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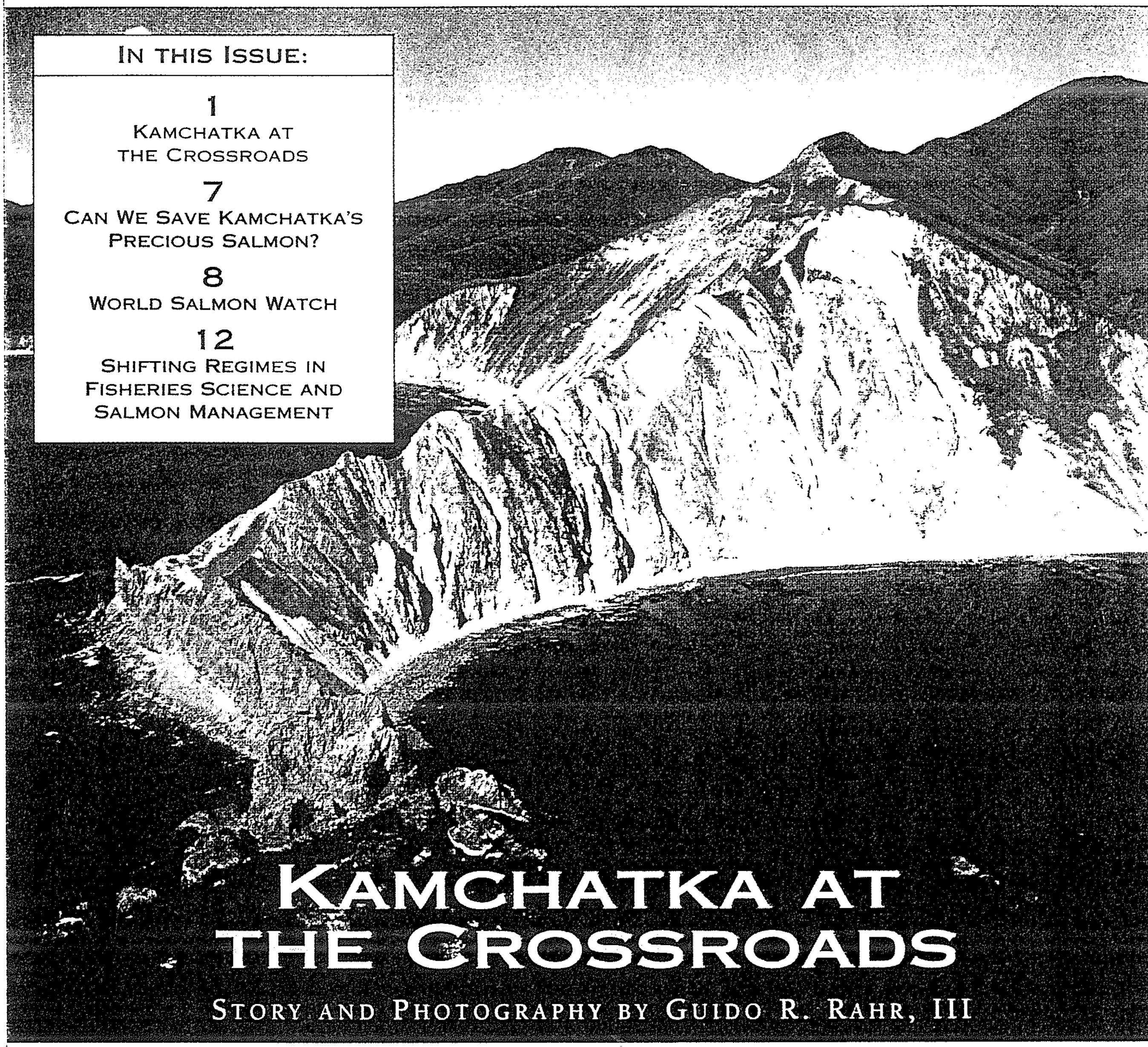

IN THIS ISSUE:

KAMCHATKA AT THE CROSSROADS

STORY AND PHOTOGRAPHY BY GUIDO R. RAHR, III

This remote and beautiful region of the Russian Far East is one of the last places along the Pacific Rim still as biologically rich as it was 1,000 years ago. Kamchatka is the world's largest remaining stronghold of healthy native stocks of salmonid fishes; rivers there account for an estimated one-third of all the wild salmon spawned throughout the Pacific. Can we save this last, best place?

