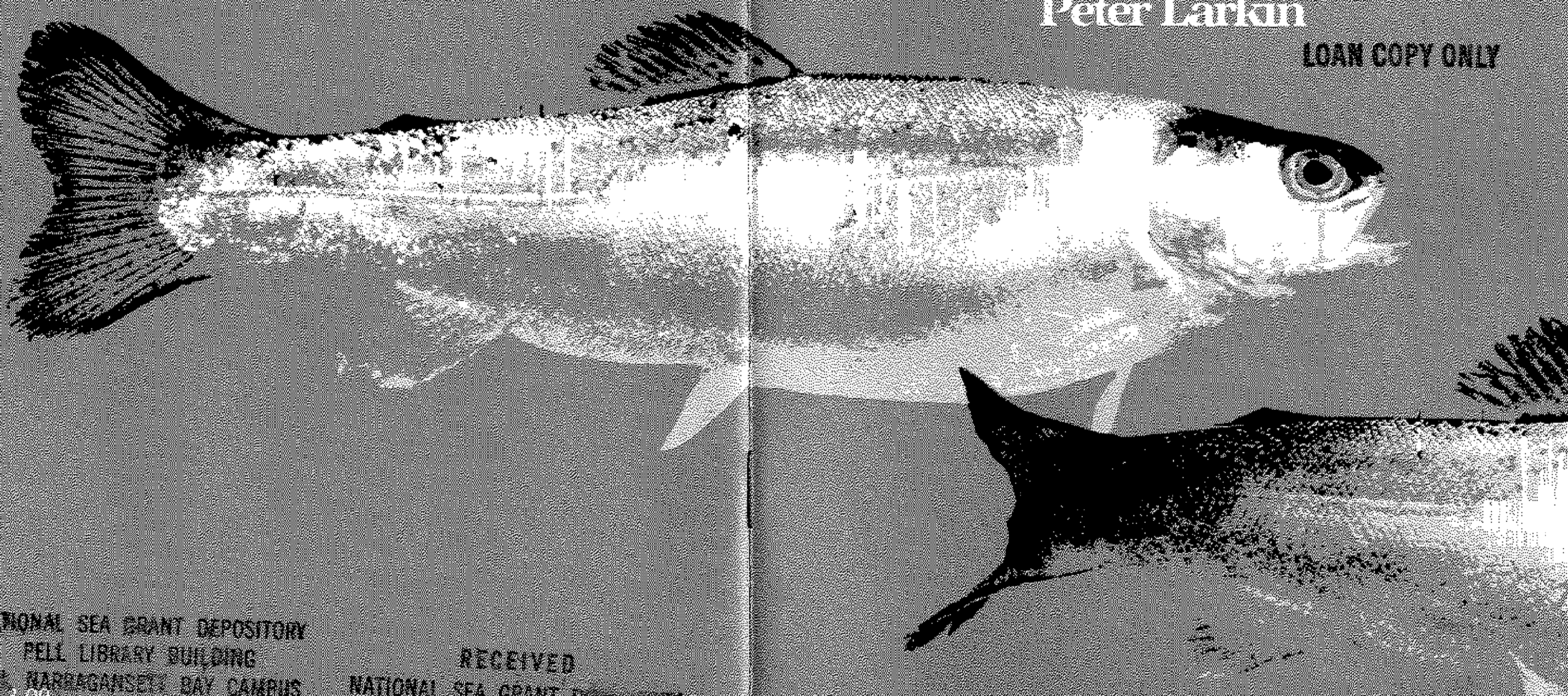
the McKERNAN lectures

PACIFIC SALMON

scenarios for the future

Peter Larkin



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Donald L. McKernan Lectures in Marine Affairs

PACIFIC SALMON

scenarios for the future

Peter Larkin

April 15-17, 1980

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Foreword

Until May 1979, the Institute for Marine Studies was directed by Professor Donald L. McKernan, distinguished fishery scientist, public servant, diplomat, and most recently, educator. In May, Don was on an official visit to Peking when he died of a heart attack. Since then, in continuing the work of the Institute, Don's colleagues have sought ways to commemorate his contributions, not only to the University of Washington but also to the wider framework of ideas in the field of marine affairs. This field encompasses the interactions among features of the marine environment and the uses to which the ocean and its resources are put, the institutions that engage in or manage these uses, and of the people who use or are used by the sea.

We early decided that an annual lecture series would be one of the most appropriate memorials. We found sympathy in the Washington Sea Grant Program and its Director, Dr. Stanley Murphy, who agreed to provide the necessary funds. An Institute committee, chaired by Professor Edward Miles, then selected the lecturers.

The first selection was particularly felicitous—that of Dr. Peter Larkin, since 1975 Dean of the Graduate Studies at the University of British Columbia and a fishery scientist of first rank. Dr. Larkin is also associated with the Institute of Animal Resource Ecology at U.B.C.

