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.

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[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 Columbia River 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 show that

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[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.

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.

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[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.

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

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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

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.

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)

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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

[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.

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.

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

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[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.

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 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

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[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.

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.

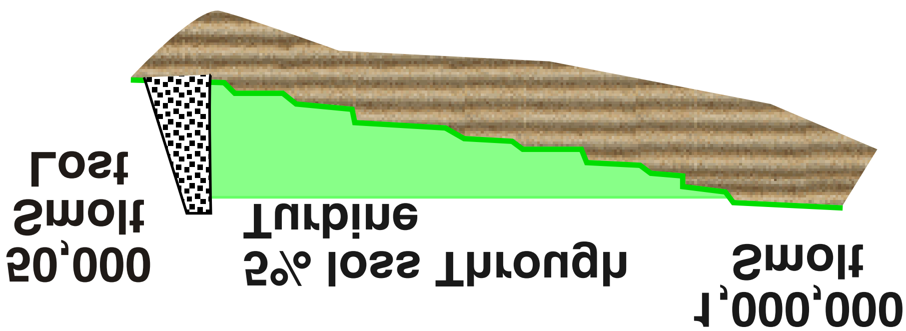

Figure 1. Salmon Loss With Dam

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.

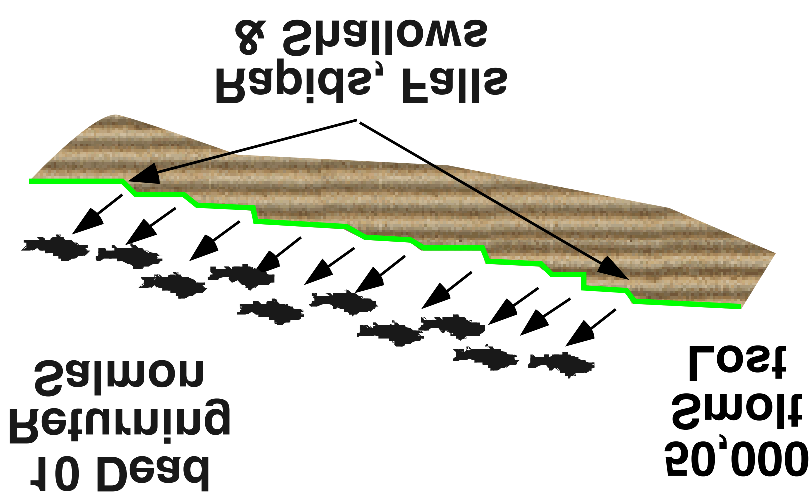

Figure 2. Salmon Loss Without the Dam

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 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.

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[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
[20] _______ ,1996, Independent Scientific Group, Return to the River, page xvi

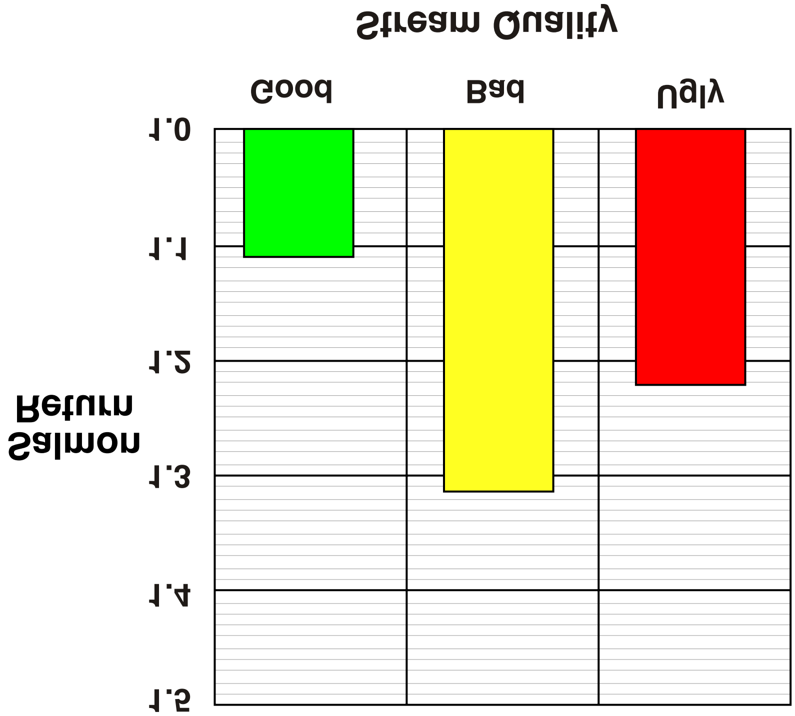

Figure 3. Salmon Return as a Function of Stream Quality

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 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

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

[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.

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, 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.

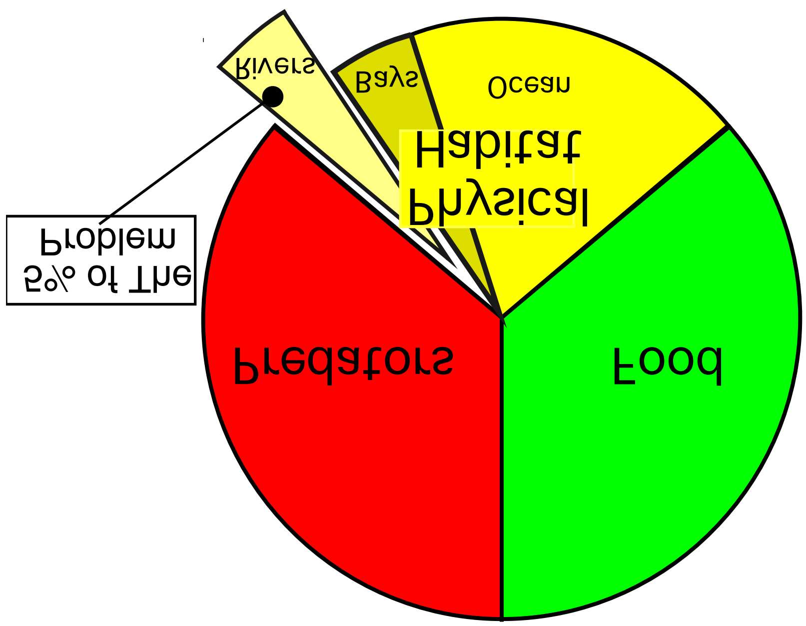

Figure 4. Major Factors Involved in Survival of a Species.

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]

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.

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

[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 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 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.

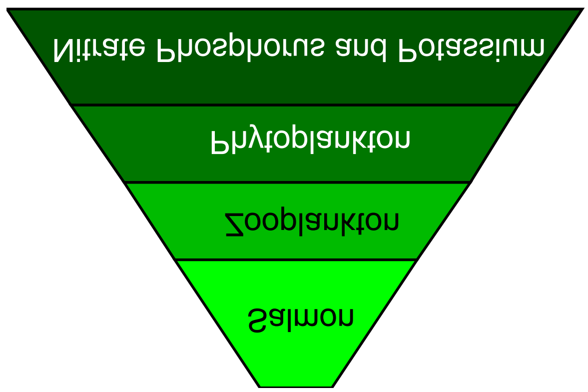

Figure 5. Food Pyramid.

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;

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

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 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.

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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

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 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.

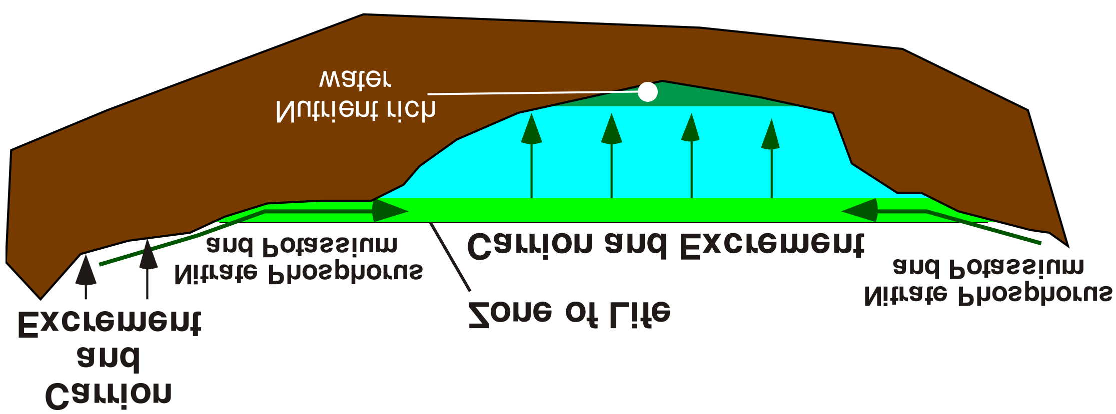

Figure 6. Ocean Cross-Section.

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.

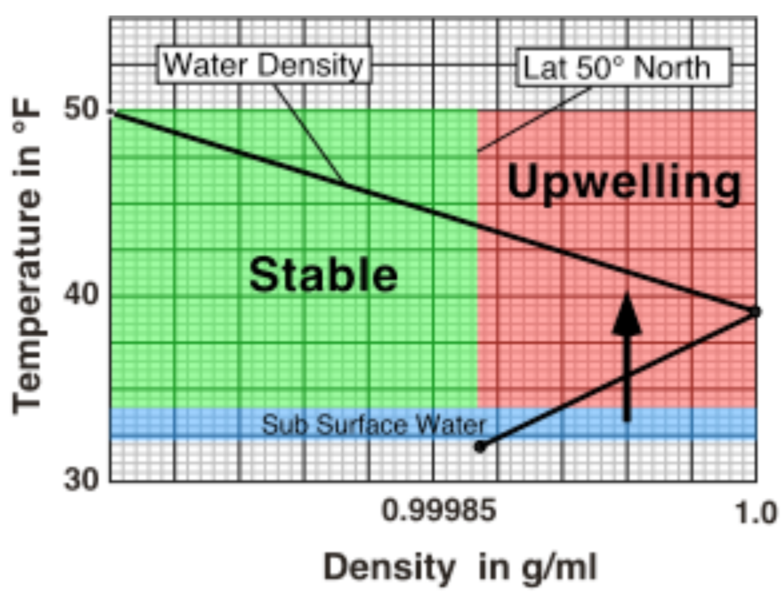

Figure 7. The Return of Nutrients

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.

The weather affects surface temperature and wind patterns, which in turn affect current. In the North Pacific the maximum area of possible upwelling occurs in January and the minimum area in July. See Figure 8. Once the 43-degree surface temperature contour moves north of the Aleutian ridge in May, the North Pacific nutrient pool is inaccessible until November.

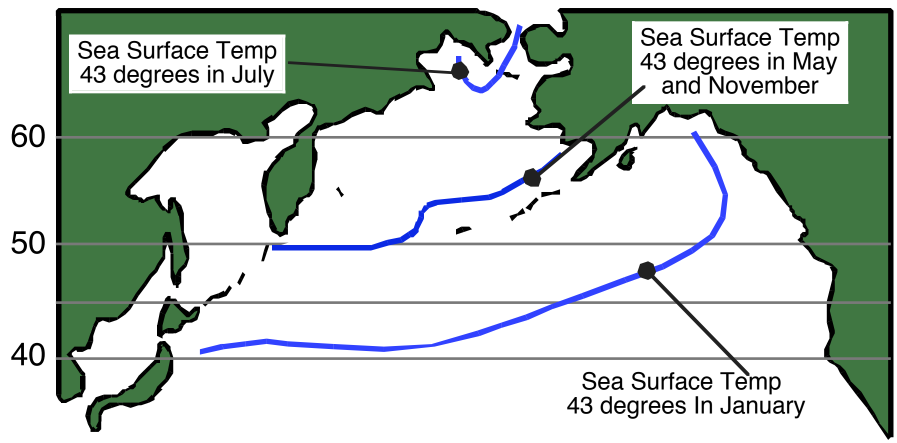

Figure 8 Limits of Sea Surface Temperatures

Ocean Currents

Once on the surface, the distribution of the nutrients depends on current to carry the nutrient laden water south to climates that are more temperate. These currents are generated by wind and weather patterns, and the rotation of the earth. In the northern Pacific, the flow is counter clockwise roughly around the center of the ocean.

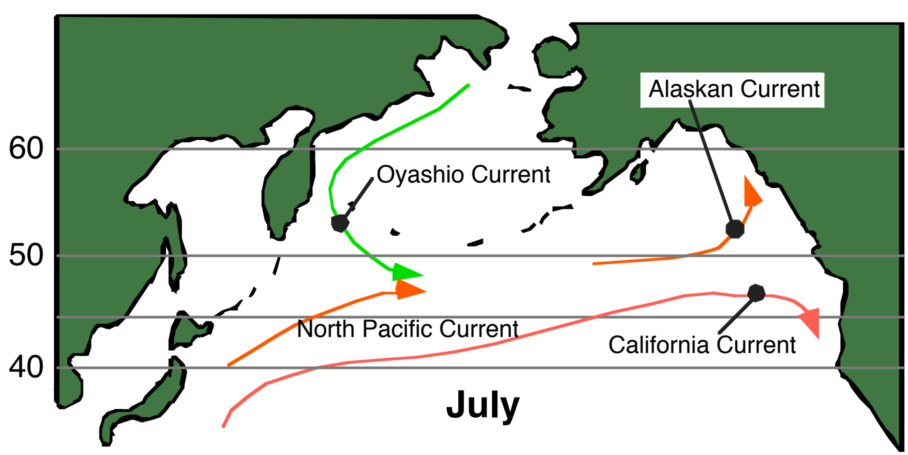

Figure 9. Current patterns in the North Pacific in July

Pacific Coast salmon are strongly influenced by the North Pacific, California and the Oyashio surface currents. The North Pacific current has its origins around Honshu Island in Japan and flows northeast between 40 and 50 degrees north latitude. This current strikes the North American continent in July somewhere around northern Vancouver Island depending on weather patterns. The part of the North Pacific Current that turns south is called the California Current. The part that turns north is called the Alaskan Current. See Figure 9.

The Oyashio Current flows out of the western Bering Sea striking the North Pacific Current and turns eastward. Since the 43-degree F. temperature line is now north of the Aleutian Ridge, the only nutrients reaching the North Pacific Current are those carried out of the Bering Sea by the weak Oyashio Current.

In the winter, the North Pacific current moves south with the northern edge of the current south of the 43-degree temperature line, and now strikes the North American Continent opposite the Columbia River. See Figure 10. However now the Oyashio Current is stronger and as it flows through the area where upwelling can occur it can carry nutrients from the deep ocean pool back to the surface. Thus through this process, for a short period during the winter deep ocean nutrients are available to surface life.

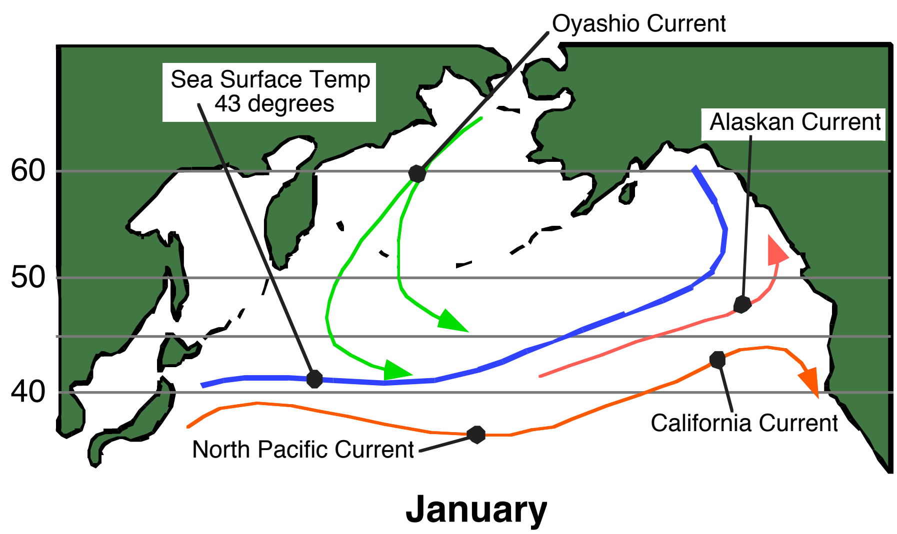

Figure 10. Current in the North Pacific in January

If the cold nutrients rich water is slowly warmed as it journeys south, the nutrients will stay accessible. However, where the cold Oysahio current meets the warm North Pacific current, the warmer lighter water over rides the colder water, forcing some of the colder nutrient rich denser water down beyond the reach of surface life once again. As the current moves east some temperature adjustment of the surface water due to mixing and convection occurs and some nutrients rise again. Finally, when the current reaches the coast of North America some of these mid level nutrients can be recovered by upwelling caused by onshore winds and local weather patterns.

