North Pacific Research

Saving Salmon

Draft

Interim Report rev 7.00

(An Unfunded, Independent Review of the Science Surrounding the Salmon Issue)

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Executive Summary

The current effort to save the salmon is concentrating on the river physical habitat, (i.e., riparian zones, water temperature, condition of the river bottom, rip-rap, culverts, obstructions, etc.). The probability of success from this approach alone is low. Simply stated, the survival of any species depends on three factors: food, predators and physical habitat. Physical habitat is about 30 percent of the problem. Salmon spends 2/3 of his time in the ocean, thus the ocean represents about 20 % of the total problem and the remaining 10 % is divided between the rivers and the estuaries. Therefore, the river physical habitat represents about 5% of the problem.

River Physical Habitat

Research as early as 1950, shows that river habitat was not necessarily connected to salmon decline. Later core sampling of the ocean floor shows that ocean fish and salmon declined similarly casting doubt on the role of river habitat in the decline of salmon. Recently the on-going Keogh River study shows the decline in salmon population is not related to river habitat and that the present approach to habitat reconstruction is not performing as expected. Studies on 23 tributaries to the Columbia River show that popular human conceptions of proper river habitat are not the same as the salmon's conception of proper river habitat. Streams with "poor" and "bad" habitat are out producing streams with "good" habitat. Excellent stream habitat is available, but is not being used by salmon.[1] **We have been using incomplete science to save the salmon for 100 years; maybe we should begin to listen to our rivers.**

[1] Reeves, Gordon H., Everest, Fred H., Sedell, James R., Hohler, David B., 1988, Influence of Habitat Modifications on Habitat Composition and Anadromous Salmonid Populations in Fish Creek Oregon.

If we want to save salmon, we need to look at the other 95% of the problem, predators, food, and ocean conditions. Recent research has shown that in the last 100 years there has been an increase in number of predators, decrease in food supply and change in ocean conditions, all factors, which would produce a decline in salmon population. Contrary to popular belief, there are considerable opportunities that can be addressed in these areas that will markedly improve the salmon population; for example, effective predator management and nutrient restoration programs.

Predators

To ignore the role of predators in the drastic reduction in salmon population over the last 100 years is a major oversight in the current science. A partial list of salmon predators includes at least 137 different species. One often-cited reason for the decline of the salmon is the over-fishing by humans between 1870 and 1920. However, one must realize that human fishing exists on salmon left to us by the other natural predators. Since the turn of the 20th century, legislation has been passed to protect many of the salmon's predators and their habitats. The result is that the total number of salmon predators has been on the rise since the early 1900s.

Sea lions, harbor seals, northern fur seals, gulls, cormorants and Caspian terns are responsible for the loss of almost 200 million salmon per year. Evidence shows that at least two species, sea lions and cormorants, are at historic population highs. In addition, these six species are also responsible for a substantial reduction in the salmon's food supply because they also prey on food sources common to salmon. **It is true that one reason salmon are in decline today is over fishing. However, it is by nature and not by man**. "It seems that marine mammals are managing men and salmon."[2]

Since there is a strong connection between the amount of prey and the number of predators, if we increase the number of salmon by any means without artificial predator control, we will simply increase the number of salmon predators. If we are ever going to get salmon back into the rivers, we must reduce the over fishing by predators.

Food

In the ocean and the rivers, the salmon sits at the apex of the food pyramid. The base of the pyramid consists of basic nutrients that include nitrate, phosphorus and potassium. It takes large amounts of these basic nutrients to feed the next layer, simple microscopic plants that manufacture their food from sunlight and these nutrients. Sitting on top of the simple plants are simple animals. Sitting on top of the simple animals are all the rest of the aquatic life including salmon.

There is only a finite amount of food on this planet and very little goes to waste. Current programs are designed to provide old growth forest and pristine streams. These are very pleasing things but in truth not very functional. The studies of 23 ColumbiaRiver tributaries and the paired river study in Canada concluded that pristine streams are starving our fish. In other words, clean water is dead water. Studies also

[2] Parks, D.L., 1993, Effects of Marine Mammals on Columbia River Salmon Listed under the Endangered Species Act. Technical Report 3 of 11 BPA. Page 9.

show that stands of red alder provide up to 3 times the nitrogen to streams compared to conifer forests.[3]

Other recent studies are showing that salmon carcasses are a major source of the basic nutrients needed by all life. They provide nitrate, potassium, phosphate and other minerals that are needed to support the food chain in both the ocean and the rivers. However, salmon carcasses are not the only source of those nutrients. They are also supplied by the disintegration of any carrion or feces, for example, cow manure. While it is true that there are differences between salmon and cow manure, it is also true that once it is broken down into the basic nutrients, the simple plants do not know or care about the source of the phosphate. Current US regulations on handling of feces and carrion is to saturate this material with lethal poisons, place it in a plastic lined ditch and seal it away from the environment with another layer of plastic. We need to modify current policy to utilize this valuable resource.

Ocean Conditions

It is often said that humans have little influence on ocean conditions and can do little about them. But that is not so, those basic nutrients that flow down the rivers and into the ocean are already in molecular form and will stay on the surface available to fuel ocean life. Billions of tons of these precious nutrients are presently being removed from our streams and rivers by the Clean Water Act, and stored where they are inaccessible to the life cycle. **Thus, the Clean Water Act is killing our streams and severely limiting the amount of nutrients reaching the ocean from our rivers.** Fifteen years ago, the forest practices act was shown not to be environmentally sound because it required removal of woody debris from the streams. It is time we examined our other environmental laws as well.

To conclude that humans can do little about ocean conditions is a defeatist attitude. Changes in the ocean obviously have a major impact on salmon. There is little doubt that the primary cause of the very large runs of salmon in the Columbia River in 2000 and those expected in 2001 are due to small changes in ocean conditions. Small changes in ocean conditions may well be within our capabilities.

For example, recent studies have shown that over the last 30 years, supply of basic nutrients has been steadily declining. There are many causes for this decline. We have already alluded to one, the loss of nutrients in our streams, which also effects the nutrient level in our coastal waters. Another involves how the ocean reprocesses its own nutrients. In the ocean, most life is in the top 300 feet of water and this zone produces the bulk of the excrement, and carrion. Unlike on land, the excrement and carrion do not stay on the surface, but sink thousands of feet downward to the bottom before it decays. Thus, there are huge stores of these precious nutrients in the deep ocean waters. The process by which these nutrients are returned to the biosphere is poorly understood at this time. It involves ocean currents, weather and the physical properties of water. Presently these factors are modified by nature in a seemingly cyclical pattern. Evidence exists that shows the number of salmon in the Columbia River has often been below 500,000 fish prior to 1800.