During much of his career, Dr. Larkin has been in charge of something, usually the Institute of Fisheries and/or the Department of Zoology at U.B.C., and for several years of the Pacific Biological Station at Nanaimo. As an oceanographer interested in fishery matters, I have known him in several of these roles, but perhaps best through a series of papers with provocative contents and titles—examples include "An epitaph for the concept of maximum sustained yield" and "Play it again Sam: an essay on salmon enhancement." The topic he has chosen for the first McKernan lecture is one of consuming interest in the Pacific Northwest, "Pacific salmon: scenarios for the future."

I would like to thank the Department of Oceanography for the use of its auditorium and to comment on how appropriate it seems to me to have lectures on fishery science and policy arranged by an institute of marine affairs and presented in oceanographical facilities. It is an ecumenical touch that would have appealed to Don McKernan.

Warren S. Wooster

April 15, 1980

Preface

I am honored and pleased to have been asked to be the first of the Donald McKernan Lecturers at the University of Washington. Don and I were not close personal friends, but over a span of more than 20 years, we kept bumping into each other "along the trail," as Benny Schaefer would have said. Don and I shared the outrages of the annual Pacific Fishery Biologists' meetings, the tedium of many international negotiations, and on many occasions, in far away places, a not-so-quiet evening arguing fisheries matters over a few beers.

When it came to argument, Don had few peers. He spoke well and convincingly. He was never in doubt about the cause for which he was an advocate, nor of the greatness of the country he represented. But more than that, more than might be expected of a skilled and mature professional, he was an extraordinarily personable representative for the United States. Anyone who knew him won't forget his sense of humor, his natural and healthy wit, and the unfailing personal generosity which accompanied his fierce national pride.

It is with these qualities of Don McKernan in mind that I express the hope that these lectures will be the kind he would have liked—sometimes blunt and provocative, but always friendly and in good humor.

Peter Larkin

PACIFIC SALMON

scenarios for the future

As Things Now Are

It was the best of times, it was the worst of times,
it was the age of wisdom, it was the age of foolishness . . .

These opening lines of *A Tale of Two Cities* by Charles Dickens are an appropriate introduction for describing the state of affairs we see today in the Pacific salmon fisheries on the west coast of North America. The price of salmon was never higher. Thanks to modern technologies, we can catch these fish with ever greater efficiency. The management of the fishery is probably the most sophisticated of any in the world. Our knowledge of the biology of the Pacific salmon probably exceeds that for any other small group of species of marine fishes. We have an advanced technology for increasing the numbers of salmon. The recent establishment of 200-mile limits has protected substantially many of the fisheries interests of coastal states, and there is at least *de facto* recognition that anadromous fishes should be harvested exclusively by the state of origin. The erstwhile concerns that salmon would be decimated by environmental degradation have now been heard and are increasingly heeded. For what more could one ask in this best of times for salmon?

Well, for starters, it's the worst of times for regulation of the salmon fisheries. The high price of salmon attracts many fishermen who invest in the best of fishing gears; in consequence, the permissible catch may be taken in a matter of a few hysterical hours per week. The different kinds of fishermen—trollers, seiners, gillnetters, union, non-union, native or non-native, sport or commercial—all vie with rancor about who is to get how much of the catch. The efforts of the fishery manager are increasingly eroded by a variety of petty larcenies and chiselings, which reflect a decreasing respect for management authority. On the knowledge ledger, what we don't know about salmon is still much more impressive than what we do know. An objective appraisal of the technologies of increasing the numbers of salmon, based on the evidence of the last century, would of necessity reach the conclusion that to date we have failed at least as often as we have succeeded, and that some of our successes show conspicuous signs of inadvertence. Some of the current extravaganzas of hatchery construction border on insanity. The 200-mile limit is indeed a source of solace, but international arguments between the United States and Canada on the question of interception of each other's salmon drag on and on, and are now almost due for a silver anniversary Bronx cheer. Finally, only ingenuous optimists could be convinced that the case for the environment of salmon has been won, once and for all. It is the worst of times for salmon.

In such a mixed bag of circumstances, it is not surprising that it is difficult to see what the future holds for salmon. Many of the old hands are privately settling into a Dickensian "winter of despair" at the same time as they publicly wear a pasted-on smile to project an institutional image of a "spring of hope." If they had the time, they say, they could figure it all out, and accordingly, they plan for early retirement to have time to figure. Others, like myself, retreat into university administration, to occasionally venture forth with prophecy, consoling ourselves in advance with the thought that, if the

predictions don't come true, it won't be because they weren't reasonable predictions, but because other people didn't know how to administer. With those preliminary remarks, I now embark on my prophetic voyage.

As Things Might Be

New Knowledge: The Biology of Salmon

It is not too difficult to predict what new knowledge we will gain about salmon in the next 20 to 40 years: the shape of things to come is quite apparent from the literature of today. The relevant sources of prophetic inspiration are not, of course, confined to the literature on Pacific salmon, but concern the progress in many disciplines, all of which pertain to our appreciation of how the world works.