The onshore wind patterns can set up relatively shallow vertical currents by driving the water downward near the shore and upward further off shore. These vertical currents can bring the midlevel cooler nutrient rich water back to the surface. Rich blooms of phytoplankton are observed after these episodic upwelling events. Between 1960 and 1981, a strong correlation existed between the intensity of the coastal upwelling and the smolt to adult survival of Coho salmon.[30]

The location and angle that the North Pacific current strikes the North American Continent effects the amount of flow turning north or south, which in turn effects the amount of nutrients flowing north or south. Ten or fifteen years prior to the early 1970s, much of the nutrient rich water was flowing south along the Pacific Coast.[31] The result was the salmon thrived for a short time and their numbers increased along the south coast and decreased in Alaska. In the early 1970s, the California Current changed course and most of the flow was deflected north into the Gulf of Alaska.[32] The result was a weaker, warmer, less nutrient rich current flowing south along the pacific coast. Thus, the wind driven upwelling found no depressed nutrient rich waters.

As a result of these changes in current and weather patterns, nitrate became undetectable in the California Current during the summer months in the 1990s.[33] During this same 30-year period, the lack of food caused the average weight of the salmon caught to decrease by 25 percent.[34] Another study places the blame for the decline of British Columbia salmon on the warming of the North Pacific waters off Vancouver Island and the accompanying loss in food productivity. The study concludes that over the next 50 years the expectation is that good salmon waters will shrink to relatively small patches in the Bering Sea. As seen earlier the Bering Sea is not a major source of deep nutrients.[35]

The cause of the shrinking supply of cold fertile waters is attributed to the warming of the atmosphere. Whereas, there is evidence that the oceans and atmosphere are warming, it is yet unclear as to the cause. However, the production of greenhouse gas and the quality of our atmosphere is contributing to this warming trend. Any increase in burning of fossil fuels to replace the power generated by Snake River dams is a step in the wrong direction.

Ironically, the environmentally driven decision 30 years ago to rely on fossil fuels rather than other less polluting power sources may be related to the loss of Pacific Salmon. For example, it can be shown that the decision to stop building hydro and nuclear power plants caused the burning of 135 million billion BTUs more fossil fuel than would have been burned had dams and nuclear power plants been allowed to be constructed. Certainly, it should be evident that removal of dams would increase the use of fossil fuels and would aggravate the atmosphere, energy and thus the salmon problems.

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[30] Nickelson, T. E. , 1986, Influence of Upwelling, Ocean Temperatures and Smolt Abundance on Marine Survival of Coho Salmon in the Oregon Production Area. Can J. Fish. Sci. **49**: 783-789

[31] Kaczynski, V.C. 1994, Comments on the Potenially Critical Habitat, Personnel Communication.

[32] Pearcy, W.G., Fisher, J., Brodeur, R. and H]Johnson, S., 1985, Effects of the 1983 El Nino on Costal Nekton off Oregon and Washington. El Nino effects in the Eastern Sub Arctic Pacific Ocean. Washington Sea Grant Program. Univ. of Washington, Seattle, Pages 188-204

[33] Hobson, L.A., 1980, Primary Productivity of the North Pacific Ocean, a review, Salmonid Ecosystems of the North Pacfic, Pages 231 -246

[34] Kaczynski, V.C. 1994, Comments on the Potenially Critical Habitat, Personnel Communication.

[35] Welch, D. W. Ishida, Y. Nagasawa, K. 1998, Thermal Limits and Ocean Migrations of Sockeye Salmon, Can. J. Aquat. Sci. **55**:937-948

It is pointed out by the author of the paper on ocean conditions off Vancouver Island, that the Snake River salmon use the same area off Vancouver Island to mature. Thus, the decline of the Snake River fisheries is also connected to changing ocean habitat. By comparison, the abundant Hanford Reach salmon in the Columbia River, feed farther to the north in colder waters where the food is adequate. These two facts seem to minimize the effects of river habitat compared to effects of ocean habitat. It is also apparent that ocean habitat is a very complex and sensitive environment. A few degrees of surface temperature warming or cooling can radically influence the food supply. Without food in the ocean, improving river habitat is of little value.

Ocean Survival Rates

Management of salmon over the past century has concentrated on the hatcheries and harvest while considering the ocean habitat to be an inexhaustible pasture. The current approach of concentrating on the river habitat makes a similar erroneous assumption. Another common belief about the ocean habitat is that nothing can be done to change it. Both of these commonly held opinions are questionable.

Ocean-estuary survival rates can be measured by comparing the number of salmon leaving the rivers to those returning. It has long been know that ocean survival rates must remain above 2.7 percent to provide sufficient Coho salmon in order to maintain a population without any harvest.[36] If we look at ocean survival rates for the Oregon Coast Coho over the 30 years from 1965 to 1995 as shown in Figure 11, we can see a steady decline. [37]

[36] Caughley, G., 1967, Parameters for Seasonally Breeding Populations, Ecology. Vol **48**:834-839

[37] Kaczynski, V.C. 1994, Comments on the Potenially Critical Habitat, Personnel Communication.

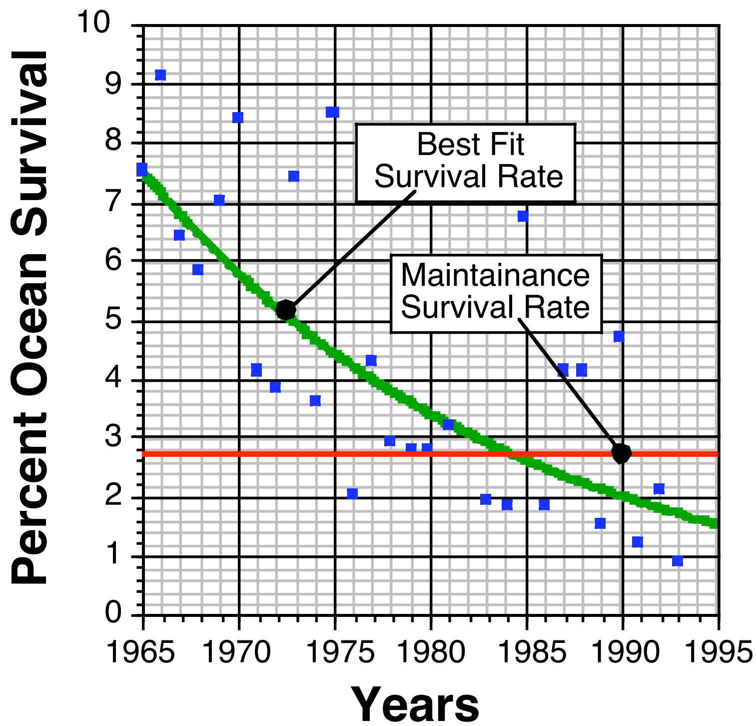

Figure 11. Ocean Survival rates for Oregon Coastal Salmon

The best-fit survival rate curve crosses the minimum survival rate curve somewhere around 1984. Thus, since 1984 the ocean conditions have been adverse (through lack of food and abundance of predators) to salmon survival.

While the southern salmon (Oregon, Washington and California) have been steadily declining over the past 35 years, the salmonid populations in British Columbia have been mixed, falling in the south and rising in the north. The changes in BC were primarily shaped by marine, not river, habitat and gradually moved northward.[38] By 1990 onward, the return of spawning fish at the north end of Vancouver Island dropped abruptly from 15 to 4 percent, while in Alaska the salmon return has nearly doubled during the same period. However, as the salmon population has increased in Alaska, there has been a corresponding decrease in the average adult size at return.[39,40] This inverse relationship indicates a limitation to the salmon-sustaining resources of the ocean.[41]

Reduction in body size is a factor in reproductive success.[42] Life history theory predicts that large body size is a premium among salmon populations that migrate over

[38] Welch, D. W. Ward, B.R. Smith, B.D., and Everson, J.P.,

[39] Rogers, D.E., 1980, Density-dependent growth of Bristol Bay Sockeye Salmon, Salmonids Ecosystems of the North Pacific. Pages 267-283

[40] Peterman, R. M. , 1984 Density Dependent Growth in early Ocean Life of Sockey Salmon, Can. J. Fish. Aquat. Sci. **41**:1825-1829

[41] Bigler, Brian S., Welch, David W. and Helle, John H., 1996, A review of Size Trends Among North Pacific Salmon. Can. J. Fish. Aquat. Sci. **53**:445

[42] Forbes, L.S. and Peterman, R.M., 1994, Simple Size-structured Moels of Re3cruitment and Harvest in Pacific Salmon. Can. J. Fish. Aquat. Sci. **51**:51-60

long distances to spawn and enter the ocean as smolt. Small body size reduces egg size, which produce smaller alevin and fry that in turn inherit a diminished probability of survival.[43] For example, small body size also decreases the salmon's ability to allude predators.

Historic Food Supply

It should be obvious by now that with such a complex and variable nutrient supply that the salmon food supply must be variable as well. If the salmon food supply is variable then the salmon population will also vary. If we are going to predict the salmon population, it is necessary to be able to predict the salmon's food supply. To be able to predict the future it is necessary to understand the past. We have only a few studies that provide an insight into historic salmon's food sources.

Anchovies and herring are known food sources for salmon. Historic data on the abundance of anchovies, herring, saury, hake and mackerel have been obtained by examining data from core samples taking from the ocean bottom off the NW Coast.

By counting the relative abundance of sardine, anchovy, hake, saury, and mackerel scales at different depths in these ocean sediments and comparing them to present stocks, estimates of past abundance of these five fish can be determined over the last 200 years.[44] It is interesting to compare this data with the historic Columbia River salmon catch data.[45] The red curve dots are the fish scale abundance estimates and the blue dots are the Columbia River Salmon catch data. See Figure 12.

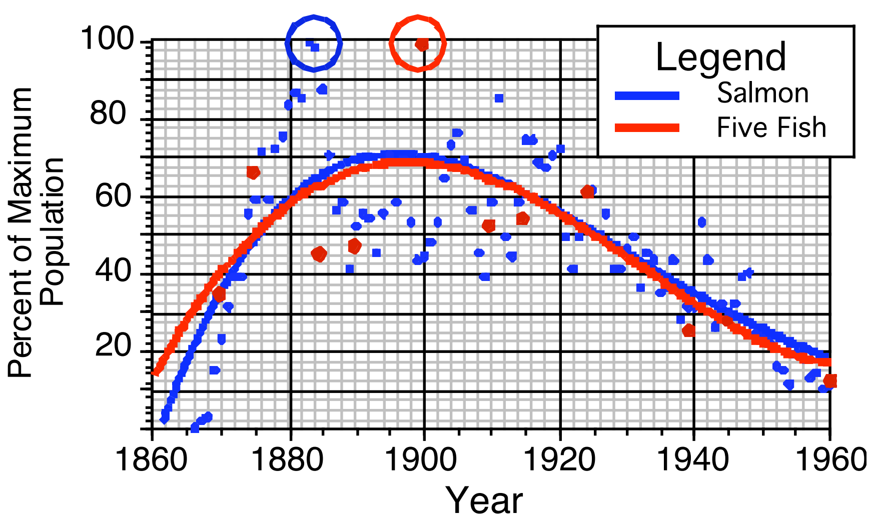

Figure 12. Comparison of Best-Fit Curves

[43] Beacham, T.D. and Murray, C.B., 1987, Adaptive, Variation in Body Size, Age, Morphology, Egg Size, and Development Biology of Chum Salmon in British Columbia, Can. J. Fish. Aquat. Sci. **44**:244-261
[44] Smith, P., 1978, Biological Effects of Ocean Variability: Time and Space Scales of Biological Response, Rapp. P-V. Revn. Cons. Int. Explor. Mer. **173**:177-127
[45] Kaczynski, V. Palmisano, 1992, Oregon Wild Salmon and Steelhead Trout, A Review of the Impact of Management and Environmental Factors, Oregon Forest Industries, Page 232

Notice that peak populations occur just a few years apart and the red and blue dots follow the same general trend. The quality of the correlation of the data can best be seen by generating the polynomial best-fit curves to these data over the 100-year period. The two best fit curves track each other remarkably well. The duration and similarity of the population trends exclude coincidence as a possible explanation. They are definitely linked and what caused the decline in one most likely caused the decline in the other. It should be emphasized that this striking correlation is not meant to imply that the lack of anchovies, sardines, saury, mackerel, and hake is the reason for the decline in salmon. This correlation by itself is not proof, it is an indicator that studies need to address this issue and determine the link. Possible links might be that:

- The six species have a common food source that was declining,
- There has been a decline in basic nutrients,
- There has been a decline in plankton,
- The six species have a common predator that is on the increase,
- All of the above.

Important River Disconnect

The correlation in Figure 12 also indicates that there are some important disconnects between the river habitat and the decline in salmon. It is apparent that all six species declined similarly. Since five of these species never enter the river, river habitat cannot be a factor in their decline. Since these fish only live in the ocean, their decline had to be due to ocean conditions. Since the salmon live partly in the ocean, the ocean condition decline would also influence the salmon. Now, if the river habitat strongly influenced the decline of the salmon, the salmon would be taking a double hit; one in the ocean and one in the rivers. In that case, the salmon curve (blue) would be below the red curve and pull away from it as the river conditions worsened. Notice that from about 1930 on, the salmon numbers are greater the other five fish. Admittedly, the amount is not large, but even if the performance was equal or worse, the conclusion must be that, the probability of the river habitat being an important factor in salmon decline is remote.

Predators

It is hard to understand why the role of predators has been ignored in the process of restoring salmon. Considering that a partial list of salmon predators would include at least 137 different vertebrate, the impact of predator populations has a major effect on the salmon population.[46] The list in this reference contains at least 53 birds, 20 mammals, 4 amphibians, 3 reptiles and 57 other species that prey on salmon on rare occasions. Missing from this list are at least seven mammals including man and all the fish predators.

Fish species that are known to prey on salmon are walleye, catfish, carp, small-mouth bass, large-mouth bass, shad, sculpin, bull trout, rainbow trout, cutthroat trout, white sturgeon, tuna, pacific hake, bullet mackerel, chub mackerel, wahoo, ling cod,

[46] 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 35

pacific perch, pacific barracudas, Coho salmon, sockeye salmon, Chinook salmon, chum salmon, steelhead, whitefish, and squawfish.

Bird predators include, rhinoceros auklet, Brandt's cormorant, double crested cormorant, olivaceous cormorant, pelagic cormorant, American crow, northwestern crow, American dipper, harlequin duck, bald eagle, golden eagle, great egret, northern gannet, common goldeneye, burrow's goldeneye, pigeon guillemot, Clark's grebe, pied-billed grebe, western grebe, Bonaparte's gull, Heermann's gull, California gull, glaucous gull, glaucous-winged gull, herring gull, ring-billed gull, Thayer's gull, western gull, black-crowned-night heron, great blue heron, belted kingfisher, blacklegged kittiwake, common loon, pacific loon, red-throated loon, black-billed magpie, common merganser, red breasted merganser, common murre, ancient murrelelt, marbled murrelet, osprey, American white pelican, brown pelican, tuffed puffin, common raven, sooty shearwater, artic tern, Caspian terns, common tern, elegant tern, Forster's tern.