[3] Edmonds, R. L. 1980, Litter Decompostion and Nutrient Release in Douglas Fir, Red Alder, Western Hemlock and Pacific Silver Fir Ecosystems in Western Washington. Can J. For. Res. 10:327-337

Recent research has shown that the ocean's influence on salmon abundance is overwhelming. The year 2000 and 2001 salmon returns in the Columbia are larger than any runs since the 1920's. The sudden increase cannot be attributed to changes made in the river physical habitat. The magnitude of these changes renders the expected changes produced by the proposed actions on the river habitat insignificant.

Holistic Approach

The current "four H, (Hatcheries, Harvest, Habitat and Hydro)" approach should be abandoned for a more holistic approach. If we are going to save the salmon, we must get a model that accurately predicts the fluctuations in the salmon's total life cycle. Present models stop at the Columbia River's mouth. Any workable model for salmon restoration must go from egg to egg and include food supply, the effect of predators, and the quality of the entire habitat (river, estuary and ocean).

Introduction

In theory, good science starts with sound assumptions and moves to a logical conclusion based on observed facts and examination of all possible hypotheses. Not all sciences are created equal. Mathematics can be quite exact, followed by physics and chemistry. Biology as a science is much less exact. This lack of precision is partly due to the indistinct variables and the difficulty of controlling all the variables in any given problem. One reason for this is the complexity of the system being analyzed. For example, in biology sometimes it is very difficult to identify let alone control all the variables.

A research project is composed of several phases; set up, gather data, analysis, and conclusions. Research starts with a theory as to how the system works. The experiment can then be set up to prove that theory right or prove it wrong. Most research is set up to prove theories right. However, greater opportunity to remain detached exists if the experiment is set up to prove the researcher's theory wrong. If the theory cannot be proved wrong, it must be right. This factor plays directly into the lack of objectivity discussed later. When setting up the experiment the researcher has considerable control over what will be studied and the expected outcome. For instance, it is not too difficult to set up an experiment to prove that fish prefer cool water.

Conversely, while gathering data the researcher follows strict requirements. Data must be recorded completely and accurately. During the analysis portion of the work, again there exists considerable latitude. The researcher is not obligated to subject the data to every possible analysis. Finally, the conclusions reflect what the researcher feels are important. Not all possible conclusions are required to be expressed. One conclusion you will usually find in a report is "more research on this subject is required." Interpretation: send more money. One conclusion you will almost never find in a report is one that makes the client angry.

Most people read the conclusions, a few will look at the analysis and even less will look at the data. This is unfortunate because the one area which can be manipulated the least is the data. This independent and unfunded review examines the conclusion, analysis and the data first to see that they are consistent, and then we look for other analysis and conclusions that can be made from the same data.

Research results take a torturous path to utilization. Consider that it normally takes two years from the onset of data gathering to publication of the report. It generally takes several more years before the report is accepted by general body of the science. Then it passes from into the hands of the regulators where it spends several more years before regulations are written and several more before the regulations are approved. Thus, regulations are based on ten-year-old science, which is out of date before the regulations become operational. The current "4d rules" proposed by National Marine Fisheries Services (NMFS) is based on 1980 science. This is certainly not the best available science required by the Endangered Species Act (ESA)

This process along with the attitude, "do something even if it is wrong" is in part responsible for the numerous failed attempts at solving the salmon problem over the last 100 years. At one time scientific opinion felt that hatcheries alone would solve the problem. Then scientific opinion added harvest control to the mix and assured us again that this would solve the problem. Then with no improvement and a little more study, scientific opinion decided that river habitat was the new reason for the decline. Clean all the debris out of the rivers and we will have salmon – no, put it all back and we will have salmon. Then water quality became the real answer, clean up the water – no put rotten fish back into the water. Isn't it about time we stop guessing, using opinions and incomplete science?

North Pacific Research's review shows that current plans to save the salmon are based on a body of science that while large, is incomplete, contains numerous opinions and untested assumptions, lacks objectivity, and seems to focus mostly on human activity in the river habitat. Further, much of the research is qualitative and not quantitative.

Incomplete Research

To date most of the science behind salmon restoration is directed at the effects of human activities on the river habitat.[4] However, there is considerable evidence that river habitat is not that important to salmon survival.[5] Fortunately there are a growing number of scientists who realize that the issue also concerns oceans, weather, food supply and predator populations. If we are going to understand the salmon puzzle sufficiently enough to predict the outcome of our meddling, we need to identify all the pieces and connect them correctly.

There are still many unanswered questions concerning the river and its effect on salmon, and the questions concerning the ocean's effect on salmon are just now beginning to be explored. In truth, we are trying to make sense out of a puzzle that has 90% of the pieces missing. Further, the idea that this is a biological problem is too narrow in scope. The salmon puzzle contains more than just biological pieces and should get input from a broad scientific base that includes oceanographers, meteorologists, agriculturists, foresters, geologists, groundwater hydrologists, and water chemists to name a few.

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[4] Botkin, Daniel B, Cummins, K., Dunne, T., Regier, H., Sobel, M., Talbot, L., Simpson L., 1995, Status and Future of Salmon of Western Oregon and Northern California: Overview of Findings and Options, Center for the Study of the Environment, Santa Barbara, CA. Page 19.

[5] McKernan, D., Johnson, D., and Hodges, J., 1950, Some Factors Influencing the Trends of Salmon Populations in Oregon, Transactions of the 15th North American Wildlife Managers Institute, Wash DC. Pages 427-449

The current approach to salmon research should be focused more sharply on the overall objective by employing proven system analysis techniques. Much of the research money is handed out in a rather random manner. A better approach to complex problems is to first produce a comprehensive characterization plan to control the research. This approach has worked in the past on similar complex issues.