THE WILD SALMON CENTER

Shifting Regimes in Fisheries Science and Salmon Management

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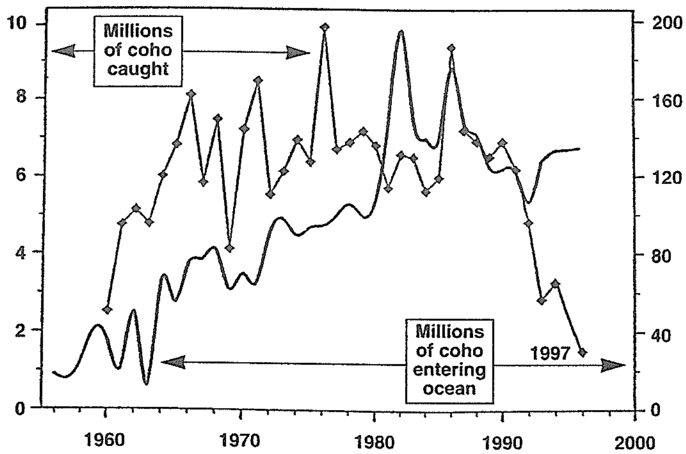
From egg to fry to sea and back, salmon have long been an important focus of fishery managers worldwide. We advise policymakers, who answer to the public. The public wants results. Accordingly, we have tended to look upon our finned friends with a sharp focus, a single biologist often studying a single river's stock for decades. And in a results-oriented world, it has mainly been in-river work that we have done with our salmon. A tremendous amount of data has been collected around the world regarding the salmon's freshwater habitat. This narrow focus has been necessary and expedient to our understanding of the fish in general—and it has indeed generated complex matrices of understanding.

"Give me something I can work with," is what we might hear from a legislator who has to answer to constituents, who has to account for a budget. In such an atmosphere, rivers—and not the ocean, where salmon spend the majority of their lives, and where over 95 percent of juvenile salmon meet their ends—have been easier to deal with. I don't speak of any sort of laziness or short-range thinking here—focusing on the possible is simply a fact of life.

But now, given the immense banks of salmonid data, and given the time to mull over what we have learned, we in the scientific community have begun to make a few connections. We have found our doors of perception open to more than we were aware of before. We are enjoying new possibilities in our understanding of salmon and what happens to them in the ocean. Specifically, and quite simply, we are discovering that what happens to salmon in the ocean matters, and appears to follow certain patterns.



COHO SALMON, SUCH AS THOSE SHOWN AT LEFT, HAVE BEEN POURING STEADILY INTO THE PACIFIC OCEAN FROM THE STRAIT OF GEORGIA, PUGET SOUND, WASHINGTON STATE AND OREGON. AS SHOWN ABOVE, ESPECIALLY IN THE 1990S, ADULT RETURNS HAVE NOT BEEN COMMENSURATE WITH JUVENILE PRODUCTION.

Stated briefly, salmon abundance—that is, ocean survival and returns—appears to be directly related to weather patterns. Meteorological phenomena such as the Aleutian Low Pressure system, the North Atlantic Oscillation, and even El Niño and La Niña have proven to work in patterns that roughly mirror patterns of salmon abundance worldwide. (My particular studies have focused primarily on Pacific salmons.)

To understand how and why, and to understand how some of us in the scientific community have changed—expanded, rather—the direction of our thinking, requires taking a step back. Somewhere in the past we came up with the idea that within all of the complexities of an ecosystem there was a way that we could stabilize fish abundances through the regulation of fishing effects. We assumed that there was a mathematical relationship that defined salmon abundance. Once we had that relationship in hand, we could confidently decide the right amount of fish to harvest, and how many were needed each year to spawn. As simple as that. When numbers were low, we often created more fish. We forgot, however, that the abundances of all plants and animals fluctuate in response to the effects of their environment and associated species. If this didn't occur, Bordeaux wines would be cheap and wheat prices stable.