Mammals include harbor seals, northern fur seals, Guadeloupe fur seal, elephant seal, California sea lions, Stellar sea lions, river otter, Pacific striped dolphin, White-sided dolphin, harbor porpoise, Dall's porpoise, killer whales, fin whales, humpback whales, Baird's beaked whale, Cuvier's beak whales, sperm whales, pilot whales, gray wolf, black bear, grizzly bear, mink, mountain lion, bobcat, raccoon, water shrew, and man to name a few. The above list brings the known number of salmon predators to 160 different species. Without a doubt, the populations of these various predators have a profound effect on the number of salmon in our rivers. Many of these species are on the endangered list, which forces us into the realization that endangered species are causing the extinction of other endangered species.

Estimating the Kill

At this point, it is constructive to estimate the magnitude of salmon being killed by these predators. The number of salmon being killed depends on, the number of predators (Np), total intake of food (I), the percentage of the intake that consists of salmon (Ds), and the amount of the salmon ingested.

$$Kill = (Np)\ (I)\ (Ds)\ /(A)$$

Each of these factors has varying amounts of uncertainty, which leaves considerable room for maneuvering. The truth lies somewhere in between. Obviously, this is an enormous task if applied to the 160 plus predators. Much of the needed data for those 160 predators is not known. However, we can get an idea of the magnitude of this number by estimating the kill by pinnipeds, Caspian terns, cormorants and gulls in the Columbia River.

Pinniped Kill

To arrive at the pinniped kill first, it is necessary to determine the total number of pinnipeds (Np). As you can see from table 1, the total numbers of seals and sea lions depends on the geographical area you consider. If you want to minimize the number, you can do so by considering only a small area like say the Columbia River, or from Netarts Bay to Grays Harbor. Current estimates by Fish and Wildlife tend to look only at the pinnipeds in the Oregon estuaries.

This assumption minimizes the number of salmon killed. The killing of salmon in confined waters is easier to observe and is better documented. Taking salmon in the open ocean is more difficult for the seals and sea lions, and is not often observed, but that does not mean that it doesn't happen. Now, we know that the salmon do not stay in the area of the Columbia River, but migrate long distances along the continental shelf spending considerable time in near-shore water and migrate extensively into the North Pacific.[47] We also know that sea lions migrate considerable distances up and down the coast during the year. Seals and sea lions are attracted to large concentrations of salmon. By nature, salmon travel in schools and are therefore always concentrated. Therefore, this migration exposes salmon to larger numbers of predators. How many Oregon salmon are killed by Alaskan seals and sea lions is unknown. How many northern fur seals exist is unknown.

Table 1. Estimated Selected Pinniped Populations

Species & Location	Estimated Population	Annual Increase	Total Population
California Sea Lions			
Oregon	10,500	5%	
Washington & California	235,000	5%	
British Columbia[48]	11,000	5%	
SE Alaska	Unknown		
Total			300,000
Northern Sea Lions			
Oregon	800	5%	
Washington	Unknown	5%	
British Columbia	38,000	5%	
SE Alaska	200,000	5%	
Total			250,000
Northern Fur Seals			
Harbor Seals			
Oregon	15,000	7%	
Washington	57,000	8%	
California	43,000	6%	
British Columbia[49]	177,000	6%	
SE Alaska	Unknown		
Total			310,000
Netarts to Grays Harbor	28,000	11%	

[47] Brannon, Ernest L., 1999, The ESA listing of Puget Sound Chinook and the NMFS Status Review, Center for Salmonid and Freshwater Species at Risk. Haggerman Fish Culture Experiment Station, Univ. of Idaho, page 4.
[48] Biggs, M., 1985, Statust of Stellar Sea Lion and California Sea Lion in British Columbia, Can. Spec. Publ. Fish. Aquat. Sci **77**
[49] Olesiuk P. et al., Recent Trends in the Abundance of Harbor Seals in the Straits of Georgia, based on Scat Analysis. Can. Tech. Rep. of Fish and Aquat. Sci., no. 1730.

The numbers in Table 1 come from various sources. Actual numbers of northern sea lions are as yet unavailable, but current estimates of the numbers are around 238,000.[50] It is unlikely that northern sea lions make it to California, but the fact that they exist in Oregon indicates that they must also be in Washington.[51]

The amount of total food consumed (I) by a seal or sea lion depends on the sex, body weight and species. Using data from Federal Fish and Wildlife fact sheets and other published reports; the present daily biomass required by each of the species to maintain body weight can be estimated. See Table 2. The Fish and Wildlife Commission assumes that California sea lions consume 15 lbs. of biomass per day, a very conservative approach, which leads to a significant underestimate of the salmon killed.[52] For example, pinnipeds in the middle of a school of salmon would be prone to gorging and may consume more than three times the biomass required to maintain body weight, increasing their capacity to as much as 130 lbs. of biomass per day. For the calculations done here we will assume a slightly higher but still conservative daily biomass consumption.

Table 2: Pinniped Required Biomass

Species	Biomass Range in lbs.	Gorging Biomass in lbs.	Biomass Assumed in lbs.	Annual Biomass in lbs
California Sea Lion[53]	10 to 25	75 to 30	20	7,300
Northern Sea Lion	11 to 45	130 to 33	40	14,600
Harbor Seal[54]	6	18	6	2,200
Northern Fur Seal				

The next factor required for the estimate is the percentage of the sea lion's diet that is salmon (Ds). This of course depends, to a great extent, on the amount of salmon available. All of the studies to determine the percentage of the diet comprised of salmon were made after the 1970's when the salmon population was severely depressed. Obviously, the pinnipeds are not going to eat salmon if they are not available. This is shown by the variance in the diet for harbor seals from 4 to 60 %. This large difference can be only explained by preference or by availability. It is unlikely that a seal would turn down a salmon meal if it were available. "When salmon are available, seals consume them in quantity."[55]

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[50] Olesiuk, P. and Biggs, M., 1988, Seals and Sea Lions on the British Columbia Coast, Pacific Biological Station, Naniamo, B.C., Department of Fishereies and Oceans.
[51] Beach, R., et al., 1985, Marine Mammals and their Interaction with Fisheries of the Columbia River and Adjacent Waters, Third Annual Report, Washington Department of Wildlife.
[52] ________, NOAA-NWFSC Tech Memo 28: Impact of Sea Lions and Seals on Pacific Coast Salmonids.
[53] Olesiuk, P. and Biggs, M., 1988, Seals and Sea Lions on the British Columbia Coast, Pacific Biological Station, Naniamo, B.C., Department of Fishereies and Oceans.
[54] Kaczynski, V. Palmisano, 1992, Oregon Wild Salmon and Steelhead Trout, A Review of the Impact of Management and Environmental Factors, Oregon Forest Industries,
[55] Parks, D. L., 1993, Effects of Marine Mammals on Columbia River Salmon Listed under the Endangered Species Act, Tech Rep. 3 of 11, BPA page 4

Further, the methods used for food habit studies tend to under estimate consumption of large fish such as salmon. For example, one method used to determine the percent of salmon in the diet consists of counting the number of salmon ear bones in the skat and stomach contents of predators. Other methods using gill rakers and teeth began in 1996 to help get a more realistic count and increased the estimates by 25 percent.[56] Note however, that gill rakers and teeth are still a part of the head. Many times, the head of the salmon is not eaten; thus, the true percentage of salmon in the diet may be considerably higher.

Table 3 lists the maximum and minimum percent of salmon in the diet for the common varieties of seals and sea lions using current practice. Again, Fish and Wildlife studies select low values for the percent of salmon in the diet.

Table 3. Pinniped Salmon Diet as a Percent

Species	Max Percentage	Min Percentage
California Sea Lion[57]	29	6
Northern Sea Lion[58]	10	10
Harbor Seal[59]	60	4
Northern Fur Seal		

The last variable is the amount of salmon that is consumed or wasted by the pinniped. A hungry seal or sea lion will consume almost all of a salmon, but as their need for food lessens, the animals eat only the choice parts such as the egg sack. The egg sack of the salmon is the most nutrient rich part of the fish and requires only a couple of bites of salmon or less than a pound. Fish and Wildlife estimates of pinniped kill assume the entire salmon is eaten.

Thus, we find the Fish and Wildlife used conservative estimates on each of the variables, which will obviously produce a number considerably below the actual number of fish eaten let alone destroyed by attacks where the fish is damaged but not eaten. It would be difficult to defend this conservative approach on a scientific basis.

It should be apparent by now that there exists a high level of uncertainty involved in estimating the number of salmon destroyed by predators. It is not in anyone's best interest to overestimate or underestimate these numbers. However, if we make reasonable but still conservative assumptions we might be able to better estimate the extent of the problem.

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[56] ________, NOAA-NWFSC Tech Memo 28: Impact of Sea Lions and Seals on Pacific Coast Salmonids.
[57] ________, NOAA-NWFSC Tech Memo 28: Impact of Sea Lions and Seals on Pacific Coast Salmonids.
[58] Olesiuk, P. and Biggs, M., 1988, Seals and Sea Lions on the British Columbia Coast, Pacific Biological Station, Naniamo, B.C., Department of Fishereies and Oceans.
[59] Kaczynski, V. Palmisano, 1992, Oregon Wild Salmon and Steelhead Trout, A Review of the Impact of Management and Environmental Factors, Oregon Forest Industries,

Table 5. Pinniped kill in millions of Salmon

Species	Population (Dp)	Annual Intake 365(I) in lbs	Salmon in Diet (Ds)	Amount Ingested (A) in lbs	Total Kill In millions
California Sea Lions	300,000	7,300	0.2	7	60
Northern Sea Lions	250.000	14,600	0.10	10	40
Northern Fur Seals					25[60]
Harbor Seals	310,000	6,570	0.20	5	80
Total					190

If the numbers in table 5 seem large, consider that 60 million fish consumed by 300 thousand California sea lions is 200 fish per year by each animal. Two 75-day salmon runs per year means that each sea lion needs to consume a little more than one fish per day. The larger male sea lions can consume 2.5 fish per day without gorging. Consider also that the half fish is left to scavengers, which results in three fish per day killed. Other Fish and Wildlife documents report that sea lions have been observed killing as many as 4.1 salmon per hour.[61] Since sea lions are not restricted to an 8 hour day, that could be as many as 40 per day.

Thus, these numbers are well within the realm of possibility and these four species alone could easily be responsible for the loss of 190 million salmon per year. Compounding this problem is that these four species of predators are also responsible for a substantial reduction in the salmon's food supply because they also prey on anchovies, herring, and other food sources common to the salmon and are protected by the Marine Mammal Protection Act. The purpose for this protection is unclear because the population of California sea lions is at a historic high.

Terns, Cormorants and Gulls

The National Marine Fisheries Service indicates that terns, cormorants and gulls in the Columbia estuary have increased from a few hundred nesting pairs to well over 30,000.[62] These three bird species are credited with killing over 40 million juvenile salmon in 1997 in the Columbia Basin alone. The blame for this killing was placed on the Corps of Engineers for piling spoil near the channel, which provided the nesting sites. While the problem may be the nesting site, it may also be too many terns. The Audubon Society successfully defeated the Corps of Engineers plan to harass the terns by showing that forcing the protected terns to Sand Island would not solve the problem and that their special interest in birds outweighs their social obligation to save another endangered species.

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[60] In 1984, Northern Fur Seals were responsible of killing about 10.5 million young salmon off the coast of Oregon. Considering a six percent per year increase in population over the last 16 years would produce a total kill today around 25 million.

[61] ________, NOAA-NWFSC Tech Memo 28: Impact of Sea Lions and Seals on Pacific Coast Salmonids.

[62] 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.

According to a three year study conducted by Daniel Roby, Larry Davies, and Carl Schreck of Oregon State University, 8,000 nesting pairs of Caspian terns consumed as many as 20 million smolt per year.[63] This is about 1250 salmon smolt per bird. To put the tern kill into perspective, we know that between 0 and 10 percent of the smolts that pass through turbines are killed.[64] Therefore, if we pass 50,000 smolts through a turbine, 5,000 will die, thus one turbine causes the same number of deaths as four terns. Caspian terns are not native to the Oregon Coast, but are protected by federal law - the Migratory Bird Act, which was passed in 1918 and amended in 1936, 1960, 1967, 1974, 1978, 1986, 1989 and 1998. Cormorants, gulls and many other birds that prey on salmon are also protected. Cormorants are at historic highs.

Other Predator kills

The numbers of other salmon predators, like bears, eagles and terns, have increased significantly in the last century. The Alaskan Fish and Game Service estimates that a single bear eats between 10 and 20 salmon per day during salmon runs. Eagles have recently been taken off the endangered species list. In 1963, only 800 eagles existed in the lower 48 states; presently there are over 11,000 birds, an increase of over 1300 percent. Salmon is a major food source for eagles. The common murre population in Oregon alone has been estimated at 40,000 birds. Studies indicate that each murre can consume 100 smolts per month.[65] Thus, the murre could easily account for 10 million smolts.

Total Kill

Thus, as shown in the above pages, the seven predators that have verifiable numbers of kill are responsible for killing close to 230 million salmon per year. Compare this with the optimum yearly catch in the Columbia River in 1883 of 2.3 million salmon.[66] Although one can argue with the predator kill numbers somewhat, and maybe it would be possible to eliminate 100 million, but then you will have to add the kill from the other 153 predators. The potential kill is enormous; 500 million salmon could easily be killed each year by predators.

Another way to approach the number of salmon killed by predators is to look at the entire ecosystem as a black box. The long time rule of thumb for hatchery efficiency is a 2.7 % return, which indicates a 97.3% loss.[67] Rules of thumb often have safety factors built into them. This rule of thumb can be examined by concentrating on a single pair of salmon. Thus, the number of salmon going into the system is just the number of eggs carried by a single female salmon and the percent of fertilization. The number of

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[63] 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.
[64] Espenson, Barry, 2000, Test Show Turbine Bennifits, Columbia Basin Bulletin, March 10, 2000 NWPPC, Page 5
[65] Mathews, D. R., 1983, Feeding Ecology of the Commom Murre, Uria Aalge, off the Oregon Coast, MS Thesis Univ. Of OR., Eugene OR.
[66] Lichatowich, James A., Morbrand, Lars. E., 1995, Analysis of Chinook Salmon in the Columbia River from an Ecosystem Perspective, page ix
[67] Kaczynski, V. W., 1998, Marine Survival of OPIA Hatchery Coho Salmon related to Marine Temperatures, Proc. Of the 49th Annual Pacific Northwest Culture Conference. Pages 131-147

eggs varies according to species and size. Table 6 lists the average number of eggs for each species and their variability.

Table 6. Egg Count per Species

Species	Average Number of Roe	Variability
Pink	1700	±300
Coho	3000	±1500
Chum	3000	±1500
Chinook	5000	3000 to 12000
Sockeye	3500	±1500
Steelhead	3500	±1500

It can be seen that the data varies to such a degree that the percent of fertilization drops out of the equation. It is not necessary to know what goes on in the box. All we need to know is the number of salmon going in and the number coming out, the difference is the number of salmon that perish inside the system. For example, consider that a pair of chinook produces about 5000 fertilized eggs. In a balanced system, where the chinook population is going neither up nor down, those 5000 eggs must return to the river a single pair of salmon. See figure 13.