Even after we get all the pieces, we need to connect them properly before the picture is clear. Studying individual pieces of the problem leads to confusion. For example, consider the research on smolt loss through turbines. Research shows that between 0 and 10% of the smolt will be killed, depending on the type of turbine, and where the smolts pass through the blades. Using the average, this research shows that 50 smolt out of 1000 passing through a turbine will be killed. The conclusion from this study alone is that turbine removal saves smolt. Simple and straightforward enough for even the media to understand. However, another valid piece of research shows that if you pass 50 smolt by Rice Island they will feed five baby terns for one day. Connecting these two pieces of the puzzle produces an entirely different conclusion, that is, removal of turbines will allow us to feed more terns. An idea the Audubon Society would certainly promote, but it is also now not clear that turbine removal will save salmon.

Whereas we have produced several models, for example, the PATH and CIS model, none are satisfactory because they cover only part of the river system, produce conflicting results and ignore the other two thirds of a salmons life.[6] A proper model must be complete, verified and validated. While some verification, (checking of the code to see that it reflects the intent of the model), has taken place; no validation, (checking to see that the model reflects what is actually occurring in nature), has been done at all.

Untested and Invalid Assumptions

The surest way of getting invalid results is to begin your research with an invalid assumption. For example, the assumption that the salmon returns in 1883 were typical of the salmon returns before 1800 is false and now feeds a popular myth. The connection between climate shifts and Pacific salmon population is well documented.[7,8,9] New research from the University of Alaska shows that large fluctuations in salmon population have existed for at least 300 years.[10] See the discussion later in this text on Salmon baseline.

Also implicit in the past and current approach to salmon restoration is the assumption that the ocean is an infinite source of food and offers no hazards to salmon. This underlying assumption is the basic reason that all past and current salmon restoration programs have and will continue to fail.

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[6] Anderson, James, J., April 18, 2000, Testimony before the Subcommittee on Water and Power, Cascade Locks, Oregon

[7] Beamish, R. J., Bouillon, D.R., 1993. Can J Fish. Aquat. Sce. **50, 1002**

[8] Mantua, N. et. al., 1997, Bul. Am. Meteoraol. Soc. **78**, 1069

[9] Francis, R.C., Hare, S.R., Hollowed, A., Wooster, W., 1998, Fish. Oceanogr. **7**, 1

[10] Finney, Bruce P. et al, 2000, Impacts of Climatic Change and Fishing on Pacific Salmon Abundance over the past 300 Years, Science Vol. 290 Page 795

Opinion

According to the Oregon Coastal Salmon Restoration Initiative (OCSRI), the salmon crisis is a product of a long sequence of assumptions and decisions made by humans.[11] One of the major reasons the OCSRI felt that past salmon recovery plans failed was because the conceptual foundations were largely based on untested assumptions.[12] It appears that history is about to repeat itself.

The draft Environmental Impact Statement (EIS) for the lower Snake River Juvenile Salmon Migration states, "...the 1995 Biological Opinion provides the basis for the actions contemplated in the FR/EIS."[13] National Marine Fisheries Services (NMFS) indicates that the 4d rules are based on biological opinion. Note the word opinion; opinion is far from, and should not be confused with scientific conclusions.[14]

Reports, scientific or otherwise, that contain words like "possibly," "we think," "in our opinion," "could be," "may be," and so on are typical of research that is still incomplete. At best, it could be said that these words indicate a theory in progress. Remember that anything is possible; the probability that it will occur may just be remote. It is possible that you could win the lottery; or successfully adjusting nature's pattern without complete understanding but the probability of either is remote.

One thousand years ago if was the common scientific opinion that the earth was flat and the center of the universe. Those who disagreed were treated severely. Those opinions retarded the sciences of navigation and astronomy for many years. Certainly successfully landing a man on the moon was not based on opinion, scientific or otherwise. Likewise, major decisions cannot be based on theory in progress, especially decisions, which alter natural laws that have been in existence successfully for over 4 billion years. Current biological opinion recognizes that causing premature extinction may produce far-reaching effects. It is strange that these same biologists will not recognize that preventing extinction may also cause far-reaching consequences. Science to remain science needs to deal primarily in facts. Ideology deals with opinions.

Qualitative Rather than Quantitative

While considerable research shows that various human activities do degrade the river habitat for salmon use, degradation is not an absolute variable. There are degrees of degradation and little research is yet available that clearly connects degradation to the amount of salmon actually lost due to the specific degradation. Studies show that dams, river flow patterns, organic and sediment input, riparian habitats, migrational impediments, dissolved gas levels, pesticides, and industrial and municipal waste all degrade salmon habitat. However, degradation is not an absolute variable. Degradation has a wide range of values. Consider the difference in habitat degradation from adding a few pounds of silt to a stream compared to adding 500,000 cubic yards of silt to the same stream.

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[11] ________, 1998, Oregon Coastal Salmon Restoration Initiative Conservation Plan. Chapter 5 page 1

[12] ________, 1998, Oregon Coastal Salmon Restoration Initiative Conservation Plan. Chapter 5 page 9

[13] ________, 1999, Draft Lower Snake River Feasibility Report, US Army Corp of Engineers, Section 1 page 6.

[14] Botkin, Daniel B, Cummins, K., Dunne, T., Regier, H., Sobel, M., Talbot, L., Simpson L., 1995, Status and Future of Salmon of Western Oregon and Northern California: Overview of Findings and Options, Center for the Study of the Environment, Santa Barbara, CA. Page 18.

Presently, many of these studies are qualitative and we do not have the capability to distinguish between the effects on the salmon due to extremes of the variables, let alone comparing one form of degradation with another. What we need is a more quantitative understanding of the relative effect of habitat change. Until we can put better numbers on the amount of degradation, we do not have the science to judge the outcome of habitat mitigation action. The answer to such questions as, "How much wetlands?" or "What is the proper width of a riparian zone?" is not, "As much as we can get." Qualitative research has led to many questionable policies.

For example, the current science does not or cannot estimate the number of salmon that will return if the four Snake River dams are removed. The costs in dollars and degradation of human and natural habitat are considerable. Will Stelle from NMFS was unable to tell how many salmon would be returned by removing the dams. The NMFS and COE scientists working on the project concede that it may be none. If we do not know how many salmon will return, dam removal is not unlike buying a pig in a poke.