Now we are seeing that hatchery production—aside from its potential threat to genetically-distinct and important wild stocks of salmonids—is not necessarily the answer. Ironically, though, our monitored infusion of millions upon millions of hatchery-reared salmonid juveniles into rivers flowing seaward has provided us with a wonderfully controlled experiment: We know how many salmon are entering the ocean as juveniles. And through monitoring of rivers and harvest from commercial fishers, we have a pretty good idea of the numbers of fish returning. In many instances, such as the recent crash in coho abundance in British Columbia, ratios of outgoing smolts to returning adults are not consistent. Declines in coho returns to Vancouver Island, Washington and Oregon in the early 1990s were met with increased hatchery production; yet as output rose, returns continued to drop, and they are still dropping. The fact that more coho have been entering the ocean, followed by fewer and fewer returning to spawn, suggests that, freshwater habitat aside, something is amiss at sea.

WE ARE DISCOVERING THAT WHAT HAPPENS TO SALMON IN THE OCEAN MATTERS, AND APPEARS TO FOLLOW CERTAIN PATTERNS. STATED BRIEFLY, SALMON ABUNDANCE—THAT IS, OCEAN SURVIVAL AND RETURNS—APPEARS TO BE DIRECTLY RELATED TO WEATHER PATTERNS.

Other species, too, have shown marked effects from ocean conditions. In the early 1980s, a Japanese scientist noticed that sardine catches fluctuated sychronously around the Pacific. Sardine populations off Chile, California, and Japan all did the same thing at the same time. Abundances increased dramatically in the 1930s. They crashed in the 1950s and 1960s. They increased again in the 1980s and crashed again in the 1990s. The Japanese sardine abundance fluctuations were so large (six to 10 times the total catch of all Pacific salmon) that actual sardine fishing communities would develop and disappear in sychrony with the fluctuations, which can be traced back to the 17th century.

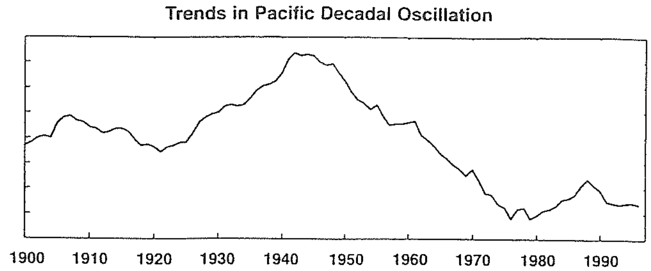
Interestingly, it has been noted in the scientific community that these fluctuations in sardine abundance occurred in a rather constant relation to abrupt changes in weather patterns. A few years ago, a small group of scientists from countries around the North Pacific found relationships between long-term trends in climate and in ocean conditions. There were associated connections to abundance of plankton and to salmon catches and catches of other species. The climate shifts were abrupt changes from one climatic state to another. The years of change were amazingly consistent among the various indices that were all measuring slightly different processes in different places at the same time. Changes registered in the North Atlantic as well as the North Pacific occurred in 1925, 1947, 1977, and in 1989. There may even be another change occuring now. It is believed that these long-term changes, or regimes, have always occurred. The sardine catches noted above appear to have fluctuated in direct relation to these changes in climatic regime. Recent studies indicate that such fluctuations—as well as salmon abundance changes, addressed below—are natural, and are not from commercial harvest. This does not mean that fishing impacts are unimportant. What it does mean is that we need to evaluate natural impacts on salmonid and other stocks as well as fishing effects.

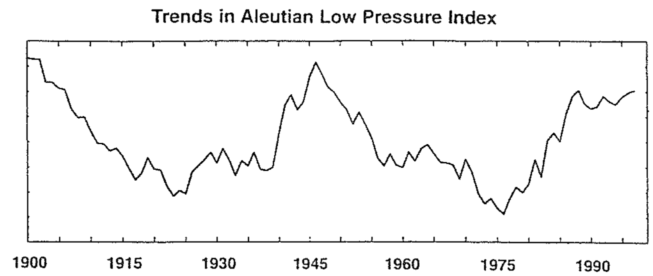
Accordingly, a next step in fisheries management is toward understanding how a particular species—such as pink salmon—fits into its ecosystem management. We do not mean that we will manage ecosystems. A mistake we have learned from in the past was our assuming that somehow we were in charge. We in fact have very little understanding of how we will assess the impacts of the environment and other species in relation to fishing effects. But we know that we must at least try, much as cancer research must continue onward though success has not yet been met.

