet from the forebay and a second parallel router on the hill to the north which covers the entire canal.

These nets will be used both for SCADA services along the whole canal, but also to collect whatever data the scientists will generate. The dual purpose is possible because the SCADA data traffic from monitoring and controlling flow in the canal is minute. The video will probably ride on these parallel networks.

Research Nets

As money permits, and possible research warrants, and if permitted, we will extend non redundant data nets up and possibly down the Old Cow for research purposes. These radio-based nets are similar to what we are designing in other venues for remote wind data collection. If permitted and if useful network R.3 will extend up to Buckhorn Lake for fish population, flow, and research project monitoring.

Video

Video: We expect to have video capability along the canal backbone for four independent reasons, site security, fish protection, public education, and research support. The cost of this service is now minimal, and will afford better protection of production and research equipment. It is now standard at our hydro sites.

Telecoms / Community Service

It may be possible to establish a public commercial telephone cell repeater in this area. This would provide cell coverage to Whitmore residents and the surrounding valleys. The elevation

[27] In this environment, random acts of incidental sabotage performed by hunting birds (eagles and ravens attracted to shiny surfaces) are common.

geomorphology of the forebay will made it possible to economically allow commercial public telecoms, video and Ethernet networks for both Project use and Community Services.

A Bunk House and Kitchenette

Fish and their predators can be very active at night[28], so it will be useful to monitor experiments locally at night, and/or on a continuous basis. Both DH and research people need local places to stay without continuing to lean on generous community members. The closest hospitality area is all the way back to Redding. Therefore, we would like, in the first few years to incorporate a bunk space and a few very small rooms for visitors to stay while engaged in hydropower operations, or – more commonly in scientific work at the site. This will allow for rested 24-hour presence for studying the following types of issues: nighttime upstream and downstream passage, predation feeding, and other research issues.

Operations

Normally hydropower operations are unattended most of the time assuming equipment is functioning properly. Other times hydro sites can be manned 24/7 with staff observing hydro operations during equipment problems or weather uncertainty. Typical examples include fires in the area, ice sheets, rocks, or leaks in the canal, screen management, fish counting, electrical problems, and other processes that need constant monitoring. The operations overseeing hydro operations are similar to those for many field experiments, so it makes a lot of sense to set up human and mechanical systems to assist in both functions. Once again, we see little conflict, and great economy in setting up joint projects and joint use of communications systems.

[28] For some unknown reasons hydropower problems tend to occur in the middle of the night.

Appendix 6 The Powerhouse: A Living Historical Monument

The powerhouse will be maintained in its present condition with only a few changes. The generator controls will have to be updated to comply with a new interconnection agreement and needs for remote internet-based telemetry and site management. In terms of looks and historical preservation, DH suggests that the current control panel will be maintained as it is with no changes for historical beauty. The actual control of the turbines will be turned over to a new inconspicuous PLC (programmable logic controller) that will comply with modern standards.

As an aside, automatic controls and interface with CALISO will be made for the control and dispatch of ancillary services. This is useful so that ancillary services can be sold into the capacity market. This service will reduce the need for generation capacity in California, reducing environmental burden.

In the yard in the back of the powerhouse we expect to have more information placards connecting the visiting public to the stream and its fish. The back area will also be fitted with a simple picnic table and benches.

Appendix 7 Example Paths Forward

Davis Hydro LLC as Principal

While this discussion refers to actions of Davis Hydro as the licensee, the hydropower operator, the research facility owner, as a "Davis Hydro" project, all small hydro projects are set up as their own corporations or LLCs to enable them to operate efficiently without interruption from any other DH project. The Foundation will be supported by the profits of the Kilarc Project, not Davis Hydro LLC, allowing it to operate independently from Davis Hydro. Funding the Foundation would be by a FERC license condition codifying this relationship for whoever takes on a new Kilarc FERC License in the future.

Scenarios

In the first year – or hopefully well prior to the transition, community and agency people come together and discuss what they want for and need from a continued Kilarc operation.

The needs and desires of the community have been made clear. Among other things, they don't want an increase in forest or community fire risk with the removal of the forebay. They would like their domestic water sources – to the extent that they are influenced by the Kilarc Canal to remain or improve. They want their Kilarc recreation unchanged and fishing related businesses to survive and they would like fishing generally to stay as it is or improve. The fish resource agencies want healthy fish populations as representatives of healthy ecosystems. These objectives may not be incompatible. There is no conflict here; only opportunity in that hydropower has the capacity to generate resources to enhance fish resources far beyond what would occur naturally. Natural fish resources, were they ever again to thrive here, would be limited by natural migration barriers. With work, under a new hydro operator interested in the fish, we can more rapidly create an anadromous population and improve other fish resources not only in the Old Cow, but up and down the Sacramento River.

The historic difficulty is that the resource agencies have seen the hydropower facility at Kilarc as a contributor to the decline of fish resources in the area. That is a difficult premise to sustain in the case of the Kilarc facility because of its temperature effects and natural barriers. This issue is discussed in Appendix 8. The solution proposed here is to constitute the Kilarc Project with a new FERC license so that it produces more fish and a healthier habitat than destroying the facility.

What would implementation of the Davis Hydro scenario look like? In the two sections below are two fantasies in that direction. These presented fantasy scenarios assume that DH is allowed to focus not only on using the Kilarc facilities directly for fish production, habitat maintenance, and research, but also will allow us to extend our work up and down the Sacramento River through the Kilarc Foundation. In the following two scenarios, there is no intent to suggest a final arrangement. Nothing presented here is to be taken as agreed to or even, in some cases, discussed. The ideas are presented here as starting points only to be improved on by people interested in creating solutions to a serious series of problems rather than on what cannot be done. Why not try?

A Possible Scenario I – PG&E Leases Kilarc

Year 1

This scenario assumes that the first year will be dedicated to repair of the facilities and the first half of upgrading the turbine controls toward eventual independent operation. This will be required by PG&E as part of the separation of the facilities. Depending on the amount of deferred maintenance, this work may take longer than a year.

This first year will see the discussion and start of the following projects undertaken by Davis Hydro internally:

1. A dual data backbone network installed to allow communication up and down the headrace for both operations, and environmental monitoring, and the beginning of the conversion of the old transformer building to an office/lab for operations and research.

2. The Kilarc Foundation will solicit directors from the appropriate resource agencies and from the community. They will review the charter, mission statement, and incorporation of the Kilarc Foundation and discuss how its structure should be constituted and who are the most appropriate directors.