Another example is the need for a riparian zone, which is based on mostly qualitative studies that show that salmon prefer cool water, and other qualitative studies that show trees along small streams can cool the water. From these two qualitative studies comes the requirement for riparian zones. Whereas these studies are valid, they do not necessarily represent what is happening in the real world. The biological consequences of elevated water temperature on aquatic communities are complex.[15] There is little information indicating direct mortality of fishes as a result of water temperature changes related to canopy removal.[16] Certainly eastern Oregon and Washington would qualify as a clear cut, yet the Columbia has been producing salmon in this area for eons.

Consider, in the late 1800s water temperature was measured in many of the tributaries to the Columbia River by the US Fish Commission. The data show many of the rivers and lakes with salmon and temperatures as high as 83.5 degrees. The obvious disconnect is rooted in the lack of quantitative research. Another obvious disconnect is the Hanford Reach, the most prolific spawning ground in the entire Columbia River system, yet it is located in a desert with nothing but sage brush in the riparian area. It is hard to imagine that a two-foot tall sagebrush 200 feet from the river edge can cool the mighty Columbia River. Sometimes a little knowledge is a dangerous thing.

There is also a need for theoretical research to complement current practical research. Studies show that salmon prefer cool water for breeding, however the studies do not indicate why. If we knew why, we might be able to reconcile some of the inconsistencies. For example, other studies show that salmon avelin bury themselves in streambed gravel for protection when emerging as fry.[17] Obviously, in order for the avelin to bury themselves, the gravel needs to be loose. We know that an upward flow of ground water loosens gravel. We know ground water is considerably colder than surface water. It is entirely possible that the salmon are using the water temperature to sense

[15] Cederholm, C. J. et al, 2000, Pacific Salmon and Wildllife Ecological Contexts, Relationships and Implications for Management, Wildlife-Habitat Relationships in Oregon and Washingotn, Page 20
[16] Beschta, R.L., et al, Stream Temperatures and Aquatic Habitat: Fisheries and Forestry Interactions, pages 191- 232.
[17] Lannan, James, 2000, personal corrospondence.

locations where gravel is loose due to groundwater upwelling. By cooling the stream through other methods, we may be defeating the salmons ability to protect its offspring, by tricking the salmon into thinking that the cool shaded water is due to upwelling and the presence of loose gravel.

Lack of Objectivity

Lack of objectivity appears in the type of studies performed and the lack of looking at alternative, valid explanations. There are numerous studies that support the idea that human activities caused the decline in salmon and few that detract from that opinion. To simply assume there are none is not good science. The real world problems are not black and white but many shades of gray.

For example, most studies deal with the harm dams cause and few deal with the help they give to salmon. Rapids, waterfalls and shallows are dangerous areas for returning salmon. Predators find the fish easy prey at these constrictions in the rivers. Rapids and waterfalls require large amounts of energy to negotiate, they also bruise and damage fish, and shallows sunburn their backs. The result is that many spent salmon die before they have a chance to lay their eggs. A single dam can remove 10 or 15 of these salmon hazardous stretches in the river and replace them with fish ladders designed to make the passage less demanding on the returning salmon. The fish ladders also protect the salmon from predator attack, reduce energy needs, and physical damage. We know exactly how many smolts are killed by a turbine. But, we have no idea how many smolts are lost due to the loss of returning salmon destroyed by the natural river conditions. To illustrate suppose 1,000,000 salmon smolt are released above the dam shown in figure 1, then 50,000 smolt will be killed passing through the turbine.

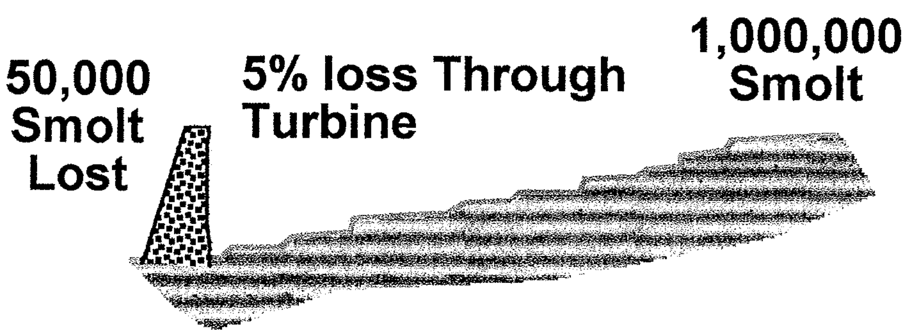

Figure 1. Salmon Loss With Dam

To avoid this loss the dam is removed. This removal exposes say ten rapids, waterfalls, and shallows. If just one returning salmon is lost at each of these features; and one returning salmon can produce as many as 5,000 smolt; the result is that 50,000 smolt are lost due to dam removal. See Figure 2.

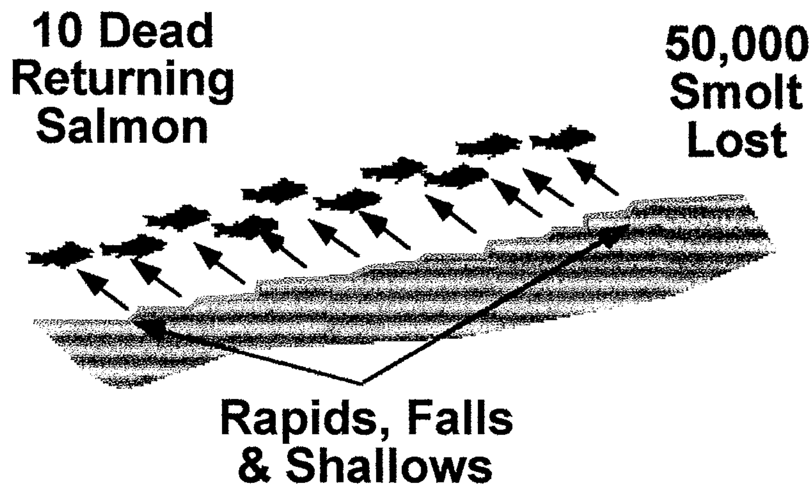

Figure 2. Salmon Loss Without the Dam

Therefore, the probability is great that the net effect of dams on salmon survival may be positive. This would account for the physical fact and research that show streams with and without dams react similarly to salmon fisheries. In other words, what is the net outcome of our action relative to the overall salmon population?

When examining the body of research it almost seems that a prerequisite for funding is the need to show human action, particularly white Americans of European ancestry, as the culprit. For example, in a study on the effects of avian predators on salmon smolt in the Columbia River, the blame is directed at the Corp of Engineers for building islands in the Columbia. The over abundance of Caspian terns (a non-native species), double crested cormorants and gulls is not addressed by the researchers or even considered as a possible cause.