One way to begin is to consider how fish regulate their own abundance. Why is the mortality of salmon eggs to fry, fry to smolts, and smolts to adults so high? How, with such incredibly high mortality rates, do some salmon from each of tens of thousands of stocks always return to almost the same site? Wouldn't it be logical for some stocks to lose all their offspring? This of course would be the end of the stock.

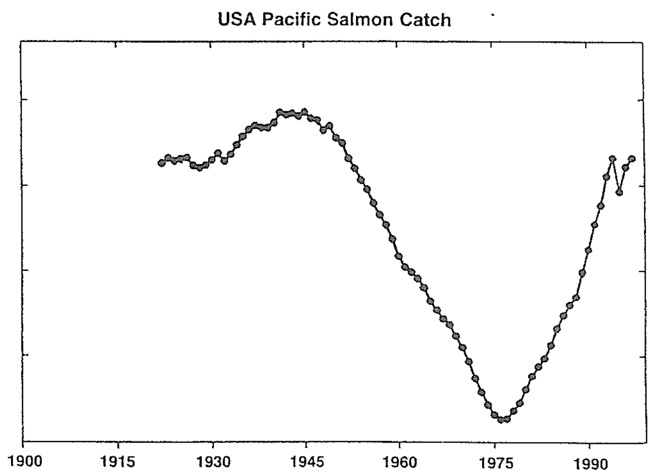
Dr. Connie Manhken and I have an idea how salmon do it. It is only an hypothesis, but it seems to fit a number of observations that have been sitting in the scientific literature for a number of years. Science by nature is dynamic. Just as we are building on the monumental work of others, so will others enter into dialogue with us and our ideas. We doubt that all parts of our hypothesis are correct and we welcome contributions to our thoughts.

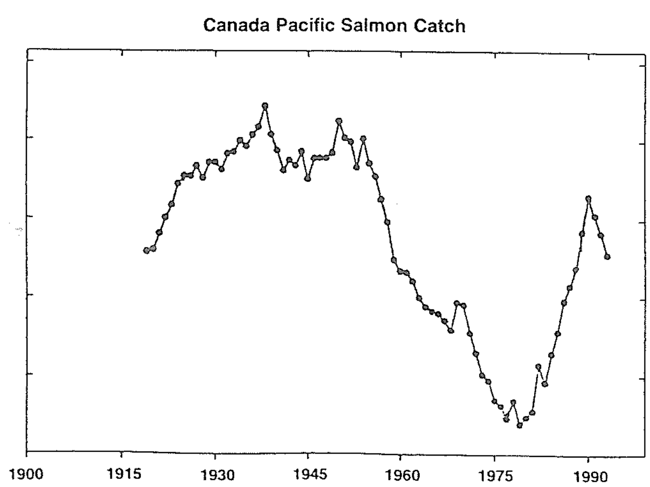
We propose that salmon and steelhead spawn in fresh water because it is a safe refuge in which babies can survive without the protection of parents. The large number of wild stocks that develop different genetic traits optimizes the species' chances of surviving in the ocean—a far more hostile habitat than fresh water. Recall that in school we learned that the abundance of plants and animals that produce





AN INTRUGUING CORRELATION: TRENDS AND CHANGES IN CLIMATIC PHENOMENA SUCH AS THE PACIFIC DECADAL OSCILLATION AND THE ALEUTIAN LOW PRESSURE SYSTEM (ABOVE) HAVE OCCURRED SYNCHRONOUSLY WITH TRENDS AND CHANGES IN AMERICAN AND CANADIAN CATCHES OF PINK, CHUM AND SOCKEYE SALMON (BELOW). STRAIGHT LINES IN THE CHARTS REPRESENT PERIODS OF PERSISTENT CONDITIONS; DOTS AND CHANGES IN STRAIGHT LINES MARK SHIFTS FROM ONE REGIME TO ANOTHER. BIOLOGISTS POSTULATE THAT SUCH CORRESPONDING REGIME SHIFTS ARE MORE THAN COINCIDENCE.





large numbers of seeds or babies is not regulated by the number of their offspring but by the available habitat.