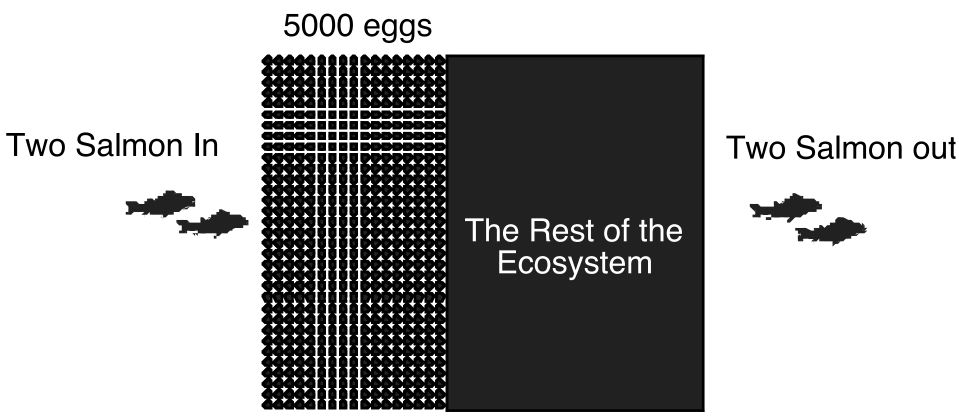

Figure 13. Black Box Approach

Thus, 4998 out of 5000 salmon do not survive for one reason or another or the break-even point is 99.94 percent, fairly close to the rule of thumb. The difference is the safety factor. To ignore the role of salmon predators in the reduction of salmon population is a major oversight in the current science. Predators are what keep prey in check. Prey and predators are tightly connected in a structure, which used to be called the Balance of Nature.

Balance of Nature

Even though the concept, "Balance of Nature," has been replaced with the more complex ecosystem, it is still useful to understand the interaction between prey and predator. See Figure 14. In this figure, there is a balance beam and three colored boxes.

The green box contains all of the salmon and is larger than the red box, which contains all of the salmon predators including man. That is because the salmon rely on a survival strategy that is based on the school or herd concept. In other words, if we can't fight them or we can't out run them, we will out-produce them. This strategy relies on producing large numbers of off spring. However, salmon do little in the way of parenting. One reason hatcheries are effective, is they provide this missing parenting to the young salmon, nurturing and protecting them during the first months of their existence.

The predators in the red box rely on the green box for part of their diet. The salmon in the blue box are the ones that escape the predators and live to produce more salmon. When nature is in balance, there are enough salmon in the blue box to produce enough salmon to fill both the blue and green boxes. Thus, the numbers of predators in the red box are fed, the black balance beam is level and nature is in balance, this condition occurs rarely, and is sometimes referred to as, “a baseline.” A baseline is a set of conditions that can be used for comparing trends in a phenomenon or interpreting the operation of a model. Later we will take a closer look at the salmon baseline.

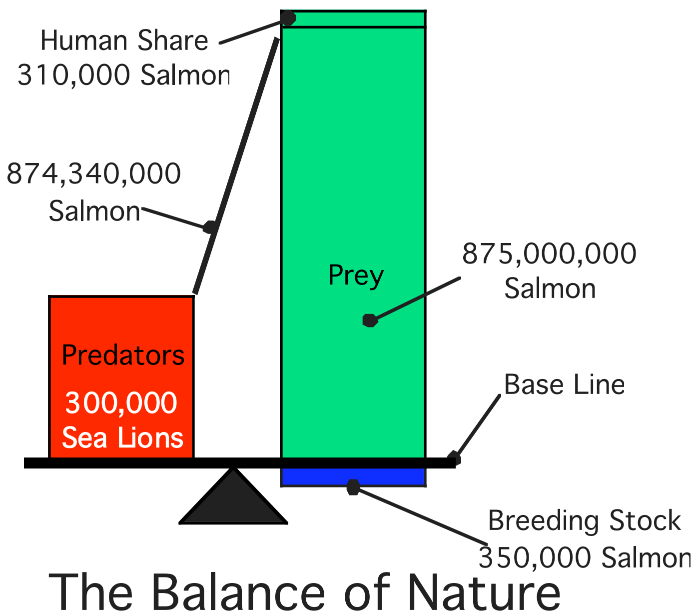

Figure 14. Concepts involved in the Balance of Nature

By using the average return of 350,000 salmon in the Columbia over the last 50 years as the number of spawners in the blue box and assuming half are female, that would produce 875 million eggs in the green box. Since the average Oregon catch over those same years was about 310,000 salmon and 350,000 must escape to the blue box again to keep the system in balance, 660,000 salmon are accounted for. This results in 874,340,000 salmon that were taken by some form of predator or 99.92 percent. Comparing these calculations with the one in the preceding section, human’s are taking about 0.02 percent of the salmon.

Now, let's see what happens if we manipulate the balance by improving the habitat in the Columbia River and add 50,000 fish to the green box. Then we will have the condition shown in Figure 15. In this situation, all predators except sea lions and are allowed to eat only the same amount of salmon they ate last year, then the 50,000 new salmon would increase the present sea lion population by 250 individuals or less than 0.1 percent. That is one new sea lion pup in every 1000 breeding pairs. An increase of this magnitude would be well within the normal 6% population increase. It would only take forty Caspian Terns to consume the 50,000 extra smolt. In reality all predator numbers will rise as well and the sea lion and tern population will only increase by a few. This shows the futility of increasing the salmon in the green box, without controlling predator population.

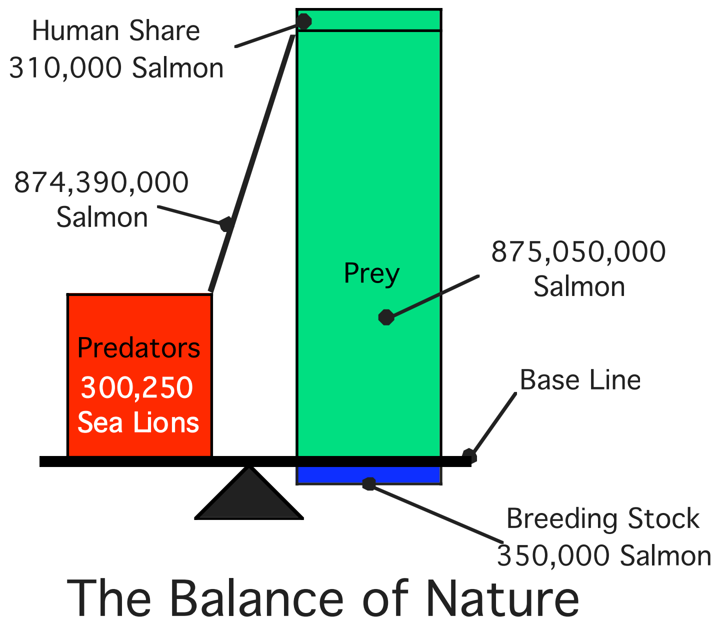

Figure 15. Adding to the Green Box.

Now lets turn to the red box. Suppose we reduce the number of sea lions in the red box by 250. Since the sea lions prey on salmon just before they spawn, the 50,000 salmon escaping would end up in the blue box. This condition is represented by figure 16.

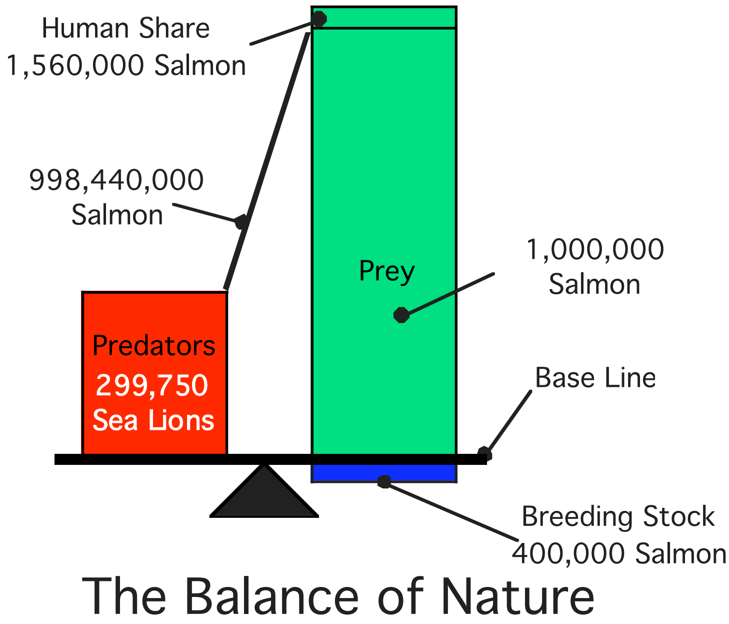

Figure 16: Reducing the Numbers in the Red Box

Now the green box is filled with a billion salmon. If man is allowed only one out of every hundred of those extra 125 million salmon the human harvest would jump to 1.56 million fish, and the rest of the predators would get the remaining 123.5 million salmon. This is more salmon than we harvested from the Columbia River in 1890. This of course assumes we could feed 125 million extra salmon, but it does show the leverage of working in the red box.

The actual salmon model will be considerably more complex than this simple model. Each of the boxes contains other boxes. For example, the red box might look like Figure 17 and the green box like Figure 18.

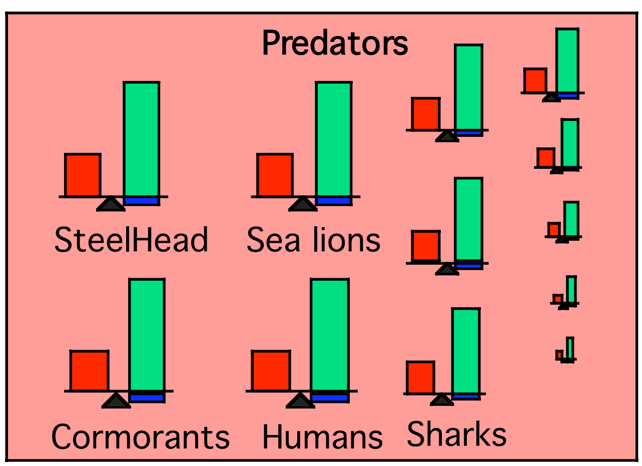

Figure 17. Inside the Red Box

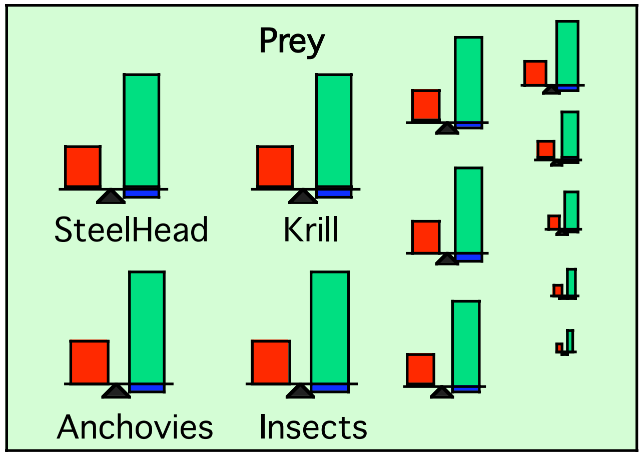

Figure 18. Inside the Green Box

Notice that there are other balances in each of these boxes representing each of the species in that box and each has its own set of balances with blue, red and green boxes filled with other boxes. There are also interconnections. For example, the seal has the shark as a predator in common with the salmon, and the salmon both eats and is eaten by steelhead.

Further, we must add to each box all of the environmental effects for each of the habitats, like turbidity, water temperature, ocean currents, dam operation, etc. There is little doubt that this model would be complex. However, if humans are to take over the responsibility of salmon survival from Mother Nature, humans must know how the system operates. The result of this model may well show that the well-meaning decisions 80 years ago to protect pinnipeds and sea birds may well be a major factor in the decline of the salmon.

Salmon Baseline

As we have seen above, the salmon baseline is the number that is used to compare performance over time. The current peer reviewed baseline for Columbia River salmon is estimated at 10 to 16 million salmon. This estimate is based on the number of Chinook salmon caught in 1883 and some rather esoteric assumptions on escape ratio and ratios between the chinook runs and the other salmon runs.[68] How this statement could be contained in a supposedly peer reviewed document is difficult to comprehend. None of the above assumptions stand up to critical examination. The pre 1800 levels of salmon can also be estimated by calculating the maximum breeding capacity and looking at historic data. See Figure 19.

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[68] ________, 1986, NWPPC, Appendix D, Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin, Page 9

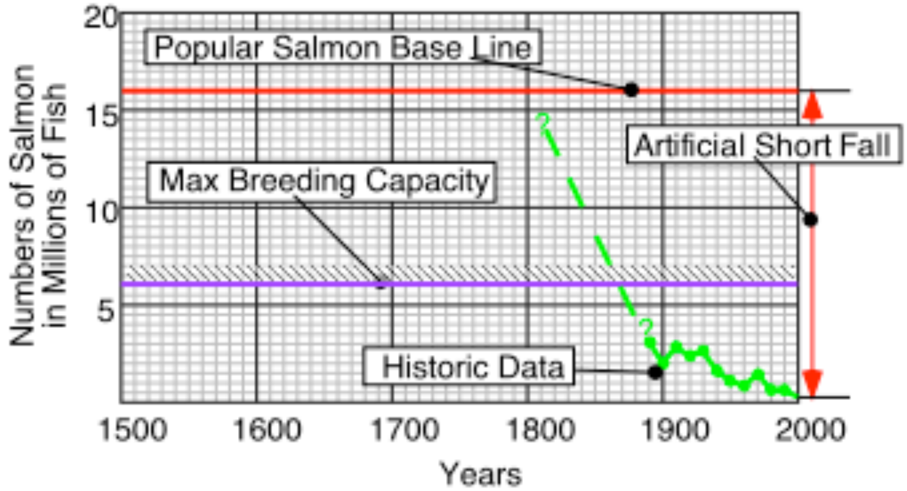

Figure 19. Columbia River Salmon Base Line

The maximum breeding capacity of the pre 1800 Columbia River system was calculated in the same report by assuming a return rate and that all available breeding space is fully utilized by salmon.[69] These calculations show the Columbia River is capable of producing about 6.2 million returning fish. Even though these calculations followed each other in the document, no attempt has been made to explain where the extra 4 to 10 million fish needed for the popular baseline were bred. The maximum breeding return is like a barrier. It would be very difficult for any river to support a return that surpassed this number significantly.

The plot of the historic data is based on the total number of salmon caught in the Columbia and the total number of salmon passing up the fish ladders at Bonneville Dam. This assumes that the number of fish caught above Bonneville was not a major portion of the total catch and represents the fish that escaped. Thus, the total fish returning to the river can be calculated. The historic data curve is a reasonably accurate estimate of the total fish returning to the river up to 1940. Before 1938, the number of fish that escaped was estimated based on the average escapement ratio calculated from the first 12 years of Bonneville data. Since catch restrictions were enforced in the early 1900s and were increased every few years thereafter, fish that actually escaped prior to 1938 would be less than this assumption. Therefore, the actual population would be less than calculated. Even using this conservative approach, the maximum fish return would be a little less than 4 million fish.

It seems highly unlikely that the total number of returning salmon in the river would ever quadruple its historic highs in ninety years. Further, the concept of a constant fish return is inconsistent with nature. Most natural phenomenon varies over time. It is entirely possible that the population pre 1800 was less than it was in 1890. In any case, it is obvious that the 10 to 16 million number for the historic salmon population is a major over estimate, which produces false expectations. This obvious error leaves two issues

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[69] ________, 1986, NWPPC, Appendix D, Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin, Page 8

unanswered, first, how did such a obvious error persist through so many peer reviews and second what was the fish population prior to the introduction of complex culture. We will discuss the subject of peer review later. To get a more accurate indication of the fish runs before 1890, we can look at eyewitness accounts, Native American ritual and evaluate core sample data.

Eye witness Accounts of Early Historical Runs

We have the accounts of two exceptionally accurate and thorough individuals who were instructed by the President of the United States to record natural wonders and resources. Lewis and Clark arrived at the Clearwater River on September 21, 1805, near what should have been the peak of the fall salmon run.[70] The question here isn't, "did they see salmon?" – the question is, "did they see a fall run as large as 8-10 million salmon?" A run of salmon that large would surely have been noted in the journals of these men, particularly because they were near starvation. When they reached the Clearwater River, they were reduced to eating dried salmon, roots, and horse and dog meat. Some of the men were so weak they had to be drug behind the horses on litters. When they reached the Clearwater, did the men gorge on the abundant salmon? If they did it is not recorded in the diaries.