Offsite Research

The offsite work evolved from what is presented here will be suggested to the Kilarc Foundation directors and staff. Environmental activities will include the initial stages of finding source populations that might be used to be introduced into the area. To the extent permitted and possible, genetic maps of local populations of rainbow will be made and examined for diversity.

Particular attention will be made to find and examine populations that have been isolated in refugia for a long time. Based on the 2010 CDFG hatchery Report (CDFG), we are not optimistic. The desire here is to collect as much information as possible about the diversity of geographically local populations. No attempt will be made at this stage to identify anadromous fish, only those fish that are as diverse as possible within somewhat similar environmental conditions. Resolution of what this “ancestral” population might look like, and whether a pre-Shasta Dam – lesser pollution tolerant genotype – adapted to their ancestral environment is appropriate or viable today will be both discussion and research topics – with no certainty of clear answers.

At the same time, we will start looking far abroad for *O. mykiss* that are living in similar habitat conditions. Work will proceed with agency and staff biologists exploring the question of balancing alleles that have expressed anadromy, local populations, and outbreeding populations that will be useful for increasing the health and genetic diversity of a re-established population. This is very complex work in a field that is poorly explored – especially in light of the new epigenetic understanding and manipulation of anadromy and geo-specific allelic specificity and

compatibility[29]. It will have to proceed slowly in that selection has to be made not only of the origins of populations and habitat compatibility, but also for disease transmission and simple genetics compatibility.

This genetic issue has to be addressed and the local population has to be started on as clear a path to a healthy balance of diversity and local adaptation as possible. Nothing here is said about anadromy, only that we want to establish a genetically diverse local population on which an epigenetic pattern can be developed, most likely through insemination from a distant anadromous population. It is uncertain how this can be accomplished in a community counting on continuous fishing. This may be impossible under the political pressure to dump millions of partially related trout into the streams for fishing. Prior reasoning suggests that if we end up with a continuation of the inbred hatchery populations, consequential genetic depression will continue and the concept of a self-sustaining population on which anadromy might be imprinted is not supportable.

In these initial discussions, the structure of the research has to deal with the stark reality that there is currently no genomic, and certainly no epigenomic map that leads to the expression of anadromy. Thus, we can only use this model for empirically exploring for the right balances of genetic and epigenetic mixing given only an initial understanding of the underlying mechanics. Later, we hope to do better – to be able to suppress or enhance genomic expression to regulate behavior, and geospecificity among other phenotypic traits.

Epigenetic work might start – if funding permits, and with a paper research program into what is the most likely imprinting mechanism, and what are the multigenerational aspects that can be expected for both imprinting and expression of our desired anadromous behavior. Given that neither the structure of the *O. mykiss* anadromous genotype has been defined or separated from the non-migrating genotype, an area of investigation will be to define what, <u>if any,</u> are the distinguishing genetic characteristics that are necessary, sufficient, or even indicative of anadromy across populations. This is not expected to be fruitful based on the extensive work that has found no genetic basis for anadromy in this summary. It might be useful to hold a small conference and clarify the question of, "If anadromy is not a genetic issue, not an endangered species issue, what is the highest and best use of our resources." We expect our work may evolve toward, "How can we best contribute to the science and use the results of research on epigenetics of anadromy?"

Meanwhile in our efforts to re-establish a healthy anadromous steelhead population, we note that one of the key determinants in defining suitable source populations for outbreeding are the congruencies of temperature profiles. By this time, Davis Hydro's temperature/ flow model[30] of the watershed should be complete and parameterized with sets of coefficients. The stream-flow/temperature modeling model will address:

[29] The paucity of references in this area is in stark contrast to the exploding research of the more nascent field of epigenetics. The latter abundance is because of the huge possibility of controlling the genetic message we are all born with. The field of human medicine is driving the research from obesity to disease remediation. If we are lucky, we will learn from the exploration of the human model a way we can help the fish.

[30] Davis Hydro has had a temperature study underway since the spring of 2010 measuring water temperatures in 10 locations in the Old/South Cow Creek watershed.

- Outflow past all points at varying hydropower flows,
- Statistics of temperature for all points,
- Typical, high low and extreme low flow model hydrographs, and
- Statistics on various high flows - for habitat access modeling.

These data will be the starting point for defining what are the potential source populations for outbreeding.

The ongoing Old Cow DH gravel structure and composition study[31] will be integrated with the flow model to make a coherent sediment transport model – matrix prediction model. The streamflow-sediment models will address spawning matrix quality, availability, and stability as predictors of a stream fecundity model. This will help us predict the best locations of spawning gravel for later inoculation.

Year 2

During this second year, we hope to make progress on three fronts: genetics, epigenetics, and habitat improvements. Genetically, we need to map out a re-introduction plan that will be considered for competitively displacing, outbreeding, or partially replacing the existing trout. It is unlikely that many of the resident-adapted rainbow trout in the main stem of the Old Cow will be useful in reestablishing a population that can grow into a healthy diverse population in a reasonable time. This is research in direct support of the reintroduction or more generally re-establishment of anadromy in the upper Sacramento River.

The early results of the epigenetic studies might be giving us some indication of the imprinting mechanism – or if not the mechanism, more likely when and how anadromy can be imprinted on the epigenome, and perhaps we can pull out of the literature, how to best use that information.

Habitat Improvements: Habitat improvements encompasses a full range of activities from community outreach to identifying the best spawning grounds to inseminate given whatever geo-adapted source are found to be most suitable. Locally, it is hoped that during year one and two local ranchers will be contacted to see if some joint projects could be started.

On matching incoming exogenous anadromous genotypes to spawning grounds, we hope that the models will be helpful, and applicable. Even if incomplete – and they will be, the models will sponsor asking the right questions about which fish should do well where on the Sacramento.

[31] DH also has been sampling spawning gravels since early 2010 for particle size analysis. This work is ongoing, and intended to give a picture of the spawning gravels in the area. Sediment transport and resulting structure is dependent on water and stream conditions. We are studying both the composition and structures of the gravels. This survey work, as we learn how to do it efficiently in the field, will become a tool for identifying the best future spawning grounds up and down the Sacramento tributaries. We also hope to be able to identify beds and to match the physical characteristics of these beds with those beds with which source populations are already familiar. The question this work addresses is, given that we might acquire fresh exogenous anadromous brood stock, how should we choose familiar soil structures, and where are the target spawning beds we want to inseminate with future anadromous progeny. To identify those locations DH has started to develop an understanding of statistical spawning bed fertility in the uncertain and dynamic natural riverbed environments.