For example, let's consider what the oceanographers might know by the year 2020. As things stand at present, there is wide awareness that the interaction between the air and the sea is crucial to appreciation of the climate of each. The sea reflects the air circulation of many months ago, and today's air reflects the moderating effects of the sea it was over yesterday. I expect that oceanographers will pretty well understand the nature of this interaction early in the 21st century, perhaps largely because their research will have been stimulated by growing concern about trends in the world's climate. Regardless of the source of stimulation, oceanographers will be in a position to predict broad trends in physical oceanographic conditions as much as a year in advance, and regional anomalies at least 3 months in advance. While they may still be enslaved by relatively crude computer simulations because they aren't smart enough to solve the problems analytically, they will nevertheless be calling their shots with increasingly less frequent embarrassment.

The biological oceanographers, having attained stature as scientists in the 1960s, will, by 2020, have vastly improved their abilities to predict the ecosystem consequences of patterns of physical circulation. To be more specific, they will be telling us that because of the forecast temperature, salinity and nutrient profiles, primary production will be this much of that ensemble of phytoplankters, which in turn will ensure this much of these species at secondary and tertiary trophic levels. This will mean, then, that we could know where and when the oceanographic conditions were more or less favorable than average for fish production in general, and in the North Pacific for salmon production in particular. It may be a bit much to expect that we might be able to draw maps of the North Pacific for a year hence, on which we could overlay maps of racial migration and so predict (or even control) racial contributions to the eventual harvest. But certainly even before the year 2000 the biological oceanographers, true to their current form, will be carping about the salmon biologists who are not taking advantage of the available knowledge to decrease their chronic uncertainties about salmon production.

The salmon biologists will be answering these criticisms by observing that, while biological oceanographers may be excited when they can predict within an order of magnitude, something more is expected of salmon managers. So, despite the promises of marine ecosystem studies, the salmon biologists will rely more on their own substantial bag of 21st century tricks.

For example, it is almost certain that by the year 2000 or shortly thereafter, it will be known how salmon find their way around the ocean and eventually back to their home streams. It is already established that, in fresh water, the juveniles imprint the odor characteristics of their environment. If they remember these odors in the sequence in which they committed them to memory, which is now seen as likely, they should have the capacity to find home once they reach inshore waters. It is also known now that salmon can get some sense of direction from the sun and from the plane of polarization of light in the sky. It is suspected that salmon may be able to sense the gradient in electric potential generated by the movement of an ocean current in the earth's magnetic field. Sensitivities close to that required have already been demonstrated in Atlantic salmon and American eels, and sensitivities that are more than adequate by an order of magnitude have been demonstrated for sharks and several species of electric fishes. To top it off, it has already been shown that some species of fish can orient in natural strength magnetic fields. The mysterious X factor in the well known experiments of Groot on juvenile sockeye has all the earmarks of magnetic sensitivity, and I understand that Thomas Quinn, a graduate student at the University of Washington, has demonstrated orientation of sockeye salmon in simulated natural strength magnetic fields. Finally, though it may be irrelevant, I have recently demonstrated in my own lab that muscle tissue of sockeye, coho and chinook salmon is weakly magnetic. It seems only a matter of time until it is demonstrated that from some combination of directed and passive movement, a salmon should be able to navigate by sensing a mix of natural and induced electro-magnetic fields. Shortly thereafter, it should be possible to assemble the hierarchy of decisions that result in salmon finding their way home.

Rather surprisingly though, solving the riddle of how salmon find their way home may not prove to be as important as the realization that the salmon find their way *around* the ocean as well as *back* to their home streams, and it is this capacity to find their way around, on a tight time schedule, that may be the greater natural spectacle. I suspect that by the year 2020 we will know and be capitalizing on the knowledge that, starting with their lives in estuaries and fjords, the various races of the various species are continuously involved in a naturally orchestrated partitioning of the pelagic grazing resources of the North Pacific. To exploit the potential for producing salmon, we will know that we must fit our plans into a comprehensive ecological picture.

There is a danger, of course, in putting too fine a point on such speculations. Nature doesn't work with the romantic perfection that Disneyland serves up to the credulous. But on the other hand, it is almost equally simpleminded to believe that the natural world is unordered. As a force for molding the ways of things, natural selection operating on genetic variability is about as subtle as carving toothpicks with an axe, but given time it can shape a world of recognizable form. There is no doubt in my mind that there is order in the utilization of the ocean's resources by the various races and species of salmon, and by the year 2020 we should be using our knowledge of that order to plan our programs of salmon production.

One of the obvious inferences of this kind of conjecture is that we would

place high priority on the need for preservation of all natural stocks. As a first approximation to whatever perfection Nature can achieve, what better than to restore all natural stocks to their historic levels of abundance? But I don't believe we will think that way. Aside from the fact that many of the natural stocks have already been exterminated and that more will be by then, it must be recognized that the world, from a salmon's point of view, is not the same place as it was a century or more ago. What will be needed will be an artificially orchestrated utilization of the production of young salmon that will achieve the contemporary oceanic potential for adult production. That is what salmon managers will be talking about at meetings of the Pacific Fishery Biologists in the first two decades of the 21st century.