Lewis and Clark journals clearly talk about salmon 44 times during the four to five week trip down the Clearwater and Snake rivers. The journal entries also complain about stomach trouble from their diet of salmon. However, almost all of those 44 times they obtained the salmon from the Indians. It is hard to believe that backwoodsmen would trade for salmon if they could catch salmon from the river. Certainly, they had the skills, especially in a river that was boiling with salmon as we have been led to believe. There is only one notation in the journal where they caught fresh salmon. That event occurred four days after they reached the Clearwater and they only managed to catch six fish.[71] If the rivers where indeed teeming with millions of fish, why did these experienced backwoodsman not catch more salmon?

On the last day of September, they noted a great number of small ducks passing down the river. It is curious that they should mention a few hundred ducks, and not mention the millions of salmon presumed by popular notion to be in the river. The salmon that they ate on the Clearwater and Snake was dried salmon. The men did not like dried salmon. The dried salmon was made using spent salmon.[72] Spent salmon are those salmon that have died naturally from exhaustion and starvation. The fat content of these salmon was therefore lower and the natives found that dried spent salmon kept better than fresh salmon.

Nowhere on the Snake or the Clearwater did Lewis and Clark come across any natives harvesting salmon. One entry in the journal mentions natives fishing, but fishing and harvesting are two different matters.

On October 10, after being on the river for 3 days and passing 30 rapids they came to an Indian village. They discussed the lives of the natives living on the river as

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[70] Moulton, Gary E., 1989, The Journals of the Lewis and Clark Expedition, Univ. of Neb. Press. Vol 5, page 227.
[71] Moulton, Gary E., 1989, The Journals of the Lewis and Clark Expedition, Univ. of Neb. Press. Vol 5, page 233.
[72] Wilkes, Captain, 1841, Wilkes' Narative, Vol .IV

the pursuit of summer and fall salmon fishing.[73] However, there was no notation about any ongoing salmon harvest, which should have been a big event for the village. In addition, some salmon at least should have been noted leaping in some of the rapids, as well as references to dead and dying spent salmon.

On the 13th of October, they came to Monumental Rock in Walla Walla County and noted that this was obviously a great fishing place. They noted, "a number wholes of fish." The spelling is so bad, that one is not sure whether Clark meant fishing holes or whole salmon. However, they neither noted large numbers of fish, alive or dead, nor Indians harvesting fish.[74] Thus, on the entire trip down the Clearwater and Snake Rivers this starving party of backwoodsmen dutifully recorded when they ate duck, dog or deer, but recorded eating only six fresh salmon. This from two rivers that the biologists would have us believe were teeming with fish, "Historically the Snake River fall component of this ESU (salmon) was the predominant source of production."[75]

Finally, on October 17, 1805, Lewis and Clark reached the Columbia and made their first notation about observing great numbers of dead salmon.[76] They spend a day exploring up stream near Pasco and found the Indians apparently near the middle of the fish harvest. They reported salmon drying on racks and dried salmon stored in baskets. Thus, the salmon run must have been going on for some time. Why were there so few salmon in the Snake and the Clearwater? If we assume the Indian salmon catch was several hundred thousand, where were the 7-9 million dead salmon left over from the run?

The average individual has a difficult time in comprehending the magnitude of 7 to 9 million anything. Imagine a 3-foot long dead salmon in the center of a six-foot square piece of water. Eight million salmon would fill a football field wide river 180 miles long. This field of dead fish would have required Lewis and Clark 6 days to pass through. The number of animals and birds attracted to this bountiful harvest would have been noted in their journals. No dead salmon were noted in the Snake or the Clearwater. Does that mean the Snake was not heavily used for breeding?

They did begin to partake and enjoy fresh salmon on the Columbia, although they were still starving and eating dogs and horses. They made several more notations on salmon as they passed Indians fishing further down the Columbia. On the 22nd of October, they reached Celilo Falls; the great pinch point on the Columbia, where the salmon were forced into expending tremendous efforts to pass upstream. Eight to ten million salmon passing this spot would require 4 to 16 salmon a second leaping up the falls, for 8 or 12 weeks, an event that would astound any observer and leave a lasting impression.

Yet, these skilled observers said very little about salmon. The notations in the journals are rather subdued. Instead a notation about the great number of sea otters (now

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[73] Moulton, Gary E., 1989, The Journals of the Lewis and Clark Expedition, Univ. of Neb. Press. Vol 5, page 259.

[74] Moulton, Gary E., 1989, The Journals of the Lewis and Clark Expedition, Univ. of Neb. Press. Vol 5, page 268.

[75] ________, 1996, Status Review of Chinook Salmon from Washington, Idaho, Oregon and California, NOAA Tech. Mem. NMFS-MWFSC-35, page xxiv

[76] Moulton, Gary E., 1989, The Journals of the Lewis and Clark Expedition, Univ. of Neb. Press. Vol 5, page 286.

thought to be seals) below these rapids 200 miles inland.[77] They mention large numbers of seals two other times as they proceeded down river. This speaks to the abundance of seals, not salmon, and the direct connection between the two. Lewis and Clark journeyed up the river during the spring salmon run of 1806, again with minimal notation about salmon.

The truth about the Lewis and Clark expedition was the party barely survived the ordeal. Consider that their trip through Oregon, Washington and Idaho was through an aboriginal landscape with no dams, farms, logging, industry, no pesticides or roads. An environment that some characterize today as the perfect environment. If the land was truly bountiful, why was the home to a mere 200,000 natives and why was the expedition forced to eat dog and horse meat to survive?

Careful reading of other early diaries shows similar lack of salmon. Captain Wilkes in 1841 speaks of Indians complaining of scarce salmon in his Diaries. Historic accounts of Fort Vancouver and Astoria do not mention the commercial value of large salmon runs.

Indian Ritual

The science of anthropology and sociology provide further evidence of very small salmon runs before development of the Pacific Coast. It is common knowledge that the Indian nations along the Columbia River relied on salmon as a major food source. Since the Indians' culture was built around not wasting natural resources, they would only take what they could eat or trade. The Indians traded salmon as far away as the plains.

It is also known that many of these nations had developed a ritual around the arrival of the first salmon to ensure that the runs would be bountiful. This implies that there were runs that were not adequate and these shortfalls occurred often enough to generate the need to invoke divine intervention to ensure success.

Based on studies that place the aboriginal take of salmon between 500,000 and 900,000, the 100 to 200 tribal groups along the river would be hard pressed to use and catch any more than 25,000 to 50,000 fish each.[78] Since the ritual was for a specific tribal group, there must have been many years when a single tribe caught less than 25,000 fish. Assuming that the Native American’s catch efficiency, before 1800 was only 5%, (compared to as high as 85% attributed to the catch of 1883[79]), this would indicate aboriginal runs in the Columbia River of less than 500,000 salmon on numerous occasions.

Core Sample Data

Estimates of prehistoric fish runs can be generated by examining fish scale deposits in ocean bottom core samples.[80] The number of scales at a given depth in the

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[77] Moulton, Gary E., 1989, The Journals of the Lewis and Clark Expedition, Univ. of Neb. Press. Vol 5, page 327.
[78] Craig & Hacker, 1940, The History and Development of the Fisheries of the Columbia River, US Bureau of Fisheries Bulletin, Pages 133-216
[79] ________, 1986, NWPPC, Appendix D, Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin, Page 9
[80] Smith, R. L., 1978, Biological Effects of Ocean Variability: Time and Space Scales of Biological Response, Rapports et Process-verbazux des Reunions **173**: 117-127

sample is related to the fish population and the depth of the scale in the sample is related to time. The data from that study was subjected to a fourth order polynomial curve fit and are plotted on figure 20 as the red line. The green line is a 4th order polynomial curve fit to the total Columbia River salmon return data, and the blue curve is a 4th order polynomial curve fit to the Sockeye salmon abundance data take from a study of Alaskan lake sediments.[81]

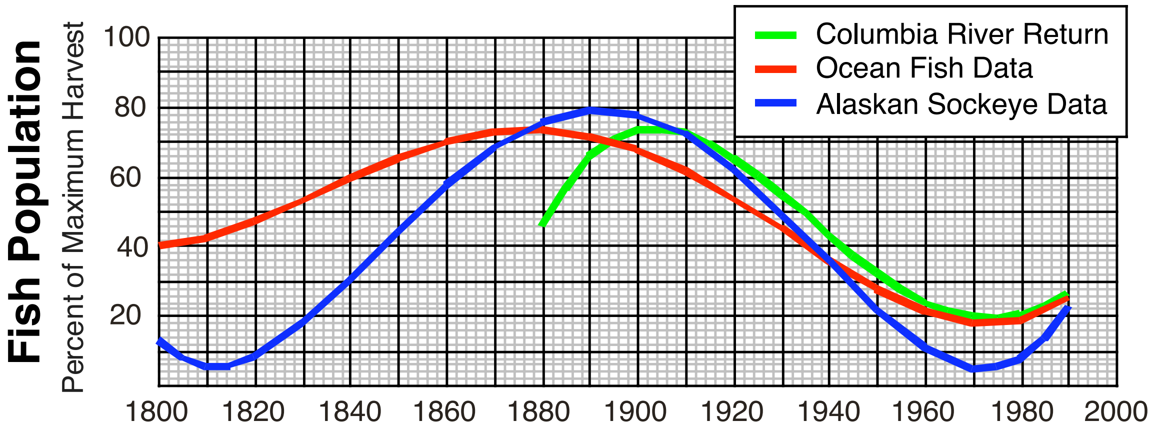

Figure 20. Estimate of 1810 Salmon Population

The steep drop off of the Columbia River total return (catch and escapement) after 1890 is due to the lack of Columbia River data in the early 1800s. One way to get an estimate of the Columbia River salmon early in the 1800s is to use these curves. Since they track each other remarkably well from 1990 to 1890, it is reasonable to expect they would continue to be similar to the year1800. Therefore the Columbia River salmon population in 1800 would be somewhere between 40% and 15% of its maximum level. Using the average value of 26.5% would produce an aboriginal salmon run of about 1.1 million fish (0.27 x 4,000,000). That is significantly less than 16 million constantly quoted by the popular press.

Therefore, based on historic accounts, Indian ritual and scientific data it appears the popular pre-1805 salmon runs are grossly overstated. This data shows the aboriginal runs in the Columbia River between 0.5 and 2 million fish, which is very close to the current salmon runs. Thus, the whole basis for returning the river to pre-1850 conditions goes away.

Notice all sets of data show population peaks in the late 1800's and lower populations in mid1960s and the early 1800s. This is remarkable because they are population data on such distinctly different species; that is five ocean fish, Alaskan and Oregon salmon. Climate effects usually increase Oregon salmon while decreasing Alaskan Salmon or visa versa. The ocean fish are not influenced by river conditions. Therefore, this bulge in population near the end of the 1800s must be due to other factors.

[81] Finney, Bruce P., et. al., 2000, Impacts of Climatic Change and Fishing on Pacific Salmon Abundance over the Past 300 years. Science, Vol 290, October 2000.

A Century of Killing

In 1800, the human population reached 1 billion, technology was improving transportation and weapons, and by the end of the century the population had almost doubled. Humans were becoming a global force while still clinging to the idea that nature was there for us to exploit. History relates that, as early as 1780, seal hunting was big business along the Pacific coast.[82] Throughout the 1800s, fur trading was big business in the Pacific Northwest. Seals, sea lions, and otters were hunted extensively for their fur and oil. Much of this killing was done by the Native Americans. It is true that western culture brought the means (guns and a market), but the Native Americans had the skill set to harvest large quantities of pelts.

The western powers merely provided the means for gathering the pelts and getting them to the market. For example, the Hudson Bay Company and various other American and Russian trading charters and the cities of Astoria, Oregon and Vancouver, Washington were founded on the fur trade. The Russians developed fur-trading colonies as far south as Fort Ross in California.

Large numbers of ships sailed the Pacific Coast carrying millions of pelts to China. A single Russian ship, *Neva*, arrived at Canton, China with 151,000 fur seal pelts in 1805.[83] The result of this slaughter was that by the late 1800s these animals were driven to economic extinction and hunting stopped. In 1892, the Audubon Society reported that only seven individual Guadeloupe fur seals existed on the Pacific Coast.[84]

From the 1850s, pioneers and settlers poured into the northwest killing eagles and bears along with many other salmon predators. There are few counts of actual predator populations, but it is common knowledge that a great many of the salmon predators were near extinction by the end of the 1800s. The dodo, passenger pigeon, buffalo, and several species of whales were driven to extinction or near extinction during the same period. As a consequence of harvesting large numbers of whales, the ocean's food supply shifted dramatically. These large mammals consumed great quantities of biomass. A single whale can consume 35 million plankton.[85] The killing of 500,000 whales would free 17 million, million plankton to feed other species.

Thus by the end of the 1800s due to the massive reduction in whale population, food was available to feed other ocean species, and predators were severely reduced through the combined actions of one to two billion humans; not just Euro-Americans, but Native Americans, Europeans, and Asians as well. These conditions would obviously influence the numbers of salmon, sardines, anchovies, hake, saury and mackerel and produce the bloom reflected in the historic data. The assumption that the 1883 run of Chinook in the Columbia River was a normal aboriginal run is obviously false. If human activity produced the bloom in salmon, what produced the drop in salmon population?

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[82] Whitaker, John O., 1980, The Audubon Society Field Guide to North American Mammals, Alfred A. Knopf, New York, Page 611

[83] Gibson, James, R., 1992, Otter Skins, Boston Ships, and China Goods, Univ. Wash. Press, Seattle, WA page 14.

[84] Whitaker, John O., 1980, The Audubon Society Field Guide to North American Mammals, Alfred A. Knopf, New York, Page 612

[85] Engel, Leonard, 1961, The Sea, Time Life Pub. Page 104

A Century of Conservation

After the century of killing, a century of conservation followed. Visionaries like Muir, Audubon and Teddy Roosevelt saw the consequences of this senseless killing. Through their efforts, legislation was passed to protect many of these species and their habitat. It certainly seems like a humane thing to do. Unfortunately, the pendulum of human opinion never spends much time in the center. The conservation philosophy gained momentum and final dominated in 1973 with passage of the Endangered Species Act; legislation designed apparently to prevent species from extinction. For four billion years nature has been driving species into extinction, some of them mass extinctions. Then in 1973, the US congress decided to take control of evolution away from nature and place it in the hands of US bureaucracy. A well meaning, but misguided and totally unworkable act, that ranks above the attempt of the Roman Senate to legislate the value of PI as 3.000.

Fifty years ago, people did not want to see lions killing impalas. Today, we seem to have come to terms with the fact that death is necessary for life. Likewise, extinction is necessary for creation. There is only a finite amount of food on this planet and thus a finite number of biological niches. For four billion years, superior species have driven inferior and over specialized species into extinction. Life is dynamic and must remain flexible. Wooly mammoths and sabre-toothed tigers once dominated the environment, but the environment changed and they went extinct, making room for a species that was more in tune with its environment. Today we have laws that artificially protect a specie simply because it no longer fits its environment. The wisdom of this practice is unclear.

Whereas the conservation movement had good intentions, it is naive to think that increasing one species would not seriously affect another. It is one thing to protect a species and another thing to feed them. The result is that the salmon's food supply over the last 100 years has decreased and the total number of salmon predators has been on the rise since. Human activity has thus unbalanced nature and set it against the salmon.

To illustrate this point, let us examine the fall and rise of just two of the salmon predators, seals and sea lions, off the Pacific coast. In the last hundred years, harbor seals alone have increased from around 100 animals to over 310,000, California sea lions from 1000 to over 300,000.[86] Some investigators feel that the number of California sea lions today exceeds any historic estimate.[87] Thus, from around 1100 animals in 1911 the numbers have grown until today there are over 850,000 if the northern fur seals and northern sea lions are included. Over the same period, the population of the six fish we have historic data on has plummeted to less than 10% of their maximum numbers. See Figure 21.