Outreach – Beyond the Cow: Possible micro-spawning beds are found in many small creeks up and down the Sacramento River. While examining these for temperatures, pollution, and gravel, DH personnel will be checking out the results of the gravel prediction model.

Kilarc canal activities: There may be independently-funded research projects starting up in the headrace, and experimental production beds, screens and netting projects will start – possibly mostly in-house by Davis Hydro if outside funding cannot be found.

Year 3

During the third year, revenue from Kilarc hydro operations is expected to be significant and can provide funds for on and offsite projects. Onsite projects will be worked out with Davis Hydro – offsite projects will be started under the direction and funding of the Foundation. Any identification of what these might be is purely speculative.

Hopefully, some off-site ranch projects have been identified for collaborative arrangements, such as conservation easements, fencing, diversion improvements, or irrigation management systems. Up and down the northern Sacramento River DH has identified a series of small unscreened diversions for action. These are targeted for community-based fish return screens and programs.

Research: Davis Hydro will continue its own agenda of research on informal screening, spawning bed cover and hydrodynamics, and other projects in the canal – hopefully in cooperation and under the direction of some local academic research institution.

Davis Hydro in collaboration with CDFG continues inseminating carefully chosen remote micro spawning beds with non-hatchery trout to improve genetic mix up and down the Sacramento. The timing of these plantings has been determined in research, and the seed trout bred from robust epialleles pre-imprinted with anadromous tendencies from prior generations.

Year K

In this year, the Kilarc Project continues operation of the facility as approved by the resource agencies, and is no longer probational. PG&E surrender is accepted by FERC pending approval of a new license by FERC and acceptance of all forthcoming License conditions by all agencies. Davis Hydro applies for a new license with prior agreements of license conditions in-place with all agencies.

In this year, Davis Hydro will be operating small research projects in the canal and directly involved with co-funding small research projects related directly to its operation. Its operators will also be under contract to provide diversion maintenance services and perhaps ditchwalker services regulating irrigation water to provide just enough water to meet all needs with no field runoff.

The Kilarc Foundation is receiving about $ 87,000 dollars this year from the Kilarc Project. About 25 percent of this is matched by grants for various projects and conservation easements.

This year there was a $ 5,000 deduction made from the Foundation's support because it preferred to have flows change in the headrace in various manners for experimental design. The experiments were designed so as not to conflict with Davis Hydro's fry diversification and propagation efforts also in the canal. They were not completely successful.

Motorcyclists were caught on the security/wildlife TV cameras running their motorcycles through some research spawning beds.

Having anadromous trout in a stream has led forest practices to be modified because of anadromy in the streams and a loss of revenue. DH works with Sierra Pacific and other farm or resource companies for protocols and regulatory changes to reduce the secondary economic effects of inseminating streams in Placer County with anadromous trout.

Year N

With Dr. Ely in his 80's and the Foundation not listening to a word of his suggestions, Davis Hydro sells its interest in the Kilarc Project to a new owner/operator. The license transfer is approved by the FERC. This is the same year that PG&E no longer has any obligations for facility removal should the Davis Hydro plan fail. Up until this point, PG&E has been very cooperative in assisting the Kilarc project to succeed perhaps because it fosters community relations, helps the natural resources, provides green power, and saves the ratepayers the expense of facilities removal with its attendant lawsuits.

The number of trout now in the Sacramento River is increasing the number of lamprey, which prey on them. NMFS is shifting its focus from anadromous Salmonids to sturgeon. DH offers to construct a sturgeon diversion passage research lab near the confluence of the Old and South Cow. The ranchers in this area are anxious to help with the project.

DH continues its outreach to ranchers to gain permission to plant anadromous trout fingerlings in small streams further down the Sacramento River.

Scenario I Conclusion

If we take some steps out lined here based on the evolving restoration sciences, we believe we will be good position to help the fish. How we do that will primarily be up to the Kilarc Foundation. The Foundation will command when and how much of the surplus resources of the project should be spent. Clearly this scenario requires the work of all who want to see the fish restored. We seek their ideas on ways to make it possible.

An Alternative Scenario II – PG&E sells the Kilarc Site

For amusement and consideration, we now provide another (shorter) Scenario.

In this scenario, PG&E is allowed to sell its interest in the Kilarc site for terms that include providing a remediation bond or similar instrument to remove the site should the purchaser request it. This was a condition imposed by the FERC for the sale. In this scenario, the purchaser is the Kilarc Foundation. The Foundation has the obligation to spend about 100% of its income on fish enhancement projects. The Foundation leases the hydropower facilities to Davis Hydro for 30 % of the profits of operation, along with various commitments that allow for continuation of successful fish production and other research to continue with small amounts of support from the Lessee and continued use of various other facilities such as the lab and data links.

There are many variations, dependent almost entirely on what the more constrained participants want to do, and how we can best structure a long term entity that will best serve the community and the fish resources.

In this Scenario, the Foundation is the lead actor, and the lessor. Davis Hydro operates and maintains the hydropower site as lessee. Since the control is with the Foundation, and the Foundation has a mandate to protect the fish resources and the community, all objectives are served for the long term. The actions under this hypothetical scenario are as follows:

Year 1:
The Kilarc Foundation buys the site and a remediation bond callable for ten years from PG&E. FERC and the fish agencies approve the transfer since this will resolve all outstanding objectives on the Kilarc site. The license remains with PG&E for the time being. They are to hold the license until surrender that will, with the help of PG&E, create a strong functioning entity to support the community and the fish.

When it is clear that this will work, and a solution is found for the South Cow issues, the Surrender can be completed in the interests of all parties. PG&E again has every incentive to cooperate in that it wants the Foundation to succeed in its objectives so that it will not have its bond called to remove all the facilities. The agencies will cooperate because they will acquire a permanently-funded community partner in fish restoration and habitat enhancement.

In year 1, the relationship between all the parties is agreed to and implemented. Since the PG&E license is still operative and there is – in effect a new operator, there need be no break in power generation or community services. However, what will change will be a rededication of the facilities and all actors into a completely different formation.

In Year 1 and 2, we will have to be rebuilding the facility with new controls, interconnections and infrastructure to function as a non-utility generator on the PG&E system.

On the environmental side, The Foundation will be working with the DH staff to build the lab, rebuild the headrace, and make other changes to the facility to carry out its fish production, research, and fund generation agendas.