Review of that work in progress shows an attempt to blame hatchery practices for the loss of the salmon.[18] The line of reasoning given was based on the disproportionate number of hatchery salmon killed compared to wild salmon. However, their data does not support that conclusion. The analysis in the study does not compare the number of each type of salmon killed to the percentage of that type of salmon but to total number of salmon. Since the hatchery smolt made up the predominance of the smolt, you would expect the hatchery smolt to be killed in larger numbers. When comparing the numbers correctly, percentage killed to percentage of total sample, there is no difference between the percentage of hatchery and wild smolt killed. Their refusal to consider that the birds may be a part of the problem and their unsupportable attempt to link hatchery practices to the salmon loss are indicators that objectivity is lacking in this study.

Focus on River Activity by Humans

Recent evidence shows that fresh water conditions are not the controlling factor in salmon population.[19] Yet, regulations seem to be directed solely at human activities on

[18] Collis, Ken and, Adamany, Stephanie, Robe, Daniel, D., Craig, David P., Lyons, Donald E., 1998, Avian Predation on Juvenile Salmonids in the Lower Columbia River.

[19] Bottom, Daniel L, 1999, Managing for Salmon as if the Ocean Mattered, Proceedings of the Symposium on Ocean Conditions and the Management of Columbia River Salmon. July 1999, page 29

the river. For example, consider the attitude that a single cow in a stream causes degradation to the stream, but a herd of elk does not. Regulations may require all cattle to be fenced away from natural drainage paths. Will regulations also require fencing all streams in the natural forests to keep deer and elk away from them as well? Further, these regulations do not take into account the number of cattle or the size of the drainage path, both important variables in determining pollution potential.

The present effort to restore the salmon is being directed at restoration of river habitat. Over the past 30 years, human activities along the river habitat have been subjected to increasing control by government agencies. These actions have not altered the decline in salmon population.[20] The common explanation for this failure is that actions taken have not been sufficiently restrictive, and that more regulation is needed. However, an equally valid conclusion to the lack of results is that regulating river habitat has little effect on salmon population.

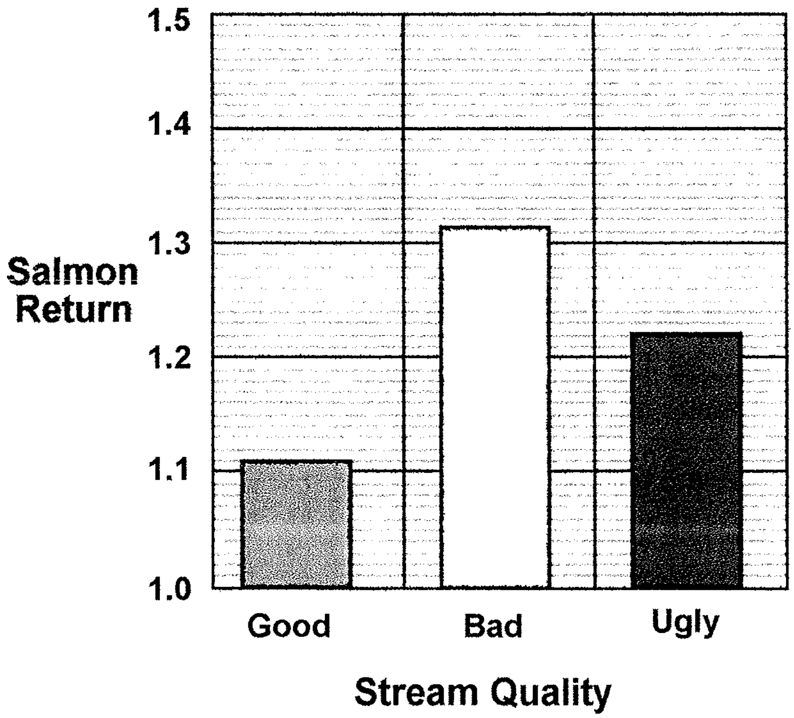

Figure 3. Salmon Return as a Function of Stream Quality

In fact, we are not even sure what fish consider a good habitat. Certainly, old growth forest and clean free running streams are beautiful to behold. The assumption that beauty is related to environmental functionality is false. A recent study of 23 tributaries of the Columbia River shows that the beautiful pristine habitat the humans feel is important is not producing fish.[21] See Figure 3.

The premise that habitat restoration alone will overcome all salmon population problems appears to rise from a lack of scope and breadth in the model. The "science" is

[20] ________,1996, Independent Scientific Group, Return to the River, page xvi
[21] McNeil, William J., 2000, Progeny to Parent Ratios for Columbia Basin Stream Type Chinook Salmon, Yakima Basin Joint Board of Irrigation and Iadaho Water Users.

not yet at a stage where cause and effect connections can be made.[22] Incomplete data leads to contradictory solutions, such as, "take the debris out of the stream, - oops, put it back."

There are many credible alternative reasons other than stream habitat for the decline in the salmon population. For example, an increase in number of predators, a decrease in food supply or changes in ocean conditions may have caused the decline in salmon numbers. To ignore or under evaluate the effects of credible alternatives can lead to flawed conclusions and solutions that are ineffectual and even damaging.

Peer Review

Peer review is one of the processes by which science minimizes errors. It consists of a review of a piece of research by a board of scientists who are also experts in the field. The product of the review is a list of issues, questions and concerns that the peer group has about the research. For the author to claim that the work has been peer reviewed all of these issues must be resolved to the satisfaction of the reviewers. That is the author must:

Accept the reviewers comments or changes,
Convince the reviewer to retract the comments,
Reach some agreeable compromise,
Remove the offending segment from the report.

Consider that during this process it is often necessary to negotiate an agreement between the author and several different dissenting peer reviewers all with different opinions. The result is a difficult and time-consuming process that relies heavily on facts for resolution. If these rules are not followed then the peer review is unreliable and misleading. As example, some of the conclusions in the documents discussed in this report have been described as peer-reviewed, however, some of the conclusions are obviously wrong. What does that say about the value of the peer-review?