[86] ________, NOAA-NWFSC Tech Memo 28: Impact of Sea Lions and Seals on Pacific Coast Salmonids, Page 1

[87] ________, NOAA-NWFSC Tech Memo 28: Impact of Sea Lions and Seals on Pacific Coast Salmonids, Page1

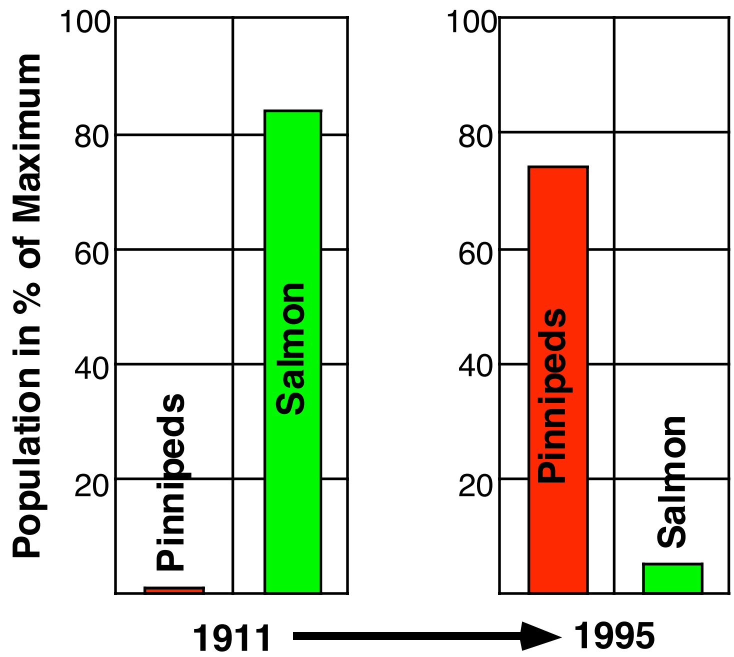

Figure 21. Population changes during the 20th century

To believe that these facts are unrelated is myopic and irresponsible. What is ironic is that human activities have indeed caused the decline of salmon, but it is not the activities of logging, farming or hydropower, but the activities of over zealous environmentalist.

A Century of Doubt

As we enter the 21st century, the human population is approaching 6 billion. By the end of the century it may well be 20 billion. We now have environmental laws that are confusing and conflicting. The Marine Mammal Protection Act and the Migratory Bird Act protect species that are killing endangered species protected by the Endangered Species Act. The Clean Water Act removes from the rivers, estuaries and oceans important nutrients needed to feed endangered species. We are now faced with numerous decisions that have far reaching consequences that we have neither the skill nor the science to make correctly. Further, we are surrounded by special interest groups who confuse the issue by dealing in half-truths.

Presently, we are basing important decisions on opinions, and environmental dogma. There are many of the basic precepts of the environmental movement that are not true. Precepts such as, life is fragile, biodiversity is necessary, human impact is all bad, nature is all good.

Life cannot be fragile. Nothing that has been around 4 billion years is fragile. One hundred thousand years ago, all of eastern Oregon and Washington was a sea of molten lava. Yet, life abounds there. The Mount St Helens eruption devastated 100's of square miles, killing all life in the area. Yet, one year later, life was back and twenty years later life is flourishing. The truth is that life on this planet will survive. Man may not.

There have been many times during that 4 billion years when biodiversity was significantly reduced and life flourished. In the beginning there was only one species, biodiversity was totally absent, yet all life originated from that single species. Many mass extinctions have taken place over geologic time. The extinctions after the last ice age and the dinosaur extinction are two that are commonly known. One of the major reasons that extinctions occur is that the environment is constantly changing. Species that cannot adapt simply go extinct.

We look at the Mount St. Helen's eruption as a natural wonder and a clear cut as an unnatural disaster. In truth, neither are intrinsically good or bad, they just are. Good and bad are human terms that require an arbitrary basis for judgment. Nature has no good or bad, it just has life and death, creation and extinction, what works, works. Success is measured on how well the species thrives. Nature can do that because nature has no vested interests in who survives.

If paleontology has taught us anything, it has shown that overspecialization is a prelude to extinction. Many of the species we are currently struggling to support are critically overspecialized. In fact, man is critically over specialized. Certainly, we must pay attention to the environment, but not for the environment's sake but for human's sake. We must make tough decisions based on complete science as to what is fed the dwindling food supply on this planet, seals or children. These are not easy decisions, not pleasant decisions, and certainly not decisions that can be based on opinion.

It is time to look ahead to the consequences of an expanding human population. This is not the first time or the last that humans have dealt with the problem of over population. Many are calling for social change to resolve this problem. A prospective panelist for a discussion on adding nutrients to rivers was asked the following qualifying question by the EPA.

> "*The panel will address the questions of whether there is an inherent conflict between adding nutrients to watersheds to increase salmon runs vs. other societal objectives such as protecting or enhancing water quality. Philosophically, should society opt to add nutrients to substitute for the fundamental causes of the salmon decline? Will such an approach unintentionally mislead the public into thinking that the salmon decline can be reversed without major societal changes?*"

The feeling that social change is necessary is common in the environmentalist movement; sometimes so much so that the hidden agenda obscures the actual objective. Obviously, the food problem discussed at the above conference is a real problem to the survival of the fish, but this is not the first time that the philosophical environmentalist agenda has surfaced. For example, the entire hatchery/wild salmon issue has its roots deep in the philosophy that social change is needed. If hatchery salmon are counted, then many salmon sub species will not be endangered, thus environmental modification and the accompanying social change cannot be forced on those rivers.

Wild versus Hatchery Salmon

Hatchery programs have long been a part of the plan to recover salmon, certainly a major root of the 4 H (Hatchery, Harvest, Habitat and Hydro) concept. Suddenly in the later part of the 1990s, the Hatchery program came under heavy pressure. Hatchery fish and their eggs were destroyed by the millions. Entire runs eliminated under the pretext that wild salmon were endangered by the success of hatchery salmon. This seems illogical if we are indeed trying to save salmon. In fact, on many Pacific Northwest Rivers, the Columbia for example, salmon are not endangered unless you exclude hatchery salmon. Returning salmon have been counted at Bonneville since 1938. Figure 22 is a plot of the returning Chinook and Coho from 1938 to the present.

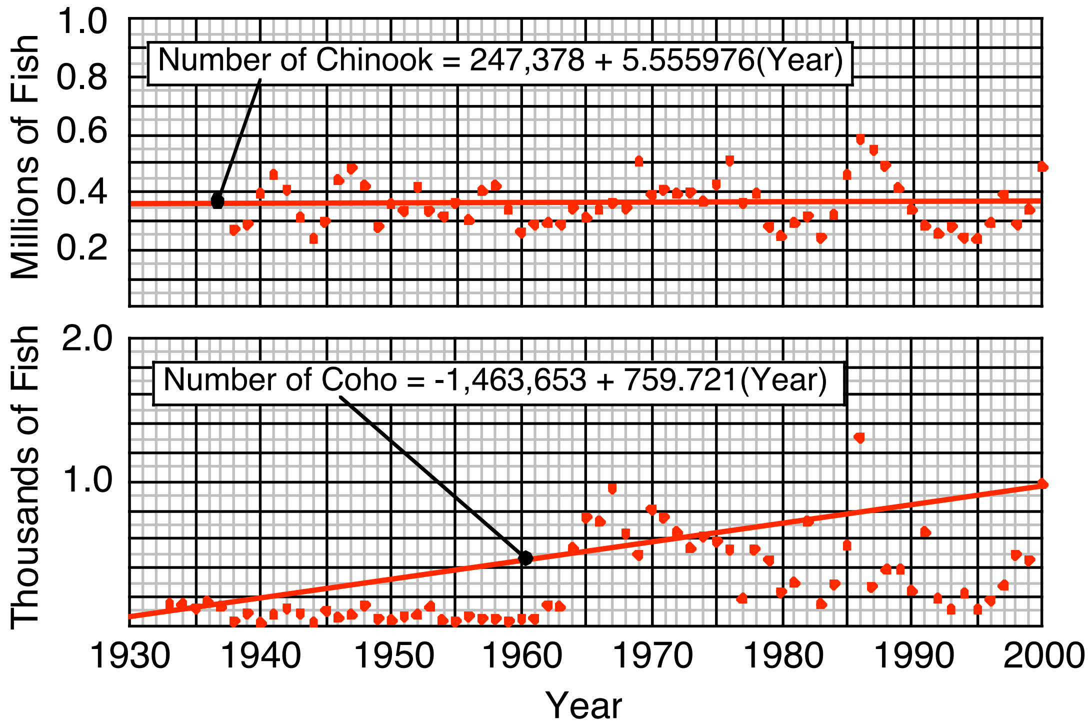

Figure 22. Salmon Return at Bonneville

By simple inspection of these curves, the salmon population of the Chinook seems to be reasonably stable for the last 62 years and the coho salmon would appear to be improving. In fact, the statistically generated best fit trend lines (given in the boxes) for both have a positive slope. Whereas the coho slope is relatively steep, the chinook gain is only slightly positive, but neither species would appear to be in danger of going extinct and therefore may not belong on the endangered species list. Taking the salmon off the endangered species list significantly reduces the leverage to induce social change.

Salmon can be kept on the list by several clever scientific tricks for example, by selecting your data groupings or dividing them into sub species. If you selectively look at the Columbia River coho after 1965, you will find the trend line is negative, indicating that the coho are endangered. Salmon have already been divided into subspecies, such as Chinook or Coho, which the Endangered Species Act allows, but we have seen that the subspecies are doing well. However, in the case of the salmon, the law was massaged a bit and the salmon were divided into effectively a sub-sub-subspecies based on a common belief that salmon unerringly return to their original spawning ground. Therefore, a separate sub-sub-sub-subspecies, of Chinook salmon could be defined as the

Columbia River/Snake River/Salmon River/South Fork of the Salmon River/Johnson Creek Chinook. Anytime a species is divided into six subdivisions the result will be a population small enough to make the species look endangered.

However, the truth is that salmon stray in large numbers and often. Otherwise, all salmon would be spawning in only one river. Studies have shown that salmon straying can be as high as 78 percent.[88,89] Twenty percent of the adult chinook carcasses on the Sixes River spawning ground were strays from Elk River. Admittedly, these studies were on straying hatchery salmon, because nobody is interested in studying straying "wild" salmon but that does not mean that wild salmon do not stray as well. The straying of wild salmon would invalidate the idea that sub-sub-subspecies are unique and therefore threatened.

Further, since Salmon have strayed in large numbers for the few years studied is it not reasonable to assume that they have been straying in large numbers since the inception of hatchery programs for over 100 years? The result of this massive straying is that no racially pure wild salmon exist as well. In other words, there is no difference between a wild Snake River coho and a hatchery coho from the Alsea River. Certainly there is no physical difference. Then, what keeps these salmon on the endangered list?

According to a few scientists, the difference is in the genes, but there is very little data to support this claim. Whereas the individual's DNA is unique, the differences in DNA that separates individuals is not well understood. Certainly there are DNA differences between ethnic groups and even members of the same family, but does that mean that ethnic groups are subspecies? The idea that crossbreeding between different subspecies will weaken the species is also false. The action by the regulatory group to utilize sub-sub species as well as use DNA differences to classify endangered species is unprecedented. Are regulatory agencies guilty of making new law?

If no truly wild salmon exist, and there is not a real difference between a wild Snake River coho and a hatchery coho from the Alsea River, we are left with many questions. Should salmon be on the endangered lists? Why are other fish whose populations have diminished similar to the salmon such as, sardines, anchovies, hake, saury and mackerel, not on the endangered list? How much of the salmon issue is involved in the perceived notion that social reform is necessary? How much did social reform shape the direction of salmon research? How many other issues other than hatcheries and nutrients have been covered up? Is social change necessary?

Social Change

It is apparent that many feel that it is important to change society back to a more "environmentally friendly" society. Certainly, the comfort of the "good old days" appeals to all of us. I for one long for the days before tongue piercing, but moving society backward is not necessarily better and has never worked well in the past. Certainly, protecting the environment is important but the idea that aboriginal people were more environmentally friendly may not be true. Further, a species that is in tune

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[88] Jacobs, S. E., 1988, Straying in Oregon by Adult Salmon of Hatchery Origin, ODFW Information Report (Fish) Portland OR.

[89] Downey, T. L., Susac, G. L., Nicholas, J. W. , 1988, Research and Development of Oregon's Coastal Chinook Salmon Stocks, OR. Dept. of Fish and Wildlife, Fish Research Project NA-87-ABD-00109, Annual Preport, Portland, OR.

with the environment has undoubtedly a better chance for survival. In fact, the more in tune, the greater the population and the longer the species exists on the planet. But, culture and environment are firmly connected; changing a modern human environment to an aboriginal environment will only produce a species in tune with its environment if we change the human culture from our modern culture to an aboriginal culture. Since modern humans are not in tune with aboriginal environments, culture catastrophe will follow.

Consider humans appeared on the planet earlier than 200,000 years ago as just another mammal that survived like all other mammals before it, searching for food, and raising young. Each family group staked out and protected a home area where the family group foraged.

In the beginning, humans followed a survival strategy that we call today, hunter-gatherers. About 12 thousand years ago, the world population was 10 million hunter-gatherers.[90] In other words, for a large percentage of that human existence the population of humans was static. In the early 1800s, there were 1 billion humans on the planet. Why had it taken almost a million years to get the first 10 million humans and then only 12 thousand years to add 990 million people? The answer lies in the term overgrazing. Twelve thousand years ago, the entire planet was saturated with humans. It takes a lot of space to feed a hunter-gatherer. No more habitable space existed 12 thousand years ago for these hunter-gatherer groups to forage.

Living in a saturated niche is not a pleasant existence. Life is hard and one individual must die before another can be born. Change was necessary. Most living things survive by changing, but they change physically, improving their chances of survival say by adding claws, changing size or stripes, or improving parenting to deal with the environment better. Around 12,000 years ago, humans made a dramatic change, but not physically. They changed their survival strategy, by changing their culture. Humans found that social change was an effective tool to rapidly improve the odds of survival. Agriculture was developed.

The change was slow at first, but farming was a superior survival skill, simply because it allowed more people to be supported on less land. Farmers were no longer living on an over grazed landscape. Food became abundant, population increased. Hunter-gatherers were forced off the land because the abundant food made farming life more attractive and the increase in population that the abundant food supported gave the farming communities political, and military strength. Humans had learned how to be more in tune with their environment.

In essence, this miracle was accomplished by using technology and increasing energy utilization. Hunter-gatherers use only the energy that strikes the earth from the sun, eating only what grows naturally on the surface. Farmers utilized the available solar energy better by allowed only edible plants and animals to use the available solar energy in their territory. Thus, they thrived and the population of humans began to increase dramatically. Good times do not last forever, eventually the population increases required new technology and additional energy to increase population density. Animal power, then water and wind power were used to produce energy. Each time additional energy

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[90] Pfeiffer, John E., 1978, The Emergence of Man, Harper & Row, New York, page 291.

was added to the system production increased along with population density. City states and finally nations began to form.

If one looks at the history of mankind over even the last 12 thousand years, it is apparent that we reached many plateaus and each time we added technology and increased energy production to continue growth. In the crucible of survival of the fittest, western culture developed. Today, we have 5 billion people on the planet and by the end of this century; we may have 20 billion. Many of the people today do not have the benefits of modern culture and are living in an overgrazed environment where food and energy are lacking. Certainly social change is needed.