In Year 3 there are significant profits to start funding projects of the Foundation independently of Davis Hydro. As the funds became available, tree planting in the headrace was started, summer work on fencing a ranch was started and proposals have been written for match funding for some research work.

Year N (approximately year 5-6), PG&E will surrender their license, and a new one will be issued to DH or the Foundation.

Note again, these ideas are presented not as final work pieces, but rather as templates that suggest what is possible with cooperation and focusing on what is best for the future rather than what has been said in the past when the options were different.

Appendix 8 A Comparison of Alternatives

This is a brief summary of the arguments. For a more complete historic dialog filed with the FERC as well as supporting documentation, please see the references in Appendix 9.

Old Cow Habitat Changes

With the PG&E's demolition Alternative, the discontinued operation of the Kilarc facility generates an increased flow down the Old Cow that increases habitat and lowers temperature in the lower parts of the bypass above the powerhouse. This increase in mixed habitat would allow more fish to be sustained in that area[32]. The habitat created by returning water to the Old Cow reach might easily sustain more fish, but these fish would be descendants of the fish in the area. Currently, there are some small trout in the area[33], which most likely are the result of downstream emissions of the inbred resident population[34] of rainbow in the area from years of planting up at Buckhorn Lake. Irrespective of their origin, these fish are not anadromous, and any epiallelic tendencies to this end have long been eroded by residence-survival imprinting.

This resident encoded population then would, and may forever, overwhelm upward anadromous fish as the numbers will always vastly favor the locally adapted fish. This means that to the extent we improve the Old Cow habitat, the more "resident adapted[35]" fish would be produced. If and as population pressures in the reach mount, some juveniles would drift downstream to below the various barriers in the Old Cow and compete with anadromous fish of several species in Cow Creek and the Sacramento. In summary, the probable effect on anadromy from increasing flow in the Old Cow might be to increase the habitat in this narrow channel, but to the extent that it is successful in increasing *O. mykiss* population the more the area will emit downstream resident-adapted fish putting competitive pressure on any downstream anadromous fish downstream.

Effect on Downstream Habitat

As outlined by Thompson, in the summer, temperature is the major determinant of habitat in the Cow Creek. The Cow in particular, and the South and Old Cow – have large areas that could become better habitat areas with plantings, pollution moderation and temperature lowering. If water is removed from the Kilarc facility and put into the stream, it will be warmer when gets below the power house than the water coming through the turbines. The cold is primarily because of the speed of delivery from the cool waters through the high shaded position of the headrace, and in a minor way due to the cooling physics of hydropower[36].

[32] Numbers of fish are indefinite here, but it should be clear from existing surveys and fishermen's reports that an estimate of less that 10 fish increase would not be unrealistic.
[33] Recent (1990's) electrofishing study by Thomas R. Payne in the area below the powerhouse for the Olsen Hydro project found some juvenile fish. No adults.
[34] Trout are prevalent upstream of the Kilarc Diversion up to Buckhorn Lake. (ref: Personal report CDFG, local fishermen, and CDFG report from personal observation)
[35] This is also expressed as: *resident ecotype*, or *resident phenotype*.
[36] It is colder for reasons of physics, also. This effect can be understood by noting that a lot of energy is removed from the water through the export of electricity, rather than the stirring if the water as it comes downstream.

This means that if water is returned to the Old Cow, the new aggregate water coming down the bypass will be warmer in the lower Old Cow and warmer to a lesser extent in the Cow itself in the summer. Since habitat in this area is both spatially and temporarily defined by temperatures (Thompson), anything that can be done to reduce water temperature extends downstream habitat both spatially and temporally through the year. Further, the hydropower water is especially cooler in the summer. This cooler water lessens the extreme and inverted temperature difference between the Cow Creek and the main stem of the Sacramento River caused by low-level releases from Shasta dam. Since this temperature regime is unnatural, reducing the temperature difference may help imported and outbred alleles adapt to local conditions.

Possible Conclusion on effects in the Bypass

Given the small area of habitat that is increased in the bypassed region of the Old Cow, and the much larger and accessible area that with be affected by the small decrease in temperature from the operation of the Kilarc hydro plant, it is probable that there will be significant decrease in total local habitat, and thermal stress on all the fish in the Cow in the summer. Habitat area is one measure, but it is important to note that the lower Old Cow and the Cow itself currently have anadromous fish present in several species quite unlike the upper Old Cow[37]. These all will be negatively affected with certainty by the small increase in summer temperatures.

Widespread Habitat Changes

The destruction of this green power resource will have tiny but widespread consequences in terms of changes in Western United States generation for decades into the future. Since virtually none of the needed local, national, or global green house gas emission targets are being met (other than promises on paper), the demolition of this facility will speed the increase in global temperature rise due to the implicit continuance of reliance on fossil generation.[38]

One can argue that California should not be bearing the huge cost of Green power since we are now contracting for between $ 0.10 and $ 0.20/kWh for future green power. In this case, choosing the DH Kilarc Project Alternative will save California millions of dollars from not having to tear it down, and pay the high prices for replacement green power – were it available. Nor will we bear the economic social and environmental costs of engaging in destructive enterprise to make up for the lost recreation, fire, community, handicapped, and ecosystem services[39].

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[37] Based on all known observations, and as reported in the study for Synergics, owners of Olsen hydro just below the Kilarc powerhouse. The highest anadromous fish have been seen in the Old Cow is below the Lower Whitmore Falls, “several years ago” source: abutting ranchers.

[38] If this green power site is demolished, the continents will warm from these and other emissions, and fish like the steelhead are driven further north. There they will encounter less fishing pressure and an increasing land mass simply because of the large masses and clean rivers of Siberia and Canada. Thus, the warming effects of demolishing green power sources may be less than positive locally, but in the larger land masses, cold north, good habitat is opening and easily expanding. Using this logic, one can see why support for demolishing green generation facilities is strongly supported for the benefit of these fish.

[39] For further discussion of the detrimental effect on handicapped fishing, increased pollution from travel, and a host of secondary, indirect, and multiplier effects see the DH filings in Appendix 9.

Widespread Effects

While the consequential global warming may or may not be good for these fish globally, any gains must be balanced against the loss of habitat and fish by the acid rains from the fossil fuels that will be burned over the next few years. The poor buffering of the waters inland from this site in California and to a less extent across our country exacerbate the acidification effect and makes pH-sensitive fish vulnerable to the acid rains resulting directly and indirectly from the incremental diminution of green electrical generation. In summary, all downwind fish will be affected by the acid and heavy metals from the replacement fossil generation.