Regardless of the character of the racial mix, it will be necessary to have at hand the capacity to identify stocks at all stages of their life histories. Although I may be optimistic, I expect that in the next 50 years we will not only have masterful techniques of racial identification, but will also be talking of better ways of tissue culturing and of exciting new prospects in genetic engineering of salmon. But that's too much to talk of all at once. Let's first look at racial identification techniques.

Although it has long been known that the various races of salmon have morphological characteristics that set them statistically apart from each other, it is only recently that electrophoretic techniques have been widely adapted to the task of separating stocks by the relative frequency of occurrence of various isozymes, especially those which reflect the existence of multiple alleles at single gene loci. It has also been known for some time that the early life history of salmon is reflected in the record of growth on their various bony parts, including their scales and otoliths. But again, in the past decade there has been a major advance. We can now examine the daily record of the life of young salmon by looking at the otoliths and can accordingly develop an even sharper appreciation of racial differences, both on the average and in particular years. New and perhaps surprising ways of identifying races of salmon almost certainly will be added to our present capacities. Bearing in mind the arsenal of automated data digitizers and computer facilities that grows so quickly and so incredibly, it seems logical to predict great leaps in handling large quantities of information.

Add it all up and the conclusion is inescapable that a series of tests should be able to identify the stream of origin of any ocean-caught salmon without the need for any such crudities as marks or wire tags. At the very least, any hatchery produced salmon will carry an unmistakable biochemical marker.

Speculating about tissue culture is somewhat more of a science fiction story, but salmon biologists could perhaps realize one of their oldest dreams as a result of the major new developments in techniques that have been perfected in cancer research. I first heard the old dream from Dr. W. A. Clemens, who told me in 1950 that there was once the idea of saving the gonads of commercially-caught salmon and bringing the eggs and sperms to maturity in culture media.

If that possibility became a reality, we could imagine fisheries on stocks for which there was *no* escapement. Gonads would be taken from freshly-caught fish whose race could be identified, and from then on artificial methods would take over. I will bet you 50 cents that we will be able to do it in the year 2000, and it will be standard practice when necessary in 2020. It may even be possible to clone fish from single somatic cells. What a boon that would be!

Now to genetic engineering, perhaps even further into the future. When it comes to genetics in general, our knowledge of fish is at least 20 years behind the front-running plant breeders and fruit fly specialists. We are only just beginning to collect the data to delineate genetic differences among stocks and species. The next 20 years then could well be taken up with getting where the leaders are now, beyond mapping chromosomes, beyond inducing mutations, and beginning to explore ways of splicing genetic material as has been pioneered by microbiologists. After that, it should be at least possible to steer breeding programs to select salmon with particular combinations of characteristics, suitable for either natural or artificial culture.

It is expected that there will be far more failures than successes in the early years of such enterprises, but the eventual returns from such fundamental understanding of how to handle biological material could be staggering.

While all of this basic research has been going on, there will also have been many technological advances of one sort of another that will make hatchery operations and aquacultural pursuits much more biologically sound and mechanically slick than they are now. For example, it is beginning to be appreciated that there may be far more in the behavior and physiology of salmon than we have realized. We raise fish in environments that are highly artificial---stainless steel tanks, *ad libitum* feeding, controlled and relatively high temperature, and so on. That kind of procedure may be fine for chickens and pigs that will go directly from the production line to the slaughter house, and may be suitable for aquaculture, but as a preliminary to spending a year or more at sea, it may leave much to be desired. This is an old chestnut in the history of hatchery controversy, but it is still a relevant chestnut that probably will be cracked in the next 50 years. Some of our shiny new fish hatcheries may have to be extensively renovated or converted into bowling alleys, but that's life.

My guess is that in less than 50 years' time we will come to know how to raise fish in hatcheries so that the physiological attributes and behavioral patterns relevant to survival are not only retained but also enhanced, and that any genetic selection for particular traits will be deliberate rather than unconscious or misguided.

Finally, on the biological research front, as a bit of comic relief from such heady stuff, I venture that by 2000 someone will have completed all the possible crosses of the five North American species of Pacific salmon and that a convention will have been adopted for naming the hybrids—the first part of the name coming from the first syllable of the female parent and the second part from the last syllable of the male parent. We will know all about Chinho, Cockeye, Socknook, Chunk and Pinhum! All of these crosses will be looked on only as curiosities, suitable perhaps for exotic gourmet markets in which any price is paid for novelty.

New Knowledge: The Biological Management of Salmon Populations

There is much current literature on the management of salmon dealing with research of the kind that is concerned with models, and their parameterization by elegant algorithms, facilitated by ever more speedy computation and more voluminous capacities of memory. If you believe in stock-recruit relations, it doesn't matter what you choose as the relation, you can readily evaluate the best strategy for management. If you can't make up your mind which relation to use, you may choose whichever fits best at the moment. If you don't believe there is a relationship, you can use the technique of multi-channel spectral analysis to give you a best statistical estimate of what will happen next if the future is like the past. In brief, there is no shortage of ways for squeezing out of the data whatever information they may contain.