However, going back to a hunter-gatherer culture is not the answer, it is not the social change that is required. Consider that 200 years ago all the people living in Oregon were hunter-gatherers. The entire population of Oregon was about 200,000 individuals and had been for thousands of years. The Pacific Northwest was saturated with human hunter-gatherers. Life was hard, and rarely lasted more than 45 years, without the plow and the axe, the land was overgrazed and barely supported the natives.

Today, we have nearly 4 million people living in Oregon. Consider the consequences of turning the environment back to a hunter-gatherer environment. For example, consider the effects of 4 million campfires on our forests, or the effects of feeding 4 million people on only the game and wild plants in Oregon. The impact would not only be on the environment but on the population, as well, it would soon return to 200,000 people.

Certainly, 4 million people in Oregon impact this environment, but what is more important is that the impact is considerably less per capita than the impact would be if we were hunter-gatherers. There is a very strong relationship between population density, technology, energy demand, and physical environment. We cannot return large areas of the environment back to a hunter-gatherer environment without severe impacts on human population.

The social change needed today is very similar to those changes we have used so successfully in the past; increase technology and energy production. We should not be stopping farming, logging and dam building, but utilizing those resources more wisely. The solutions to our problems at the beginning of the 20th century are not the solutions to our problems in the 21st century. Over the last century, conservation became synonymous with protectionism. Protecting natural resources and the environment is not the same thing as using the resources and the environment wisely. The choice is simple, we need to manage our forests, rivers, and the environment to maximize their value to humans or remove 4 billion people from the planet.

Human Activity

The National Marine Fisheries and the Fish and Wildlife Services conclude that the decline in salmon over the last 100 years has been mainly due to human activity in the river habitat.[91] They identify such things as increase in population, dam operations, introduction of contaminants, disturbance of vegetation and soils near streams due to farming, ranching and logging, etc. as the cause of the decline. Whereas these activities

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[91] ________, Oral Presentation Notes, NMFS Public Information Meeting on the proposed 4d rules.

may not appear to be beneficial, evidence that they caused the decline in the salmon population is circumstantial and anecdotal.

Influence of Human Population

Certainly human population growth and Chinook salmon population reduction occurred over the same period. See Figure 23. However, the conclusion that they are related is not well substantiated. Facts exist that indicate human activity is not the source of the salmon decline. These facts must be explained by the river theory. On the other hand, these facts are consistent with the ocean theory.

If salmon population were related to human population and development, we would find a correlation between the salmon and human population curves. We find no recognizable match in the curves, or changes in salmon at times of major changes in river habitat. In Figure 22, the human population curve (green) is concave upward. If human population is a critical factor in the decline of salmon, you would expect the salmon decline curve to be concave downward (dotted red curve). By examining the curves where they intersect, it is apparent that before 30% of the human population had arrived, over 70% of the salmon had already disappeared. Human population growth alone is not the cause of the salmons decline.

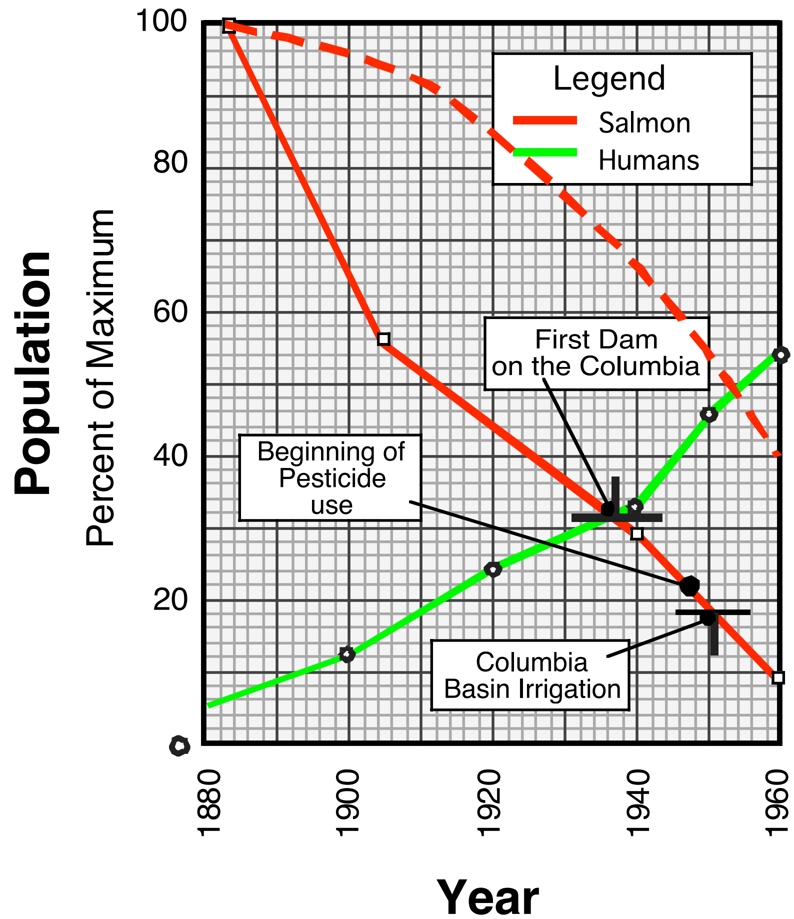

Figure 23. Salmon Reduction Relative to Human Activities over Time

Dams

Dams are often singled out as the major culprit. The simple fact that they seem to block the flow of the river is enough evidence for many. However, that conclusion is too simplistic. Consider that of the 136 dams built on the Columbia and its tributaries, 84 percent were completed after 1935. Thus, more than 65 percent of the salmon were gone before 84percent of the dams were built. The effects of dams on salmon studied by the Northwest Planning Council dealt only with the negative effects of dams.[92] Few things in this world are 100 percent bad; obviously, dams must have positive effects on salmon as well. For example, they reduce silt in the streams, they provide lakes which are important to sockeye salmon, they cool the stream water, allow control of water flow in the streams so that adults and juveniles can migrate and many other positive effects. We saw earlier where dams help returning salmon. Dams also allow a means of getting accurate counts of fish returning. Figure 24 is a plot of the chinook return past Bonniville dam. The blue and purple bars are when dams were added to the Snake and Columbia River systems.

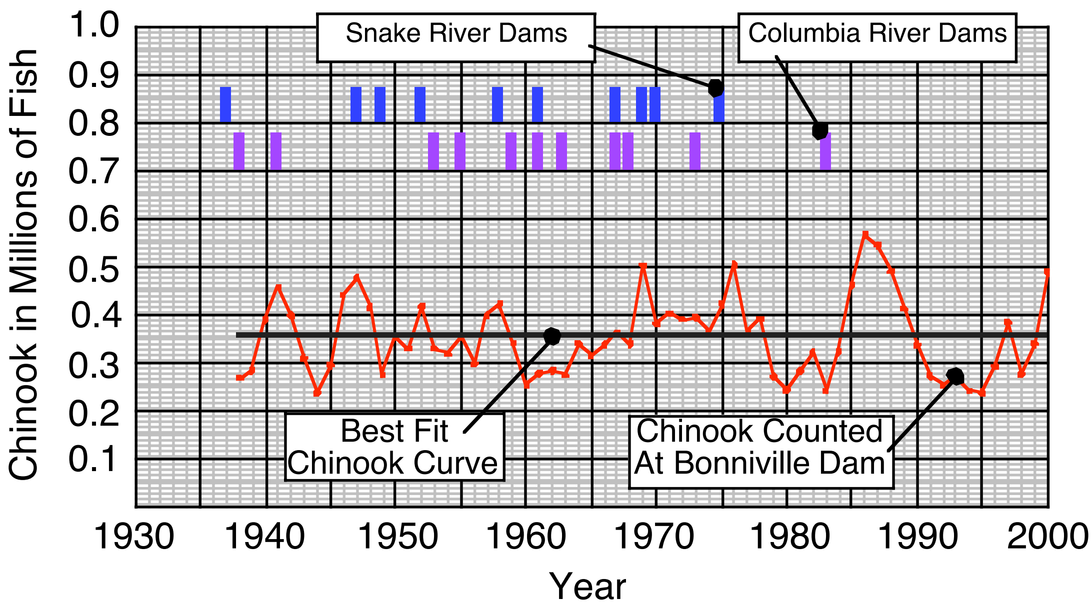

Figure 24. Effect of Dams on Return of Chinook over the Last 62 years.

If dams are the major problem for salmon, we should see a reaction to each of the additional dams. No such reaction is visible in the return curves. In fact, the best-fit trend curve has a positive slope. That means that over the last 60 years the Chinook salmon numbers are not heading for extinction but are in fact increasing in numbers.

A study of 23 Columbia River tributaries shows that the tributary with the least number of dams produced salmon as well as the tributary with the most number of dams.[93] The same study showed that the fish that spawned in a tributary that only had one

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[92] ________, 1986, NPPC, Appendix D, Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin, Page 140

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

dam in the system produced half as many fish as a tributary on the middle fork of the Salmon River in Idaho, which requires the fish to pass eight dams. It appears the data does not support the popular opinion that dams are harming the salmon. If dams were the major cause of the decline in salmon then why are there no salmon in many rivers without dams?

Farming

Looking at individual human activities, like the Columbia Basin Irrigation Project completed in 1953, which added 500,000 acres of farms to Eastern Washington and Oregon, we see that 82% of the salmon had already disappeared before this major increase in farming activity. Pesticides were unavailable for use until after the Second World War. Figure 22 shows 80% of the salmon had disappeared from the river by that time. Most of the Columbia River flows through the eastern Washington and Oregon deserts where irrigation is necessary for farming. Figure 25 compares the number of irrigated acres to the decline in Salmon population. Notice once again that 70% of the salmon were gone before 30 % of the farming was operational.

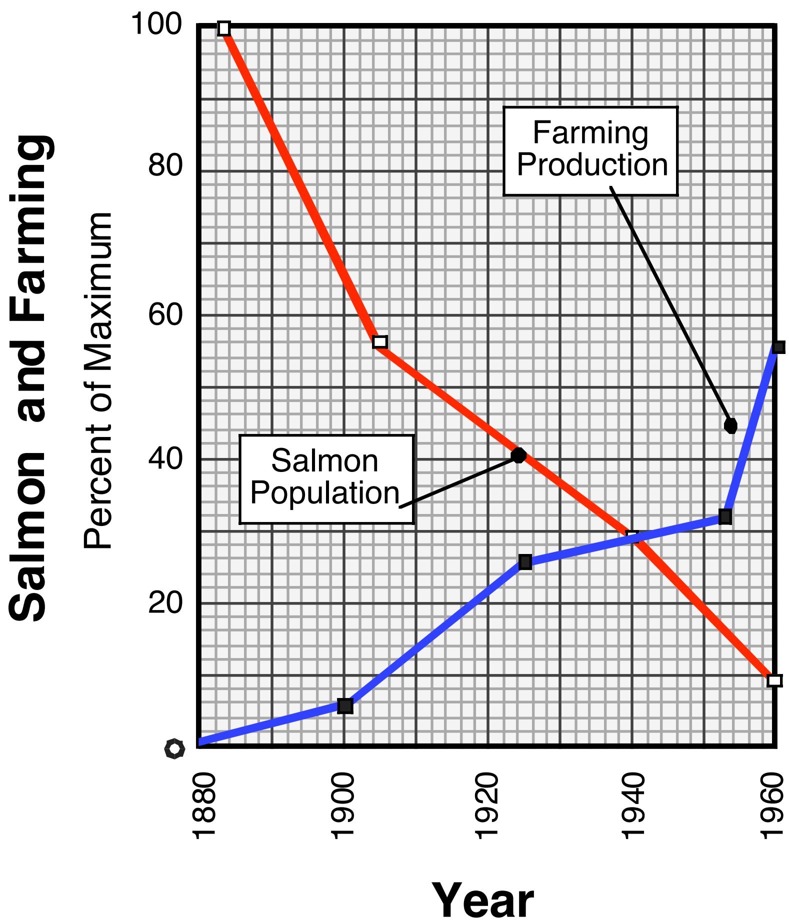

Figure 25. Salmon reduction compared to Farming

Logging

Figure 26 is a plot of the logging activity. Note that by 1920, 55% of the salmon had already disappeared and logging operations were less than 1% of their maximum. The rapid increase in logging occurred during and after World War II. By that time, 70% of the salmon were lost. Thus if we look at all human activity except regulatory activity we find that 70 percent of the salmon were already gone before any of these activities were significant.

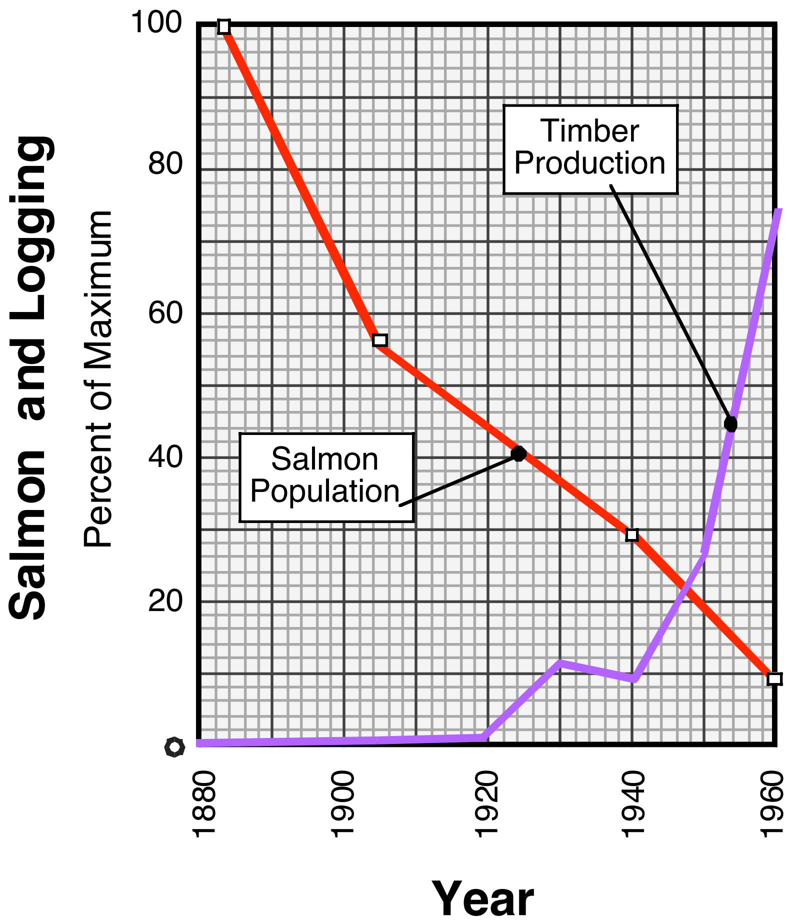

Figure 26. Salmon Reduction Relative to Logging over Time

Regulatory Performance

Before we leave human activities, let's take a closer look at what has happened since 1960. See Figure 27. Here we see that the four dams on the Snake River were not in operation until after 1960 when the salmon population had already diminished by almost 90%. Further, the salmon population actually increased during construction and initial operation of the dams. This would seem to indicate that removal of these four dams would not affect salmon recovery.

Next, we see a sharp down turn in salmon harvest in 1970. Following that there was a flurry of environmental laws passed. The Clean Water Act, Marine Mammal Protection Act and the revised Forest Practices Act were passed in 1972, and the

Endangered Species Act was passed in 1973. During the almost 30 years of increasing regulation of human activities, the salmon have continued to decline.

No fish species has ever recovered after listing under the ESA.[94] There are probably many reasons for this lack of success. One reason may be that regulating human activity is not the answer to salmon decline. If this is true, it follows that further regulation is unlikely to save any salmon as well. Thirty years of a failed program is hardly a recommendation to continue that program.