Here we begin a paradigm shift. In the past—the all-too-recent past included—the ocean has been considered and spoken of as a single, nearly homogenous environment, much like outer space. Nearly impossible to manage. Certainly any grade-schooler understands that there are large areas of ocean that are different from one another, such as the warm waters of Hawaii and the frigid, iceberg-laden waters that swallowed the *Titanic*. We understand that, too. What we suggest now is that we further refine our understanding of the ocean as habitat for salmon, and recognize that there are distinct habitats within the waters —generally cold—that salmon navigate. As such, it follows that the capacities of these habitats to support juvenile salmon is limited, and varies both spatially and temporally.

> IT IS WHEN NUMBERS ARE DOWN, WHEN OCEAN HABITAT IS UNFAVOURABLE, THAT OUR SALMON ARE IN DANGER AND THAT OUR ACTIONS—OUR INTERACTIONS—AS HUMANS, ARE GOING TO COUNT THE MOST. TOO MANY FISH IN THE FEEDING AREAS MAY LEAD TO OVERCROWDING, A CAUSE FOR CONCERN. OVERHARVEST BY OUR OFT-IMPOVERISHED COMMERCIAL FLEETS, WHEN SPAWNING NUMBERS ARE LOW, CAN ALSO SERIOUSLY AFFECT FUTURE STOCKS.

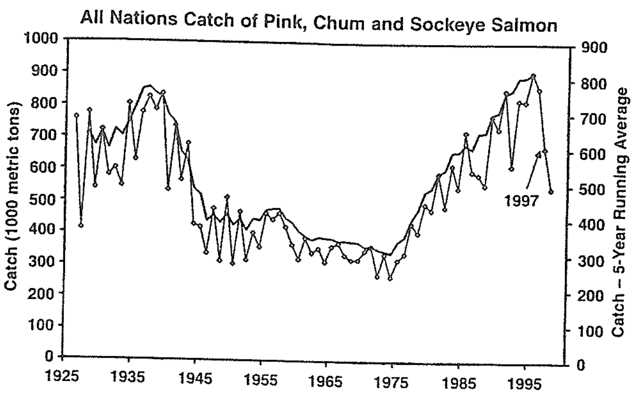
We propose that when young, small, vulnerable salmon first enter the ocean there is a large amount of mortality as predators select their prey. However, we think that a relatively large number survive to feed and grow during the summer. Our new theory is that it is this period of summer growth that determines how many will survive the winter and return to the fishery or to spawn. The fish must grow to a minimal size—eating about 65 percent of their stomach volume each day—or they will not survive the winter. It is during this period that the linkage between climate, the ocean environment and other species becomes clear. If ocean conditions are favourable because the climate is facilitating the production of suitable food—such as zooplankton, or krill—the fish will fill up their stomachs regularly and will be in good condition for the fall and winter. However, even in these favourable conditions there will be competition with other individuals of the same species, and abundance will be self-regulated by the amount of crowding in the feeding areas. In unfavourable conditions, meaning less food production, more competition for the food or warmer temperatures requiring more energy to maintain body functions—or a combination of these effects—growth will be reduced and more individuals will not meet the minimal condition by the fall to be able to survive the winter.

Something interesting has occurred in Japan, where chum salmon is a prized commodity and has been artificially reared for years. In recent years the Japanese noticed two things: that their chum were not coming back in desired numbers, and, more interestingly, that individual fish were returning in sizes remarkably different from one another, suggesting crowding and competition in the feeding areas. Some won and some lost.

As climate shifts the mean state of an ecosystem, trends in favourability change and appear to persist for periods of about 10 to 30 years. The value of thinking in terms of ecosystems is that it becomes apparent that wild stocks are important for genetic reasons as well as for numbers. Numbers of babies are important in favourable regimes, but we cannot turn an unfavourable period into a favourable period by adding more babies. In fact, we need to be careful about the consequences of such manipulations if the capacity of an ecosystem to support salmon drops. And it is also during unfavourable regimes that we need to exercise special caution in our own harvest. Our actions, we must remind ourselves, no matter the blinders we wear, are in reality interactions. A key, we believe, to directing our interactions toward responsible stewardship of the ecosystems our salmon need, is in understanding climatic and oceanic regimes and their significance.

These regimes appear increasingly to be significant, too, as we study their correlation with salmon abundance over the last century. Major strides have been taken recently, as the Earth's four major salmon producing nations—Canada, the United States, Japan and Russia—have within the last year signed a memorandum of understanding agreeing to work together to further understand our salmonid resources. One product of our collaboration is the sharing of data regarding tracking of weather patterns. Some interesting results have surfaced.