What the data may contain, though, is the message that there is not much information. Estimates of catch by stock are often hallucinations. The precision of the statistics for a few stocks has cultivated the myth that the data are equally precise for all stocks. Even when we have good counts of seagoing migrants, there are still large unaccounted for variations in marine survival. Still the best measures of the forthcoming runs are the early catches. When it comes to estimating desirable escapements by looking at spawning grounds, we are also largely guessing. We simply do not have the data now to properly manage all stocks even if our theories are correct.

Is it likely that we will obtain data in the next 50 years that can be used to manage salmon stocks according to our erstwhile beliefs in maximum sustainable yield? Although this has been our goal for the last 50 years, I doubt we will be any better at it 50 years hence. In some ways, it is tempting to speculate that, thanks to racial identification techniques, we will be able to sort out the origin of each of the fish in the catch, and thanks to electronic gadgetry, count each of the fish on the spawning grounds. (One could even express the hope that satellites might monitor the numbers of salmon at sea, though it's a bit much to believe in remote identification by species and stock.)

My guess is that some of this will happen, but it will have much less priority than it has been given in the past and will fade as we gain new perceptions for management of natural populations. There is now convincing evidence for various fisheries of the world that m.s.y., as we now calculate it, is too much. There is no margin for error, no consideration of species interactions, no allowance for the selective effects of fishing on population genetics. Already there is convincing evidence for a substantial long term decline in the size of pink salmon in the Canadian catch (from 6 to 4 pounds). It is abundantly recognized that less productive stocks are overfished in the pursuit of m.s.y. of the more productive.

In these several circumstances, the extreme alternatives are twofold: either stick to m.s.y. and focus the harvest on the most productive hatchery-assisted stocks and damn the consequences, or ease back on harvest rates of all stocks to preserve the genetic variability that may be necessary to continually convert the variable resources of the freshwater and marine environments into salmon. The battle between these approaches will be the dominant issue of management.

The first alternative of full speed ahead on hatchery-assisted stocks is the obvious route when there are strong pressures for more fish as soon as possible. Already, hatchery culture of chum salmon dominates the Japanese scene—the total catch from the Hokkaido hatcheries exceeding that of all five species of salmon in Canada. The massive programs currently getting under way in Alaska are perhaps another step along the same route. All around the range of Pacific salmon there are enthusiasms for more massive enhancement of natural production. But regionally, or even locally, none of these programs is put together with appreciation of the long term genetic or ecological consequences. They are essentially trial and error exercises in which success in the short term may be misleading with respect to prospects for the long term. To make matters worse, every short term success means intensive harvesting of wild stocks that are caught up in the fishery. Every short term failure puts more pressure on the wild stocks that are already depleted. As a prospect for the future, haphazard large scale enhancement is a high risk venture.

The alternative of easing back on harvest rates provides a better potential base for what might be called "across the board" or "orchestrated" enhancement, which would have as a goal the restoration to natural levels and subsequent maintenance of the maximum number of natural stocks of all species. The management goal might be a rate of harvesting perhaps at a level as low as one half of what we now see as m.s.y., operating on stocks that are twice as abundant and genetically far more fit than they are today. In essence, this would mean going back to the way things could have been at the turn of the century. It's a nice dream.

Somewhere between these extremes lies the biological future of Pacific salmon in the North Pacific. In large measure, we still have the option of going either way. Which way things will go will depend not on the salmon, and not on what we know about salmon, but on economic, social and political factors to which I shall shortly turn.

New Knowledge: Pacific Salmon Elsewhere

It seems fitting to conclude the biologically-oriented part of this essay with a few speculations about Pacific salmon in parts of the world other than the North Pacific Ocean. As we all know, there is a long history of transplants of Pacific salmon to various parts of the world. To name a few, New Zealand, Chile, Newfoundland, Maine, Norway and the Great Lakes.

It is first reasonable to surmise that the stocks of the species most likely to succeed when transplanted are those which wander the least distance from their streams of origin, migrate along coast lines, or are not crucially dependent on return to the home stream. Some of the coho strains of the Puget Sound and Strait of Georgia region may be prime examples. They should do well in Maine and are said to be doing so. There are also alleged to be some leakages downstream from the Great Lakes. I have recently advocated their large scale introduction on the Atlantic coast of Canada (where it could be expected that there might eventually be formed a Society for the Extermination of Pacific Salmon. By the year 2000 the battle should be well under way.) Certain strains of chinook salmon should also be transplantable,

to which New Zealand bears witness. Some limited successes with coho and chinook might be expected from Chile and Argentina.