Separately, since the Kilarc facility already exists, the demolition of this facility and the construction of its alternatives will have economic and therefore environmental effects throughout the economy. These effects will have large multipliers due to the *de novo* construction and lack of substitution effects. These construction, demolition, and economic multiplier effects will be subtle and of a magnitude that may be far in excess of all other effects combined on the global fish resources.

The global effects are not only on fresh water fish, but the destruction of green resources is rapidly acidifying the oceans, reducing all fish not adapted to more acid conditions – for example all reef fish who are rapidly losing reefs on which to feed. While we cannot assume that local agencies include these effects in their evaluation, it is hoped that National Agencies have a broader domain for their calculus. The national and global effects of the contemplated demolition of green energy production will have small but devastating incremental widespread consequences. This is perhaps one of the clearest examples of thinking locally and destroying globally.

Finally, and briefly there are substitution of demand effects that will lead to negative impacts of fish. These include an increase in fire in the area with the loss of the Kilarc reservoir and a decrease in anadromous fish in the Cow and other Rivers nearby because of anadromous fishing pressure from fishermen who can no longer fish at the put and take fishing in the Kilarc Reservoir.

Genetic Diversity

Background

Hatcheries are wonderful at producing many millions of fry from a limited number of adults. The results of this are a collapse of the genetic diversity in any geographic area. Further, the descendants are related in numerous ways so that stealth inbreeding occurs among many more cousins than just genetic siblings. This collapsed gene pool leads to “genetic depression” which results a general failure of physical and perhaps cognitive functioning (Frankham).[40]

This specific genetic collapse in California is now well documented in the CDFG Hatchery Report (CDFG). This report shows the plenary destructive effects of hatchery practices on *O. mykiss* Sacramento River stock. What the otherwise excellent report fails to do is to address

[40] This is often proxied as size attainment, fecundity, or disease resistance as in human functional metrology.

adequately what can be done to restore diversity other than stopping their current practice of dumping hatchery fish to compete with possibly anadromous ones. This limited step is being done, and in effect our efforts will pick up from there.

Why is genetic diversity important? Anadromy has little to do with genetics beyond supplying a robust and genetically diverse population. However, this robust genetic base is crucial for the population to be stable enough to do at least four things – all of which are necessary for the future not only of the species but also for a subgroup that becomes anadromous. Genetic diversity provides:

- A genetic spectrum of genotypes from which evolution can happen,
- Enough variability to respond to any long term changes in environment,
- Protection from inbreeding failure with such manifestations as functional and physical failures to achieve potential, and most important for this discussion,
- A spectrum of genotypes that can present slightly different genomes onto which anadromous epialleles can be formed by the environment.

The adaptive behavior we seek, anadromy, is representative of a myriad of behaviors this fish adopts in various settings. Anadromy is the poster child of a healthy trout population with access to the sea. It represents, not just the most sought after form of *O. mykiss*, but it indicates a healthy population supporting this behavior.

The Do-Nothing Conundrum

Any Alternative that leaves the current population in place will rely primarily on the existing resident-adapted inbred fish. This genetically narrow population provides an obstacle to the creation and establishment of a healthy genetically diverse genome base. This will inhibit and delay population restoration efforts since a healthy diverse genetic base is needed for stable imprinting of anadromy.

The Demolition Alternative

The removal of the Kilarc facility may increase the prevalence of the resident ecotype of *O. mykiss* in the area of the Kilarc bypass. This population increase will lead to an increase in emission of trout juveniles downstream giving the appearance of an improving fish population. This is both counterproductive and bad biology. Due to the saturation of the local area with hatchery fish, and subsequent years of adaptation/selection to a resident lifestyle, any population count is misleading. Most likely, there may be far fewer genetically (or epigenetically) different fish than appear. Further, even the fish from different parents – i.e. non-brother and sisters may be close cousins due to earlier inbreeding. It is possible that to foster a healthy population, most of the local fish will need to be eliminated in order for there to be room in an ecosystem for a genetically diverse population to come into being in a reasonable amount of time.

In summary, the Demolition Alternative will have no known positive effects on the development of a prevalence of the anadromous epiallele. The demolition Alternative leads to a very slow increase in the number of different genotypes that will be present with small populations with

significant inbreeding. The limited number of different anadromous phenotypes compounds this depressive effect.

The Kilarc Project

Alternatively, under the DH proposal an active program will find the best genotypes for outbreeding local fish. DH will work to create a multitude of small micro-geoadapted populations with the allelic predilection for imprinting for anadromy for small insemination locations throughout the upper Sacramento River. This will be done over years of carefully balancing local fish and outbreeding with genetically distant populations that contain a significant percentage of anadromous individuals that are familiar with conditions we find at potential micro-spawning grounds.

Outbreeding has to be done carefully so as to preserve whatever coping mechanisms the local alleles have concentrated. These might include resistance to local physical, chemical, food predatory conditions, and/or diseases. This is not simple, in that almost none of these compatibility issues can be evaluated without trials; little of this is directly measurable[41] and we have started looking at those variables. What is worth saving in the local Sacramento genotype has to be carried by the limited genetic population, and balanced against not only the benefits of imported alleles, but also of the effects on possible out-breeding depression, lack of local coping adoptions[42], genetic mismatches[43], and diseases.

Discussion

Finally, there is as yet, no way to measure many of the outcome features or numbers of interbreeding fish with these important input genes and epiallelic factors in less than a reasonable number of generations. Any poor data on the important features of the existing parent populations makes epiallelic husbandry *ex post* analysis difficult. It is made more complex by the dynamic instability of the target and perhaps source environments. Measures confounding any analyses of programmatic efficacy include stochastic weather, varying tributaries, predators, and perverse temperature regimes that will be faced by any fish brought into the region.

[41] See the discussion in footnote 30and 31 for what we can measure. Further, many studies have been made of both most potential source diseases and diseases prevalent in potential target areas of the Sacramento.
[42] Anadromy along with migration in birds and mammals are examples of a local, transient, adaptive coping strategy.
[43] Just because two individuals can mate, and probably, by human selection, carry preferred alleles, it does not mean that they will be fecund (the mule is an example), or the offspring healthy (the local disease resistance may be overwhelmed or replaced by other allelic imprints) or viable.