Since peer review requires resolution and resolution deals only with facts, the value of peer reviewing opinions is debatable. In many instances, it is impossible to reach resolution based on opinion. Somewhat like using peer review to validate a specific philosophy. Valid science is not done democratically, it does not vote on the right answer. Therefore, in many instances, the above rules were not followed and the value of peer review on current biological opinion is useless and misleading.

Complete Salmon Model

The inconsistencies discussed above are due primarily to the lack of any realistic model of the salmon life cycle. Science is the process of predicting what will happen before it happens. For example, predicting the direction a ball will go when you drop it. In order to do this you need a model. In the case of the ball, the model is simple because the system that controls the falling of the ball is simple. In the case of salmon survival,

[22] Botkin, Daniel B, Cummins, K., Dunne, T., Regier, H., Sobel, M., Talbot, L., Simpson L., 1995, Status and Future of Salmon of Western Oregon and Northern California: Overview of Findings and Options, Center for the Study of the Environment, Santa Barbara, CA. Page 18.

the system that controls the survival of the salmon is complex; therefore, the model also must be complex or the answer it produces will be inadequate.

Without an accurate model, we are reduced to randomly twiddling the knobs of nature with no real assurances of what will happen. Agencies are now making profound decisions without the proper tools. We urgently need a good model that considers all the necessary and complex factors involved in salmon survival.

Simply stated, the survival of salmon, or any species, depends on the availability of food, the number of predators, and the quality of the physical habitat as shown in Figure 4.

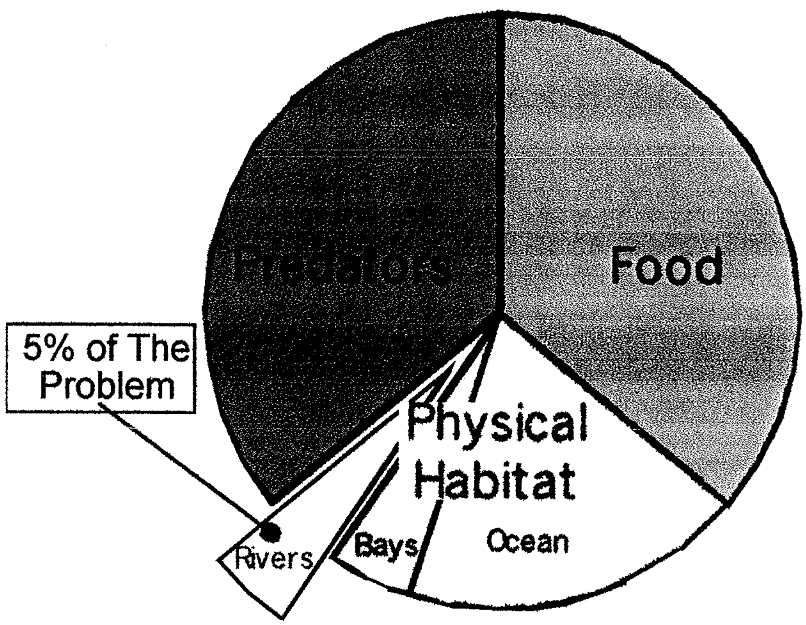

Figure 4. Major Factors Involved in Survival of a Species.

The first factor is food. Without an adequate food-supply, the species will not survive. The second factor is Predators. If predator pressure is so great that the species cannot procreate faster than it is being killed it will not survive. These two factors make up about 70 percent of the problem. The remaining 30 percent is made up of the physical habitat. Now in the case of the salmon we know that they spend about two thirds of their life in the ocean. Therefore, the ocean physical habitat is about 2/3 of 30 percent or 20 percent of the overall problem. The remaining 10 percent is divided between the rivers and the estuaries. Thus, the river physical habitat is only about 5 percent of the salmon problem. Yet, almost all of our effort today is directed at changes in the temperature of the water, addition of riparian zones, presence of rip rap along stream banks, culvert size, providing clean gravel for spawning, water depth and so on - In other words changes to the physical habit of the river. There is no verifiable evidence that river physical habitat restoration will halt the decline of the salmon.[23]

[23] Magnuson, J.J., et al, 1996, Upstream: Salmon and Society in the Pacific Northwest. National Academy Press, Wash DC.

Wild species are exposed constantly to diverse changes in their physical habitat. Both the Mount St. Helen's eruption, the Bridge of the Gods landslide, for example produced large and severe changes to the river habitats. A successful species must be able to adapt to these changes. Research has shown that natural ecosystems generally have a large capacity to absorb change even though dramatically altered.[24] In fact, a static or ideal habitat may lead to the demise of a species. It is interesting to note that while on one hand, popular biological opinion faults the hatchery fish as being unable to compete effectively in the wild because of their pampered early existence, yet they are proposing extreme measures to see that the wild fish are exposed to an ideal habitat in their early existence.

If we are going to solve the salmon problem, we need to look at more than just 5 percent of the problem. A working model of the entire system from egg to egg is needed to successfully manage salmon fisheries. The purpose of this paper is not to provide that model but to show examples of under-considered significant factors that must be contemplated and the potential effects of those factors on the model. Let's begin by examining the salmon's food supply.

Food Supply

It has long been known that food supply plays an important role in species population. What is being done to ensure the salmon have a sufficient food supply? No river habitat protection in the world is going to feed fish, and if the fish do not eat, they will not use any spawning grounds. Any workable model for salmon restoration must include the "egg to egg" food supply of the salmon.

Very few global studies have been made on the salmon's food supply especially in the open ocean habits. We do know that their food supply is complex, that they are opportunistic feeders eating almost anything that will go down their throats and that it varies over their life cycle. Early in the salmon's life cycle, they eat insects, insect larvae, and small fish. When they move into salt water, they eat krill, squid, herring, anchovies, sand lances, rockfish and the immature members of many species like sardines and hake.[25,26] In order to understand the food supply of the salmon it is necessary to understand a little about the food pyramid, then look at the supply in the rivers, estuaries, and ocean, and study historic data on the food supply to understand the past and predict the future.

The Food Pyramid

The salmon sits at the apex of the food pyramid. See Figure 5. The foundation of the pyramid consists of basic nutrients that include nitrate, phosphorus and potassium. It takes large amounts of these basic nutrients to feed the next layer, the simple plants, which manufacture their food from sunlight and the basic nutrients. Sitting on top of the simple plants are simple animals. Sitting on top of the simple animals are all the rest of

[24] Reeves, G. H. et al. 1995, A Disturbance Based Ecosystem Approach to Maintaining and Restoring Freshwater Habitats of Evolutionary Significant Units of Anadromous Salmonids in the Pacific Northwest, American Fisheries Society Symposium, page 340

[25] Hart, J. Pacific Fishes of Canada, Fisheries Research Board of Canada, Bulletin 180, Ottawa.