Successful transplants of pink, chum and sockeye may be more difficult, for all species go further to sea, and sockeye characteristically require a lake, one of which is not to be found up every stream. For these species, it seems logical to think in terms of appropriate geographies, and this leads directly to the suggestion, made several years ago, that the best source for a transplant to the east coast of North America is the east coast of Asia; and the best source for the west coast of Europe is the west coast of North America. On closer inspection, this idea is not so titillating as it first sounds, the patterns of ocean circulation being somewhat uncooperative. Nevertheless, I believe salmon are up to the challenge, and I predict that these transplants will be attempted in the next decade, that they will succeed in the following decade, and that by the year 2020 a modest fishery for pinks, chums and sockeye will be established in the Atlantic Ocean. The same will not be true for the Antarctic experiments with these species—the ocean currents are too uncooperative. And that's enough biological crystal gazing.

Economics, Politics and Social Change

I don't fancy myself as an economist, political scientist, social psychologist, or philosopher. But to speak adequately of the future of the Pacific coast salmon fisheries, it would be irresponsible to speak only of the fish. Economic, political and social conditions will provide the context in which salmon are harvested in the future. Because I propose to give economics the least attention, I shall dispose of it first. As Don McKernan might say by way of preliminary, "Some of my best friends are economists. However . . ."

It is certainly one of the major curiosities of our times that we place such high store in what economists have to say, especially when, as a rule, they often give the impression of going in opposite directions at the same time. The commentaries of economists on salmon fisheries are no exception. As we all know, publicly-owned resources seem inevitably to unfold as a "tragedy of the commons," and so for many years most economists have advocated license limitation as the only cure for the heavy capital investments and low incomes of too many competing fishermen. Especially for fish as vulnerable as salmon, market forces will not save the resource. On the contrary, the price keeps going up because the market is expanding while the supply is fixed or dwindling. So far at least, the costs of catching salmon have not risen proportionately. Hence, on the average, salmon fishermen are better off now than they have ever been. But there remains the fact that the cost of catching salmon is far more than it need be. Two days fishing a week is about the current maximum. The fishery could obviously generate larger economic rents. The only solution is for government to regulate the number of fishermen, and hence make the fishery even more profitable. That's been the standard religion of the economists, and its first commandment is efficiency. Taken to an extreme, it would obviously suggest catching most of the salmon harvest with a handful of strategically-placed traps, with a small fleet for mopping-up operations; but economists mostly avoid that suggestion—it is simply not acceptable, however logical. Like the game of Monopoly, economics has certain rules, imposed arbitrarily by social circumstances.

Sport fisheries are a different game, and the economists must rationalize within a different set of rules. As Alan Chambers of the University of British Columbia remarked to me recently, in sport fisheries the object is to maximize the amount of recreation, which means having as many fishermen as possible, having them pay as much as possible, and applauding the growth of secondary manufacturing industries that promote as much capital investment as possible in devices that will never, on the average, pay for themselves in more fish caught. The name of this game is inefficiency, and it is a struggle for economists when people enjoy the activity rather than what it produces.

The paradox of what the economics of salmon fisheries is all about is, of course, readily resolved—the object of both commercial and sport fisheries is to generate economic rent—the difference between the costs and the revenues. If you are catching fish for food, you "catch fish as cheap as you can and sell them as dear as you can." If you are in the recreation business, you are concerned not with the catch of real fish, but with the sportman's fantasies of how many fish he imagines he might catch. You accordingly make the gap between the value of what he really catches and what he will pay for what he thinks he might catch as large as he will tolerate. All of this is served up with the consolation prize of fresh air, sunburn and mental diversion. It is akin to guaranteeing a slice of bread and then maximizing the difference between how much jam there is actually on the bread and how much jam the customer thinks might be on the bread. In brief, the message of economists is that whatever you decide to do, you should do well, which certainly makes sense in limited and specified contexts.

For salmon managers this all brings little comfort, because they receive conflicting advice about what they should do from sport and commercial fishermen as well as from the various kinds of commercial fishermen. In consequence, most salmon managers try to operate so as to maximize social satisfaction which, translated, means to minimize political heat. Ultimately, I suppose, the political process should bring about an economic rationalization across the sectors of the fishery—but this is too abstract for me.

In looking to the future, then, I shall make no futher reference to the economics of salmon fisheries, except that I will leave it as understood that, in each constituent sector of the fishery, as for singleminded individual fishermen, economics should rule supreme, but in the aggregate of considerations in a salmon fishery as a whole, economics is not the prime consideration. I don't expect this pronouncement will deter economists from studying the fishery as a whole, but I offer it in the hope that it may warn them against spending too much time in trying to make sense of all of it.

As a matter of fact, I would even warn them against trying to make too much sense of the economics of single sectors of the fishery. In my experience, individual fishermen, either sport or commercial, are not rational entities in the economists' sense of the word 'rational'. The reasons they do or don't go fishing include a wide variety of personal factors best summarized under the two general headings of life style and perversity. It also has to be considered that few fishing companies confine their activities to salmon alone. The marketing of salmon is commonly part of the marketing of a whole line of seafood products, and most fishing companies operate as traders as well as resource extractors. Indeed, it has been obvious for a long time

that regardless of international arguments or agreements, our supermarket shelves remain abundantly stocked with seafoods from all over the world. The invisible hand of commerce in food is far more influential than the narrow economics of the salmon fishery.