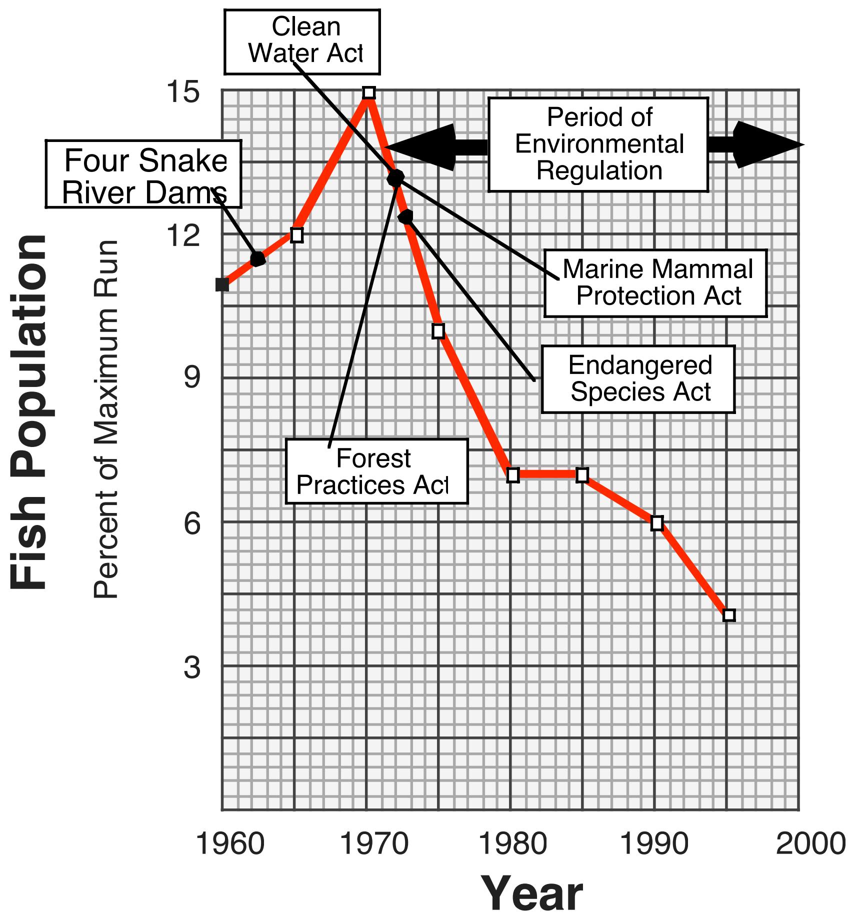

Figure 27. Salmon Reduction since 1960.

To arbitrarily blame the 70% decline in salmon population on human activities is far too simplistic an approach. River ecosystems have been subjected to natural periodic catastrophic disturbances such as glaciation, volcanism, wild fire, landslides, etc., several times over the salmons' history. Each time the salmon have progressed unassisted through a series of recovery stages over a period of decades to centuries.[95]

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[94] Williams, J. D., et al., Fishes of North America, Endangered, Threatened or of Special Concern. Fisheries **16**(6):2-20

[95] 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 334

Attempts to manage systems and resources in a static context may increase the rate of extinction.[96] In other words, to assist the salmon is one thing; to over assist them may weaken them genetically. Salmon must survive in the 21st century environment not in some human stylized, artificially reproduced 18th century environment.

River Habitat Restoration

The present solution to the salmon problem focuses almost entirely on the rehabilitation of the River habitat. The effectiveness of stream habitat rehabilitation was evaluated in the Keogh and Waukwaas Paired Watershed study on the north end of Vancouver Island.[97] We have spoken briefly about the results of this study earlier. Both rivers had similar problems of fish habitat loss and reduced survivals caused by logging in the 1940s. The Keogh River was heavily rehabilitated using riffle reconstruction, boulder clusters, single deflector log and multiple log structures, lateral debris jams, and root wads. The project included deactivating roads, establishing 1000-foot riparian zones, building ponds and channels, as well as stabilizing slopes, treating riverbanks, and adding nutrients to the Keogh River. The neighboring Waukwaas River was left as it was in 1940 and no restrictions to human interaction with the stream are in effect.

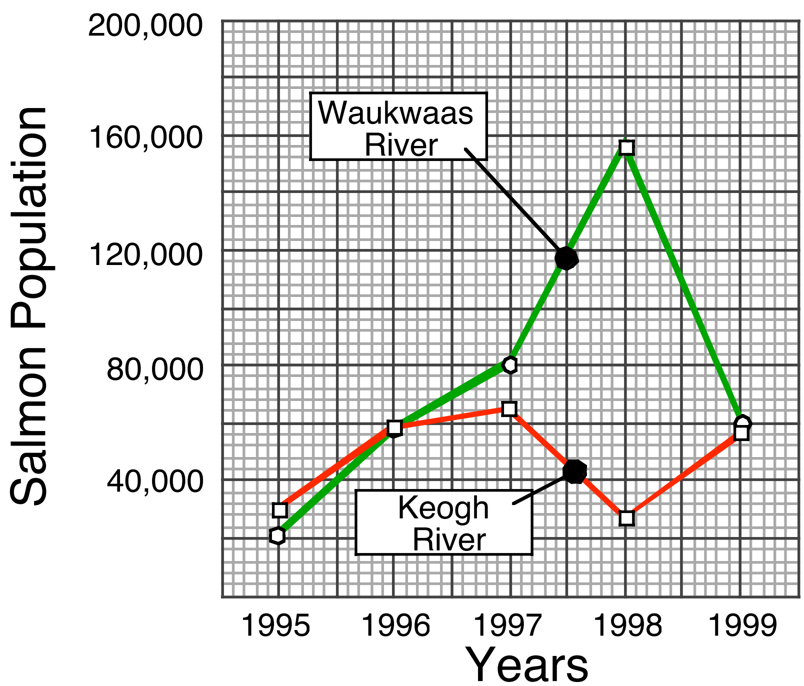

Figure 28. Salmon Smolt Production Keogh and Waukwaas Rivers

The study examined anadromous salmonid density, growth, smolt yield and survival rates in both rivers. Over the short period (5 years) of data retrieval, the

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[96] 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 336

[97] McCubbing D. J. F., and Ward, B. R., 1997, The Keogh and Waukwaas Rivers Paired Watershed Study for B. C.'s Watershed Restoration Program: Juvenile Salmonid Enumeration and Growth.

untreated Waukwaas River out performed the enhanced Keogh River in smolt production.[98] See Figure 28 and 29.

In 1998, the Waukwaas produce 8 times more steelhead and over 5 times more Coho that the Keogh. Even if the large Waukwaas production in 1998 is discounted, the production in the Waukwaas is still better than the heavily treated Keogh. The study does not expect a full response until 2001, but these early results certainly do not give one much confidence in river habitat rehabilitation as a way to save salmon. Certainly not enough confidence to go forward with extreme programs such as the adoption of the 4(d) rules proposed by the NMFS or dam removal.

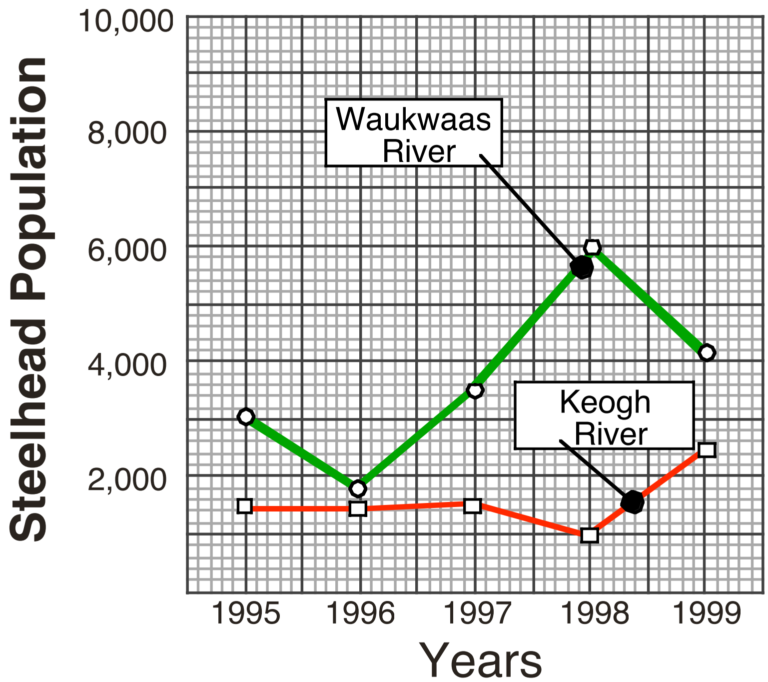

Figure 29. Steelhead Smolt Production Keogh and Waukwaas Rivers

Thus, it would seem that human activity in general, and the four dams on the Snake River in particular, are only minor factors in salmon population reduction. Other studies support this conclusion. A study in 1950 by McKernan compared the salmon catch for the Columbia River and eight Oregon coastal rivers during the period between 1923 and 1948. The study was designed to determine if pollution, dam construction, irrigation, and logging contributed to the decline in salmon population. The rivers were selected for the study because of their dissimilar habitat. The results showed, without exception, that the fisheries reacted the same on all rivers studied.[99] The inescapable conclusion is that the human activities in question are minor variables in the problem. Thus, it was known as early as 1950 that human activities may not be closely connected

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[98] McCubbing D. J. F., and Ward, B. R., 1997, The Keogh and Waukwaas Rivers Paired Watershed Study for B. C.'s Watershed Restoration Program: Juvenile Salmonid Enumeration and Growth, page 23

[99] McKernan, D., Johnson, D., and Hodges, J., 1950, Some Factors influencing the trends of Salmon Populations in Oregon, Trans. Of the 15th N. A. Wildlife Managers Institute, Wash D.C., page 427-449

to salmon decline. In the past 50 years, billions of your energy and tax dollars have been spent trying unsuccessfully to prove that conclusion wrong.

The Endangered Species Act as a Tool for Social Change

We have noted that the ESA has never saved a species from extinction, that the need for saving species to preserve biodiversity is lacking and that extinction is part of creation. Thus, there seems to be little value for the ESA except as a means of forcing social change, by punishing industry. Punishing industry punishes individuals. Industry does not shoulder the cost of cleaning up oil spills. Individuals pay that cost through higher fuel prices. Skyrocketing fuel and energy prices are a direct result of the ESA policies.

Certainly, industry can and has caused harm to human survival. This harm needs to be stopped, but the ESA is the wrong tool. Stopping a project because it threatens a species with extinction is too broad of an approach. Conservation was a valuable concept 100 years ago, but today it is too broad an approach as well. The problems of the 21st century require that humans manage their environment to optimize their chances of survival. If humans do not survive, what is the point of conservation?

Ever action has positive and negative effects on human survival. Old growth forest is not intrinsically valuable. It is not even environmentally sound. It is certainly beautiful; but what cost beauty? We have set aside other beautiful areas, Yellowstone and Yosemite for example, but we now find that too many visitors are destroying those places. What is the value of beauty that nobody or only the elite can view?

None of these questions is addressed by the ESA. The first flaw in the ESA is that it is a regulatory law, which distances the law from the people. Hearings are required, but no action needs to be taken except to have the hearings. Another major flaw is that we are trying to regulate a process, which is presently poorly understood. The regulations are not driven by the best possible science, but by 10-year old science. A third flaw is that the basis for determining action is driven by what is best for nature not people. In truth, subspecies of humans (i.e., loggers and farmers) are endangered by this law. Finally, third party law suits give tax exempt special interest groups the power to force their special interest on the public as a whole. This has taken government out of the hands of the people and elected officials and given it to special interest groups.

Conclusions

Postpone all Plans based on Current Science

Current plans for salmon recovery are founded on science that is incomplete, inadequate, out of date and based on opinions and qualitative science. Current models are simplistic, incomplete and are not validated. The present plans, the 4d rules in particular, focus almost entirely on the river physical habitat, and are open ended, i.e. have no criteria to measure success.

Current Plans Address only 5 % of the Problem

The river physical habitat is 5 percent of the problem. To continue to concentrate on improving river habitat, while ignoring that 70% of the solution is comprised of the food and predators is a prelude to failure. Any action to increase the numbers of salmon requires a sufficient food supply and without predator control, predator population will simple expand and consume any extra salmon generated.

Food

The salmon food supply is complex. Presently vast reservoirs of nutrients lie untapped on the ocean floor, waiting for whims of weather and current to return it to the biosphere where salmon can utilize it. The Clean Water Act is stripping valuable and useful nutrients from our rivers, estuaries and ocean waters near our coasts. What humans consider waste is often what nature considers food. Riparian zones act as a sink for nutrients and prevent soil born nutrients from reaching our streams. Clean water is dead water.

Predator Control

Salmon have over 160 different predators, which comprise 35% of the solution. Addressing this factor alone would be at least seven times more effective than the current regulations that deal with only 5% of the problem. Most of these predators are protected by environmental laws. Protection of endangered or threatened species is undoubtedly another major contributor to the decline of the salmon. If there is ever going to be human harvest of salmon again, it will be necessary to artificially suppress predators. Without artificial predator control, increasing the number of salmon by any means will simply increase the number of salmon predators. The relationship between prey and predator is not simple but it is a dominant factor and cannot be ignored.

Physical Habitat Modification Not Working

Studies of rivers that compare good habitat to poor habitat show that poor habitat out performs what current scientific opinion defines as good habitat. Neither, the need for or the value of riparian zones is defendable. Much of the science behind the riparian zone requirement is opinion and qualitative and the value of these zones has not been quantified or verified.

The probability of increasing the salmon runs by removing all the dams, farms, industry, towns and logging within two hundred miles of the Columbia and its tributaries; completely restoring all the wet lands and the river to its 1805 condition, is extremely low. On the other hand, the probability of destroying family farms and family timber operations is extremely high if current regulations are followed.

Saving Salmon or Reforming Society

The only physical difference between wild and hatchery salmon is the spelling of the modifier. The idea that 16 million salmon is the baseline salmon production of the Columbia River is not defendable. The maximum number of salmon in the Columbia River was about 4 million in the 1880s. Several lines of reasoning support prehistoric salmon runs in the Columbia River below 250,000 fish.

Reforming society by artificially inducing an aboriginal environment on a modern culture will devastate human culture. Modern culture requires large amounts of energy and advance industry and technology. Humans have constructed over the centuries a complex system that supports large numbers of people. Destroying that system will destroy large numbers of people.

Humans have shaped nature, but that is natural, other successful species also shape their environment. Humans need to manage our resources not hoard them. Locking up land, natural resources so they cannot be used is more miserly than prudent management of dwindling resources.

The current approach to salmon recovery involves establishing a costly and heavily regulated environment. Salmon need to survive in the 21st century environment not in some artificially generated aboriginal environment.

Do Good Broad Based Science

There is little doubt that human population has reached levels, which require human control over the environment. In order to do this successfully, humans need to understand how nature works much better than they do today. This requires a broad based multi-disciplined scientific system approach. The approach should be based on a characterization plan, address all parts of the problem, and include methods to measure success.

Re-examine Environmental Law

It turns out that short sighted although well-meaning acts to preserve some species in the early 1900s have lead to the demise of other species today. Ironically, the cause of salmon decline may be due more to the actions of the Sierra Club and the Audubon Society than farmers or loggers. In other words, saving a species from extinction is as bad as driving one into extinction, just as shortsighted and well-meaning acts like dam removal will also significantly affect the future. The current energy shortage is a direct result of the shortsighted energy policies of the last 30 years. The significant waste caused by the increase in number and size of wildfires in the last year can be traced to the changes in forest policy. The increase in loss of life and property due to flooding has its roots in changes in river management policy.

The Endangered Species Act is seriously flawed. It is used as a tool to promote social change more than protect the environment. Third party lawsuits place too much power in the hands of a few special interest groups. Regulatory laws remove the power from the people and place into the hands of Bureaucrats. The Clean Water Act, the Forest Practice Act, the Marine Mammal protection act, and the Migratory Bird Act all need to be evaluated to change their focus from protection to management.

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