In the eastern North Pacific Ocean, we have a climatic phenomenon called the Aleutian Low Pressure system. Basically, it means winter for us here in the Pacific Northwest and Alaska. The Aleutian Low has shown itself, over this century, to be remarkably consistent: It happens every year from roughly December through April, and has been monitored in the same area every year. What changes in the Aleutian Low Pressure Index—our register of the Aleutian Low—is its intensity. An "average" year was 1945; in 1975, the intensity of the Aleutian Low—and thus the winter weather—had declined significantly. Interestingly, we have noted that catches of Pacific salmon in both Canada and the United States were high around 1945, and plummeted steeply to a severe relative low in the mid-1970s. Indeed, the worldwide catch of pink, chum and sockeye salmon followed roughly the same pattern. By about 1990 all



the above catches were up; so was the intensity of the Aleutian Low.

Other weather patterns have followed similar regime shifts. The Pacific Decadal Oscillation is a combination of weather patterns and oceanic conditions measured in northern Washington; its patterns have roughly followed those of the Aleutian Low. Likewise, the North Atlantic Oscillation, measuring conditions from north to south in the North Atlantic Ocean, has shown similar changes at similar times, as have analogous phenomena studied in Russia.

Temperature, we are noting, interacts powerfully to limit the distribution of salmon in the ocean. Though the at-sea diet of salmon changes from place to place and from species to species—including jellyfish, herring, prawns and sand lance—zooplankton is a very common salmonid foodstuff. Some zooplankton (tiny, shrimp-like creatures), for example, do not fare well in changing ecosystems, and when zooplankton do not fare well, neither do salmon.

Significant changes have been noted recently that have many of us in the scientific community watching weather patterns and salmon returns intently. Nineteen-ninety five saw the highest worldwide catch of Pacific salmon recorded this century, at more than 900,000 metric tonnes. Numbers of returning and harvested salmon have dropped since. The Aleutian Low Pressure Index, we are noticing, is corresponding to this general trend in Pacific salmon catches of all nations. The intensity of the Aleutian Low increased from the late 1970s until about 1989. Since 1989 the lows have been about average, except in 1998 when an intense low reappeared. Off the west coast of Canada, Pacific salmon catches have declined dramatically in the 1990s. The 1998 worldwide catch of Pacific salmon has not yet been finalized, but it may be dramatically lower than that of 1995.

As fishery managers, we are of course concerned. It is when numbers are down, when ocean habitat is unfavourable, that our salmon are in danger and that our actions—our interactions—as humans, are going to count the most. Too many fish in the feeding areas may lead to overcrowding, a cause for concern. Overharvest by our oft-impoverished commercial fleets, too, when spawning numbers are low, can seriously affect future stocks. Some of our Canadian stocks—Fraser River pink, chum and sockeye salmon—are essentially at the southern extent of their North American range, and it is at the fringes of a stock's range where total populations erode in reaction to extreme environmental events.

As scientists, though, we are excited, for we feel that progress has indeed been made in our understanding of salmon life histories. Granted, we are barely on the brink of that understanding. And our ideas certainly need review and refinement. They must endure the tests of time. But we are making a welcome—though awkward—graduation from past thinking to a maturing science that realizes there is much more out there to learn.

Understanding that ocean and weather patterns can affect at-sea survival of salmon by no means takes the pressure off us as humans to try to manage our salmon resources. If anything, it may increase our responsibilities. Our next step might very well be to study the effect we may be having on those weather patterns, remembering that we are, indeed, interacting. The United Nations' recent studies, involving thousands of man-hours around the world, has shown that global warming and the greenhouse effect do indeed lead to more severe and extreme weather worldwide. We've learned that emissions from vehicles and factories can contribute to the greenhouse effect, and now we're learning that perhaps they can contribute to salmon's fate as well.

It is likely to be a long time before we finally figure out how to interact as effective stewards toward our salmon. In fact, considering the dynamic, evolving nature of scientific discovery, we probably won't ever be ahead of the curve. But with the recent and ongoing discoveries we have made about climatic change, ocean habitat and salmon's important at-sea growth periods, my colleagues and I are confident that we are taking steps in the right direction.