Appendix 9 Davis Hydro Filings and Sources

Version 3.4a Dated June, 2010

This abbreviated bibliography contains some of the filings of Davis Hydro and the responses of the Review Agencies. Here is presented the ideas and background for June 2010. To see a more (to our knowledge, complete and up to date) list, please visit http://kilarc.info/Docs_Maps_Drawings/Docs_Maps_Drawings.htm.

The files included here either by us or by the Agencies are not comprehensive but are intended to be fully representative. Files that are not here include:

- Unofficial e-mails with agency staff and consultants,
- Notes on telephone calls with various parties, and
- Early filings and agency inquiries.

There are few references to the Tetrick Proposal. These documents are available on our WEB site at or the FERC WEB site.

DOCUMENTS

The following documents are in order with the more recent ones at the top. There are earlier ones not included here (see "older Filings" below), but these are a snapshot of our involvement. Each has a brief annotation.

The following is Davis Hydro Comments on the Requested Scope for the EIS (FERC dated 10-25-09). This is important in that it addresses again the breadth of the issues to be addressed in an environmental analysis. This paper does not discuss or describe our proposal directly. http://kilarc.info/Docs_Maps_Drawings/Documents/KC0495%20%20DH%20Scoping%20Filing%20(Replacement)%20and%20Errata_20091026-5005(22727524).pdf .

Below is our response to CDFG comments. - We agree!! with CDFG's concerns, but disagree with their conclusions **(**February 3, 2010). This is an important paper in that a response to the only comprehensive agency response to the Davis Hydro Alternative. http://kilarc.info/Docs_Maps_Drawings/Documents/KC0537%20DH%20Response%20to%20CDFG%2020100203DHon.pdf.

CDFG's December 10, 2009 response to our June 2009 proposal. In summary, they found it "very experimental, different, and untested" (see page 2) http://kilarc.info/Docs_Maps_Drawings/Documents/KC0507%20%20CDFG%20comments%20on%20Scoping%20Process%20-neg%2020091228-0038(23231988).pdf

Below is our August 24, 2009 comprehensive response to earlier NOAA FWS & CDFG comments on the scope of the Environmental Impact Statement as then defined by FERC. We

suggest that as presented, the scope is far too narrow to comply with the goals of the agencies. This document is not a description of The Davis Hydro Alternative, only discussion of the EIS Scope.
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0466_Davis%20Hydros%20Comprehensive%20ReplyComments.pdf.

Davis Hydro. 2009b. Project Scope and Studies. Davis Hydro Working Paper, K-4. Davis, CA. July 12, 2009. This described the important scoping variables to be addressed in and Environmental Impact Statement. It is available at:
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0460_Davis_Hydro_Supplemental_20090713-5112(22071630).pdf. FERC Accession No. 20090713-5165.

The (June 2010) Davis Hydro Alternative
The following are found in the FERC eLibrary filed under P-606: FERC Accession No. 20090619-5008 Davis Hydro. 2009a. The Kilarc Steelhead Project. **An Alternative to the Demolition of the Kilarc Hydropower Project.** Davis, CA. June 2009. Also available at:
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0432_Davis_Hydro_Alternative_20090619-5008(20985259).pdf. FERC Accession No. 20090713-5112.

NMFS comments on the June 8 2009 DH Alternative.
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0342%20NMFS%20Comments-P-606-4Aug08.pdf.

These NMFS refer to earlier November 2005 comments, on a much earlier and quite different, Synergics proposal. These NMFS comments call for a large number of studies and that will delay progress for many years. These comments are important because they show where NMFS is on this project, and implicitly why Synergics and PG&E abandon the project. The earlier NMFS comments are available here:
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0044%20NMFS%20comments%20on%20IIS.pdf.

Davis Hydro's **June 8 2008 Reconstruction Alternative contained almost all of the present ideas**. It is available here:
http://kilarc.info/Docs_Maps_Drawings/Documents/Alternative_1_June_20_2008/KC0336j%20Completete_June20.pdf.

Older Filings

There is also a previous version dated April 2008, included the South Cow improvements. There are earlier versions and versions that also addressed work on the South Cow, but the South Cow objective was separated due to realization that the valuable upstream habitat needed to be restored and that the Abbott Ditch water deliveries provided a key means of protecting downward migrating fish, if ranchers permitted it.

Other Supporting Documents and Maps

In January 2010, DH released an updated Salmonid discussion paper of research topics we wish to undertake. This has not been discussed with the agencies, so it is not included above. It is available here and as we learn more, it is being updated.

The following document discusses why the local BIG Timber company opposes our proposal. It also briefly addresses our solution to the Abbott Ditch problem on the South Cow. It does not comment significantly on the Tetrick Settlement Proposal.
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0541%20DH_Comments_on_Tetrick_Settlement_Inputs_20100205-5007(23419948)[1].pdf.

The following is a NMFS response to proposal (October 15, 2009). This is very brief and contains little.
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0482%20NMFS_10-15-09_comments_20091016-5005(22664858)[1].pdf .

Tetrick motion to intervene, outlining his Alternative is at
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0458_Tetrick_Alternative_20090713-5165(22073407).pdf

All documents filed with the FERC on this Docket are available at the FERC Web Site at
http://www.ferc.gov/docs-filing/elibrary.asp.

Others – some early news articles, and perhaps simpler to access to most documents are available from Davis Hydro at
http://kilarc.info/Docs_Maps_Drawings/Documents/docs.htm.

Davis Hydro Kilarc Project Maps are primarily included in:
http://kilarc.info/Docs_Maps_Drawings/Maps/Maps.htm.

Non Davis Hydro Kilarc Project Maps are primarily included in
http://kilarc.info/Docs_Maps_Drawings/Maps/Drawings.htm.

Photographs of the Kilarc site are available from Davis Hydro at:
http://kilarc.info/Pictures/pictures.htm.

Local Community Website with news releases and other community filings is available at http://savekilarc.org. {KC LLC has helped the Community Web sites from time to time.}

PG&&E is providing some of their larger documents, environmental reports, and response to the FERC's additional information request (AIR) filings at: http://www.kilarccowcreek.com/default.aspx . The latest AIR data are currently only available at the FERC WEB site or as a CD from PG&E.

Additional Sources Providing Context for Analysis

Presentation by Desiree D. Tullos, California Water Board, July 23, 2007, "The Science and Practice of Restoration - Ghosts of Rivers Past, Present, and Future" slides available at http://kilarc.info/Docs_Maps_Drawings/Documents/KC0262%20Tullos_Deseree_Stream%20Restoration%20July%202007.pdf .