It is slightly more illuminating to consider salmon fisheries from the perspective of political science, which, academically speaking, commonly claims to subsume economics as nuts and bolts. At this level, what goes on today does make a little bit more sense. Recognizing that people generally don't like change, especially when it portends some loss of income or privilege, politicians deal in what is possible rather than what is desirable. They accordingly try to guess what the people want and verbally shuffle slowly in that direction to test the public reaction.

When they reduce their observations on the salmon fisheries into professional jargon, political scientists are prone to use phrases like "participation in decision-making," "properties of the management system," "institutional impediments to change," and "interactive elements in resource conflicts." Recognizing that all major political parties are either socialist or quasi-socialist, regardless of their labels, they usually think in terms of government intervention to soften the harshness of fate and to devise ways of making things happen less painfully. The basic premise is that "father knows best," where father is a mish-mash of elected representatives and public servants.

But, despite what they say on public platforms before they are elected, our representatives usually turn out to be defenders of the *status quo*, rather than crusaders for reform, and there is little confidence in the public service which responds to crisis with reorganization, and usually has little to suggest as a goal for the future except as the past revisited.

As in the State of Washington, current management of salmon in British Columbia can only be described charitably as "tense." The numbers of salmon of many stocks have been declining steadily over the past decade, and each sector of the commercial industry is determined not to have a lesser share in a dwindling resource. All of this has taken place over a decade or more in which there has been no shortage of "participation in decision making," no lack of self-study on the "properties of the management system," no hesitation in pointing to the "institutional impediments to change," and lots of examples of "interactive elements in resource conflicts." We have given ourselves frequent and extensive examination, have pleaded our cases to each other; we sense that the system isn't working the way it should and are now best described as simply bewildered and frustrated. In these circumstances, people do nothing or do what they have always done: they are best characterized as defensive.

Political science it seems, like economics, can tell us what has been, but aside from some generalizations about how much worse it might be with other systems of government, and some comforting aphorisms about the essential slowness of democratic processes, it contains no magic recipe for telling us how to solve our problems quickly and sensibly.

In the absence of technological, economic or political nostrums, it obviously will be necessary to probe a little deeper, looking at some of our underlying social attitudes. For example, it is one of our firmly held social attitudes that salmon are a "good thing," a part of our heritage, an integral part of our

culture—you know the usual line of language. We pick this up in elementary school; it is reinforced on the television, in the Boy Scouts, by the Sierra Club, and in dozens of other ways. I wouldn't want that attitude to change, and I don't think it will.

There are other attitudes that should and probably will change. For example, it is common to believe that everyone has the right to do anything that is not illegal. (It's the converse of T. H. Smith's version of life in the ant hill where 'everything not forbidden is compulsory.') Thus, everyone has a right to go salmon fishing. To keep the catch within bounds, it is obviously necessary to curtail fishing time, which brings us to two more social attitudes: that all should be treated equally, and none should be denied the opportunity to fish in his own particular way.

I believe these attitudes will be substantially eroded in the next 20 years. I'll tell you the means by which they will be changed in a minute or two, but first let me tell you what I think the changes will be. To begin, I suspect that sport fishing for salmon will become much more of a yearly religious festival than an every-weekend pursuit. To take an extreme position, I can visualize that by the year 2020, for a short 10-day period in midsummer, hundreds of thousands of sport fishermen will be allowed a total catch of two salmon each, and these will be prepared for eating with great ceremony and consumed with large quantities of locally-made wine. For the rest of the year there will be all kinds of boating pleasures, but no legal sport fishing for salmon. Between then and now there will be a gradual civilizing process of the sport fishermen—more of them will use barbless hooks, put their fish back in the water, and stop fishing when they've caught one. Others will have small TV screens in their boats, on which they can watch a salmon approach a lure and eat a bait that doesn't contain a hook. By the century's end, our present-day barbarisms will have been confined to that limited 10-day salmon festival in which we can all be acceptably bad mannered enough to catch, kill and eat two salmon.

The commercial fishery will also be transformed. The bulk of the catch will be taken by seiners, and the mopping up will be done by a few gillnetters operating close to the river mouths. Commercial trolling will be reduced to the activities of a very few rugged individualists who will be colorfully featured in the *National Geographic* as relics of the past. The total size of the fishing fleet will be no more, and probably less than one quarter of that today, and fishing will be for 4 or 5 days a week. The whole commercial operation will be superb technologically and extraordinarily efficient.

Enhancement facilities, such as hatcheries, spawning channels, fishways, lake fertilization projects, and so on, mostly will be looked after by the commercial fishing companies and will have to meet requirements and standards set by government. The requirements will include production of coho and chinook salmon as a contribution to the sport fishermen's annual celebration, and the standards will be enforced by frequent inspection. A few such facilities will be constructed and operated by sport fishermen groups, with a similar set of requirements and standards, and they will receive government subsidies in their efforts. The whole complex of natural and enhanced production will be planned regionally by government. How many of which race of which species is sent to sea will be geared to perceptions of

how to maximize the use of the oceanic potential for production.