[26] Love, Robin Milton, 1991, Probably more than you want to know about Fishes of the Pacific Coast, Really Big Press, Santa Barbara CA, page 54

the life including, herring and salmon. This is truly a pyramid. For example, a single simple animal may contain as many as 130,000 simple plants in its stomach at any one time. A single herring may contain 7000 simple animals.[27] A single salmon can easily fill its stomach with 10 herring thus, 91 billion simple plants are required to sustain a medium sized salmon for a few hours.

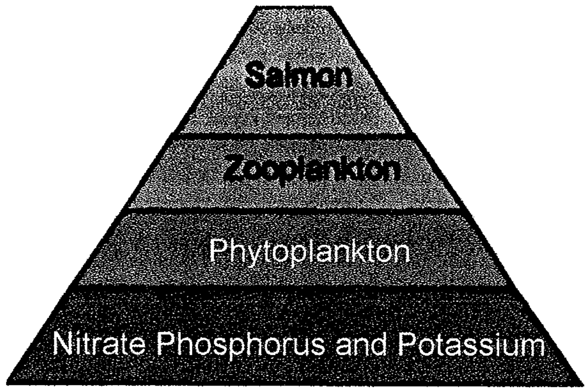

Figure 5. Food Pyramid.

Without adequate amounts of the basic nutrients that support the simple plants, salmon and other fish at the top of the pyramid begin to die. The basic nutrients come mainly from excrement, dead plants and animals. There are some basic differences in how this pyramid works depending on whether the pyramid is deep ocean, (beyond the continental shelf), or on the land. On land, the carrion and excrement simply falls a very short distance to the ground where it is broken down into its basic nutrients, and mixed with the topsoil. When this topsoil is washed into the streams, the nutrients are carried with it. Riparian zones, the Clean Water Act and the "4d rules" limit the amount of topsoil and nutrients from entering streams.

In the deep ocean, the excrement, dead plants and animals, fall through the water several thousand feet to the bottom where they decay. Since most of the life in the ocean is in the top 300 feet of water, the nutrients are now unavailable to the surface life until they are carried to the surface by upward flowing currents. Once on the surface, the simple plants can use them and sunlight to start the food process again.

Rivers and Estuaries

Why do salmon spawn in rivers? The complete answer to that simple child like question is unknown. Obviously there must be an important reason for them to undergo hardships and death to reach the upper reaches of our rivers. One reason may be because; they spend little time rearing their offspring. They simply drop the eggs and leave them to fend for themselves. Under these conditions, it is important to find a safe place to deposit the eggs. It turns out that the upper reaches of our rivers are also barren places with few predators. This is a common survival strategy. For example, it is the same reason that Canadian geese fly all the way to northern Canada to lay their eggs. Northern Canada is a barren place with little life and few predators. It takes considerable effort to

[27] Engel, Leonard, 1961, The Sea, Tine Life Books, page 104

fly to northern Canada. Geese are not stupid. They are now breeding on peoples front lawns, which is also a safe place, free of predators.

When the salmon's eggs hatch, the fry are provided with a sack lunch and stay below the surface of the gravel living in the cavities between the gravel particles. After two or three months, they emerge from the gravel into the stream. At this time, they are generally between 1 and 1.5 inches in length, depending on the species, the size of the gravel cavities and the food supply in the gravel.

Why do salmon leave the rivers? Once they exit the gravel the situation changes. They are now must actively search for food. It turns out the answer to why they leave the rivers is connected to why salmon spawn in rivers. It is a barren place without much food. Research has shown that over 30% of a fingerling's diet is terrestrial insects.[28]

Current programs are designed to provide old growth forest and pristine streams. These are very pleasing things but in truth not very functional. Pristine rivers have very little food. In other words, clean water is dead water; that is why humans drink it. Clean water will not support life because it is free of nutrients. As we saw earlier, a recent study of 23 streams that feed the Columbia River shows that expanding populations of salmon are linked to fair and poor habitats.[29] See Figure 2. This study is based on data that shows over the last 20 years the average return rate for poor streams more than doubled that of good streams and fair habitat more than tripled the output of good streams. The study concluded that pristine streams are starving our fish.

The Paired River study on Vancouver Island showed identical results. See River Restoration section page 54. For this study, the Keogh River was heavily rehabilitated and fully protected using all the latest techniques of environmental river management. The Waukwaas River on the other hand was left entirely unprotected. Almost immediately, the project determined that artificial feeding of fry was required in the Keogh. Even with artificial feeding the Keogh was still solidly out performed by the "poor habitat" of the Waukwaas River. Obviously there is a strong disconnect between what environmentalists consider good river habitat and what salmon consider good habitat.

Pilot programs have been started to introduce the frozen carcass of the hatchery salmon back into the river. These programs recognize that clean water is essentially dead water, and that these carcasses provide the basic nutrients, (nitrate, phosphate, and potassium), important for fish. However, much of what humans consider waste is poisoned and sealed away from the environment in landfills effectively preventing it from re-entering the food chain.

This process of adding nutrients to fresh water, conflicts with the Clean Water Act of 1972, which forbids the introduction of nitrates, potassium, and phosphorous in the rivers. Therefore, the Clean Water Act is now in conflict with the Endangered Species Act. This conflict poses serious problems for traditional environmental beliefs. First, it points out serious flaws in the environmental laws. Second, it opens the door to adding commercial chemicals to the streams as they did in the Keogh River, which then casts

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[28] Mundie, J.H., 1968. Ecological Implications of the Diet of Juvenile Coho in Streams, Symposium on Salmon and Trout in Streams, pages 135-152

[29] McNeil, William J., 2000, Progeny to Parent Ratios for Columbia Basin Stream Type Chinook Salmon, Yakima Basin Joint Board of Irrigation and Iadaho Water Users. Page 2

doubt on years of farmer bashing, and maybe the need for social change, because those same nutrients are contained in cow manure.