FERC Accession No. 20070731-5001
Davis Hydro's Scoping Paper on the Kilarc and South Cow License Surrender Study Plans. This paper suggested Project Surrender Alternatives and Derived Recommended Studies Presented to FERC P-606 Stakeholders including The Save Kilarc committee, The Friends of Cow Creek Preserve, The Cow Creek Watershed Management Group, Associated Ranchers and Water Rights Holders, and The People of Greater Whitmore Draft for Comment and Consideration, July 2007 by Davis Hydro, from which both the Tetrick and Davis Hydro alternatives have evolved.

http://kilarc.info/Docs_Maps_Drawings/Documents/KC0235%20Davis%20Hydro%20Scoping%20Study%20Plan%20Draft%20II.pdf.

FERC Accession Nos. 20070427-5112, 20070517-0080 and 20070531-3003
Notification of Intent to Seek A New License for FERC Project No. 606 Kilarc-Cow Creek of Davis Hydro LLC
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0070%20KC%20LLC%20%20NOI.pdf and this was denied by the FERC.
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0170%20FERC%20rejection%20of%20request%20to%20hold%20for%20filing%20of%20NOI.pdf.
This was preceded by Letter of Davis Hydro to FERC General Counsel Re: Future Licensing Options and Priority for FERC Project No. 606 Kilarc-Cow Creek (not available on eLibrary, but only at link below)
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0060%20FERC%20General%20Counsel.pdf.

Kilarc Project Related Environmental Studies

Hatchery and Stocking Program EIR/EIS California Fish and Game. This document and associated studies address the very issues raised by Davis Hydro in their Kilarc Proposal. That is the issue of genetics. This document is very large and exhaustive but addresses comprehensively the problem that the whole area is perfused with hatchery fish and now we must do something about it. The resolution of this issue is addressed at length in the genetic issues and direction outlined in the Davis Hydro Alternative. Their study is available here: http://www.dfg.ca.gov/news/pubnotice/hatchery/.

PG&E's Biological Assessment (Internal Draft) August 2009, Available from FERC – Elibrary as Pacific Gas and Electric Company (PG&E). 2007. Kilarc-Cow Creek Project, FERC No. 606, Aquatic Habitat and Fisheries Resource Report. Prepared by Entrix, Inc., Concord, CA. November 2. Available at:
20091026-5005 FERC PDF (Unofficial) 10/25/2009 10:28:01 PM
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0328 Aquatic Habitat from PG&E Dec4 2007.pdf .

Cow Creek Final Watershed Assessment 2001.This is available at http://kilarc.info/Docs_Maps_Drawings/Documents/KC0007%20Cow%20Creek%20Final%20Watershed%20Assessment%202001.pdf. It is 25 Megabytes.

Regarding temperature effects on Salmonid habitats in northern California, see Thompson, Lisa C., Larry Forero, Yukako Sado, and Kenneth W. Tate, *Impact of Environmental Factors on Fish Distribution Assessed in Rangeland Streams* in California Agriculture, Volume 60, Number 4, pp. 200-206.
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0090%20Lisa%20Thompson_Paper_Impact%20on%20Fish.pdf. and
http://kilarc.info/Docs_Maps_Drawings/Documents/KC0260%20Thompson_Lisa_%20July_2007_Restoration_Paper.pdf. "Stream Ecology from a Fish's Perspective: Habitat, Connectivity, and Flow" – a collection of 57 slides presented by Lisa Thompson and to be filed shortly on the FERC eLibrary under P-606 for reference in this proceeding.

Studies commissioned by Davis Hydro, from which both the Tetrick and Davis Hydro alternatives have evolved, include:
FERC Accession No. 20080707-5045 (4 documents found at pages 25-41 of FERC-generated pdf).

An exploratory paper written by the Environmental Ecologist: Ms. Ayako Ohara's (ne: Kawabata) , "Feasibility of a Fish Production Facility in the Kilarc Canal, A Field Report, June 2008" available at
http://kilarc.info/Docs_Maps_Drawings/Documents/Alternative_1_June_20_2008/KC0336k%20Research_papers.pdf.

Davis Hydro Commissioned a brief review of our proposals as they were developing. Cramer Fish Sciences (Joseph Merz & Bradley Cavallo), "Fishery evaluation for South, Old Cow Creek Hydroelectric Facilities" available at
http://kilarc.info/Docs_Maps_Drawings/Documents/Alternative_1_June_20_2008/KC0336f%20Cavallo%20Fish%20Biologist%20Report%20043008.pdf

StreamWise Stream Assessment and Restoration (Rick Poore) reviewed the possibility and the work required to make nature like spawning beds in the headrace. "Observations made during our April 2, 2008 site visit to the South Cow Creek (Tetrick Ranch) and Old Cow Creek (Kilarc) project areas" available at
http://kilarc.info/Docs_Maps_Drawings/Documents/Alternative_1_June_20_2008/KC0336g%20Poore%20Restoration%20assessment.doc

Todd Sloat Biological Consulting, Inc. "Summary of observations made on 2 April 2008, at the Kilarc project area" available at
http://kilarc.info/Docs_Maps_Drawings/Documents/Alternative_1_June_20_2008/KC0336h%20Sloat%20Endangered%20Species%20Winter%20Report%204-14-08.doc.

MAPS

To start: A good overview Map of the Headrace/spawning grounds is here:
http://kilarc.info/Docs_Maps_Drawings/Maps/Other%20Maps/Figure_1_Labled_The_Kilarc_Alternative.pdf

Davis Hydro and PG&E maps at various resolutions are available from Davis Hydro at:
http://kilarc.info/Docs_Maps_Drawings/Maps/Maps.htm.

In particular, electronic pdf versions of the GIS maps shared at the September 27, 2009 Second Annual Community Picnic at Kilarc Reservoir, that will also be distributed at the site visit and FERC scoping meetings next week, are found at the following links:

Figure 1 - The whole Kilarc canal showing major features
http://kilarc.info/Docs_Maps_Drawings/Maps/Other%20Maps/Figure_1_Labled_The_Kilarc_Alternative.pdf.

Figure 2 - The section of the canal showing the first two Upper Spawning sections and fish return features. (not readily accessible from the picnic at the forebay)
http://kilarc.info/Docs_Maps_Drawings/Maps/Other%20Maps/Figure_2_Labled_Alternative-Diversion_Area.pdf.