Ocean

The ocean is large, complex and poorly understood, but that is not a reason to ignore its influence on the salmon. Depending on the species, salmon can spend as much as 5 years or 60 to 80 percent of its life in the ocean. Thus, the ocean has a profound effect on salmon that cannot be ignored. The ocean environment can be broken into two broad categories; deep ocean, where the bottom is below 300 feet, (shown in blue), and the shallow ocean areas with the bottom above 300 feet. See Figure 6. The reason for this division is that most ocean life exists in the top 300 feet of water sometimes called, the zone of life.

In the ocean, the carrion and excrement fall to the bottom where it is processed back into the basic nutrients. In the shallow ocean water, above 300 feet, this is not much of a problem because these nutrients are immediately available to food chain. This is one reason that ocean life is more prevalent near land. The other reason is that nutrients are washed down the rivers into the ocean. These river nutrients are in the monocular form and stay on the surface where the food pyramid has access to them. Unfortunately, the clean water act is removing nitrate, potassium and phosphate from our rivers and thereby adversely affecting the ocean food supply as well.

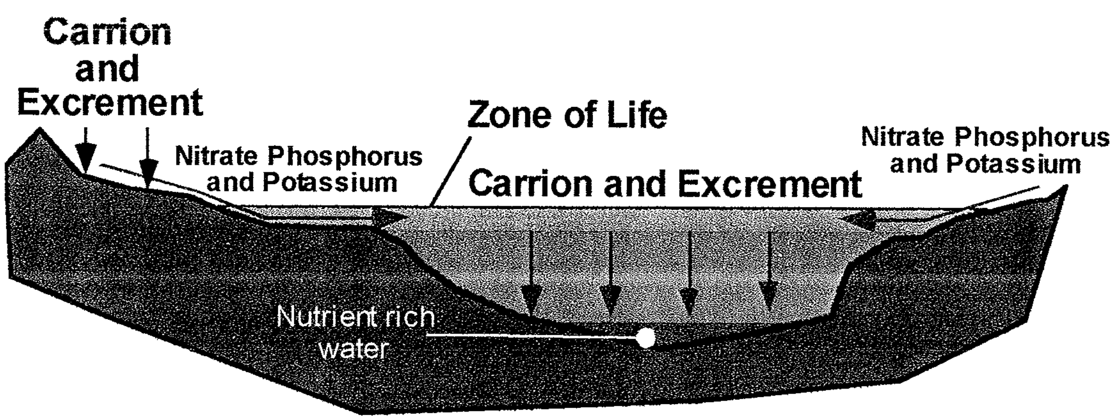

Figure 6. Ocean Cross-Section.

Now in the deep ocean things change considerably. When the carrion and excrement sink to the bottom and decays the nutrients are now out of reach of most ocean life. In the case of the North Pacific, the ocean bottom forms a huge basin much of which is 18,000 feet deep. The process by which the nutrients are returned to the surface is complex and somewhat random, and only a small portion of these nutrients ever returns to the surface food chain. The result is that large reservoirs of nutrient rich water exist in the deep ocean basins. That which is not reprocessed is eventually deposited in ocean sediments and ultimately turned into fossil fuel. One hundred million years from now, these deposits may be important. However, today an adequate supply of nutrients on the surface is vitally important. To tap this resource it is essential to understand the natural process by which nature returns nutrients to the surface. The upward flow of nutrients is presently controlled by temperature, surface and deep ocean currents, bottom topography, weather and other factors.

Temperature

The temperature in the ocean varies widely, both horizontally and vertically. The range is from 90 degrees F. at the surface in the Persian Gulf to 28 degrees F. near the bottom in the Polar Regions. In general, the top 300 feet, or zone of life, is roughly the same temperature as the surface due to wind mixing. Below this layer is a zone of rapid temperature decrease. At depths greater than 1200 feet, the temperature is everywhere below 60 degrees F. Waters deeper than about 2,000 feet are below 34 degrees F. This sets up an interesting process, which is unique to water.

Most substances become denser as they get colder. However, ignoring salinity, water as it gets colder stops become denser at about 39 degrees F. The density of water at 32 degrees is roughly the same as its density at 43 degrees. See Figure 7. Thus when the surface water cools below 43 degrees, the sub surface water containing the nutrients, which is just above freezing becomes lighter than the water above it and changes places moving the nutrients to the surface. In effect, we have a pump that works with gravity to return deep ocean nutrients to the surface. Unfortunately, it only works in cold climates where the surface temperature is below 43 degrees F. This process is one reason why life abounds in the polar oceans.

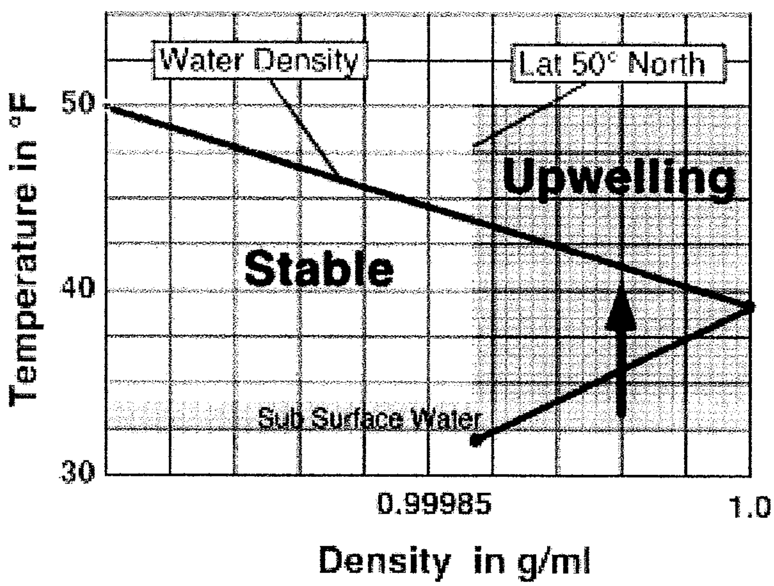

Figure 7. The Return of Nutrients

Unfortunately, the conditions necessary for upwelling in the North Pacific are hindered by ocean topography, weather, and currents. The deep North Pacific basin is cut off by the Aleutian Ridge on the north, which rises 12,000 feet. The Bering Sea north of this ridge is a shallow sea about half of which is less than 300 feet deep. The result of this topography is that any substantial upwelling of deep ocean nutrients must occur south of the Aleutian ridge.