Figure 3 - The Lower Section of the canal showing the fish return options.
http://kilarc.info/Docs_Maps_Drawings/Maps/Other%20Maps/Figure_3_Labled_Alternative-End_of_Study%20Area.pdf.

Forthcoming Data

Davis Hydro is in the process of developing and will supply GIS-located photographs of the entire Kilarc bypass taken every 50 to 75 meters. The photos focus on the falls, barriers, cover, and condition of the stream bottom. They include photographs of possible gold working artifacts from the Kilarc bypass region that are.

1. • Photographs of ospreys in the forebay and snakes eating fish in the Old Cow.
2. • GIS located gravel samples from the lower half of the Kilarc bypass.
3. • Mosaiced low altitude aerial high-resolution photographs of the Kilarc canal and bypassed Old Cow Creek.

Appendix 10 References

(with notes, underlining for emphasis, and partial abstracts)

Since this paper is not intended for scientific publication, comments, partial abstracts, and Web references have been added for transparency and access.

Araki H., Cooper B, Blouin MS. Genetic effects of captive breeding cause a rapid, cumulative fitness decline in the wild. Science.;318(5847):100-3, 2007
http://www.ncbi.nlm.nih.gov/pubmed/17916734?dopt=Abstract

Aubin-Horth, N., Landry, C., Letcher, H., and Hofmann, H. Alternative life histories shape brain gene expression profiles in male of the same population. Proceedings of the Royal Society B. 272, 1655-1662, 2005

Blouin, M. S., Virginie Thuillier, Becky Cooper, Vindhya Amarasinghe, Laura Cluzel, Hitoshi Araki, and Christoph Grunau
Note: No evidence for large differences in genomic methylation between wild and hatchery steelhead (Oncorhynchus *mykiss*) Can. J. Fish. Aquat. Sci. 67(2): 217–224 2010
http://rparticle.web-p.cisti.nrc.ca/rparticle/AbstractTemplateServlet?calyLang=eng&journal=cjfas&volume=67&year=0&issue=2&msno=f09-174

CDFG DFG Hatchery Operations Final DFG Environmental Impact Report (EIR) / Environmental Impact Statement (EIS) released January 11, 2010
http://www.dfg.ca.gov/news/pubnotice/hatchery/

Clemento, J., Eric C. Anderson, David Boughton, Derek Girman and John Carlos Garza
Population genetic structure and ancestry of Oncorhynchus *mykiss* populations above and below dams in south-central California Anthony Conservation Genetics Volume 10, Number 5, 1321-1336, 2008
{Abstract: Genetic analyses of coastal Oncorhynchus *mykiss*, commonly known as steelhead/rainbow trout, at the southern extreme of their geographic range in California are used to evaluate ancestry and genetic relationships of populations both above and below large dams. Juvenile fish from 20 locations and strains of rainbow trout commonly planted in reservoirs in the five study basins were evaluated at 24 microsatellite loci. Phylogeographic trees and analysis of molecular variance demonstrated that populations within a basin, both above and below dams, were generally each other's closest relatives. Absence of hatchery fish or their progeny in the tributaries above dams indicates that they are not commonly spawning and that above-barrier fish are descended from coastal steelhead trapped at dam construction. Finally, no genetic basis was found for the division of populations from this region into two distinct biological groups, contrary to current classification under the US and California Endangered Species Acts.

Frankham, R., Ballou, J.D.,Briscoe, D.A. Introduction to Conservation Genetics, Cambridge University Press 2010. {Core study text}.

Garrett, I. D. Masters These Proposal Stream Environment Effects on Gene Expression: Developmental Plasticity and Life-History Strategies in Oncorhynchus *mykiss*. PORTLAND STATE UNIVERSITY 2010
http://web.pdx.edu/~justc/courses/GrantWriting/10GrantWritingDraft2/GarrettIan.pdf

Ho, D. H., W.W. Burggren, Epigenetics and transgenerational transfer: a physiological perspective The Journal of Experimental Biology 213, 3-16 2010
{An excellent plenary discussion of the transgenerational aspects of epigenetic field as of 2009}

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Kittilsen, S.; Schjolden, J; Beitnes-Johansen, I; Shaw, JC; Pottinger, TG; Sorensen, C; Braastad, BO; Bakken, M; Overli, O Melanin-based skin spots reflect stress responsiveness in Salmonid, Fish Hormones and Behavior [Horm. Behav.]. Vol. 56, no. 3, pp. 292-298. Sep 2009

{Shortened Abstract: … Within animal populations, genetic, epigenetic and environmental factors interact to shape individual neuroendocrine and behavioral profiles, conferring variable vulnerability to stress and disease. … Here we show that individual variation in stress responsiveness is reflected in the visual appearance of two species of teleost fish; rainbow trout (Oncorhynchus *mykiss*) and Atlantic salmon (Salmo salar). … Taken together, these data demonstrate a heritable behavioural-physiological and morphological trait correlation that may be specific to alternative coping styles. This observation may illuminate the evolution of contrasting coping styles and behavioral syndromes, as occurrence of phenotypes in different environments and their response to selective pressures can be precisely and easily recorded.}

McPhee M. V, Utter F, Stanford JA, Kuzishchin KV, Savvaitova KA, Pavlov DS, Allendorf FW. Population structure and partial anadromy in Oncorhynchus *mykiss* from Kamchatka: relevance for conservation strategies around the Pacific Rim. Ecology of Freshwater Fish 2007: 16: 539–547. 2007
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"… We found lower heterozygosity in Kamchatkan populations compared with North American populations, but population structure was substantial (region-wide FST ¼ 0.11) and followed an isolation-by-distance pattern similar to that reported for older North American populations. We found no evidence for genetic divergence between resident and anadromous individuals in the Sopochnaya River or between typically anadromous individuals and 'half-pounders' in the Utkholok River. A review of other studies of reproductive isolation, in combination with our results, suggests: (1) that pristine populations of steelhead should be expected to exhibit partial anadromy; and (2) that managing anadromous and resident individuals separately without demonstrating reproductive isolation is biologically unsound."

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Techniques to define: " Detection of anoxia-responsive genes in cultured cells of the rainbow trout Oncorhynchus *mykiss* (Walbaum), using an optimized, genome-wide oligoarray The breadth of mechanistic analyses of environmental stress responses is greatly enhanced by the use of contemporary post-genomic screening technologies, notably including massively parallel transcript analysis by microarray. These genome-wide investigations are entirely dependent upon the creation of a suite of resources that are directed against the species under investigation. Here, the authors describe the use of in silico techniques …"

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