The government agencies will thus still play an important role in overseeing the entire operation, but instead of taking the blame for everything as they do now, they will be allocating the blame to those who didn't play their part. In short, the locus of operational responsibility will soon shift away from government into the hands of the users of the resource.

Now, by what means do I imagine that this will all come about? It is first important to realize that the majority of us alive today will be alive in the year 2000, and that most of those who haven't been born yet, will not, by that time, have opinions worth hearing (or a vote). Those of us alive today who won't be around in the year 2000, or won't be very influential then, are presently 50'ish, as I like to call myself. The really important people are those who are now between 15 and 50, who have long been recognized as the stabilizing force of society, and who will dominate social attitudes as they age to 35 to 70 by the year 2000. Finally, of these, the majority are the babies of the boom years, 1945 to 1965, who are now 15 to 35, and who will range from 35 to 55 at the century's end.

These people (i.e., those now between 15 and 35) don't think like those of us of the preceding generation, but thanks to us, are much better educated and more sensible (at least about natural resources, if nothing else!). The inevitability of compromise comes more naturally to them, at the same time as they are totally uncompromising on certain issues, such as conservation in the best sense of the word. I fully expect then that salmon will persist because of their convictions. But, because of their acceptance of responsibility as a *quid pro quo* of privilege, they will opt out of demanding their rights to go fishing, provided it is left to others who are demonstrably prepared to accept a public trust. Hence they will not insist on their rights as sports fishermen and will recognize that being out of doors is far more important than catching fish. They will, therefore, go along with only a once-a-year binge as a traditional and sentimental occasion. And also, hence, if the commercial fishing industry will shoulder the load of maintaining the resource (as industry already does for much of our forests), they, the public, will accept the argument that it is economically efficient and socially responsible to put the commercial operators in charge.

Strangely enough, these attitudes are already held with respect to other sectors of our economy. Forestry has already been mentioned in passing. Even more vivid is our virtually complete acceptance of the management of all kinds of mineral resources by private enterprise, subject of course to government surveillance. It is only a matter of time before the attitudes which support this way of doing things finally reach the last resource frontier, which we call fisheries. No one has put it better than Roy Jackson, former Deputy Director General of FAO, when he said that fisheries were the last vestige of the traditions of cowboys and Indians. The game is almost over internationally, and civilizing influences have prevailed. It is only a matter of time until we put our national affairs in order.

You can be sure that, in the course of making these many changes, there will be a great deal of discussion, wrangling, distorted publicity, and considerable use of the arts of persuasion. You can be sure that information by itself, however complete, will not change attitudes.* You can be sure that successful persuasion will have to take into account the reasons underlying attitudes, as well as the attitudes themselves. You can be confident that audience participation will help to overcome resistance and that the people you may want most to be in the audience often will be least likely to be there. And you can expect that the effects of persuasive communication will wear off.

Nevertheless, you should expect that the changes will be inevitable. They will be accelerated, of course, by events. There will be poor seasons for salmon fishing, and they will occur with increasing frequency. Commercial companies will fold, and fishermen won't be able to make mortgage payments on their boats. Sports fishermen will rage over the incompetence of government officials and will complain bitterly about poor catches. Emerging from it all will be a commercial fishery that is economically rationalized, a sport fishery that has been socially rationalized, and a fishery as a whole that has been politically rationalized.

There is also the larger context of reconciling salmon production with all of the other demands on water resources. For as long as I can remember, there has been much talk about "multiple resource use," and great efforts have been made to try to ensure that the aggregate of benefits should exceed, by as much as possible, the totality of costs. Economic theory has been stretched to the limit in finding a common algebra for optimization, but that theory has fallen short in representing political facts of life and the underlying social attitudes they reflect.

Again, I believe that the next generation or two will be more clear-headed than we have been, will see social objectives more plainly, and will entertain more willingly compromises that are demonstrably in the public interest. Political observers will sense that willingness and what will emerge will be acceptable solutions that are neither ecologically perfect nor economically singleminded. It will be the way we want it to be, perhaps seemingly irrational, but very satisfying.

The International Scene

To conclude this fanciful tour of how things may be in the future, it is appropriate to turn to Don McKernan's favorite topic—international relations in fisheries. It was a major event of Don's time, in part attributable to his efforts, that many countries of the world declared for 200-mile limits. The question of how to handle highly migratory fishes is, as you know, still unsettled today, though there is widespread acceptance of the notion that anadromous species, especially salmon, should be harvested by the country of origin, which foregoes other uses of freshwater environments to maintain salmon populations. On this subject, the United States and Canada have been fully in agreement for a long time and presented a common front in negotiation with the Japanese concerning high-seas fisheries for salmon. The two countries also presented a common front on the matter of indiscriminate

* I am indebted for this and the following assurances to the book *Persuasion: How Opinions and Attitudes Are Changed* by Marvin Karlins and Herbert Abelson, Second Edition, 1970. Springer: New York.

harvesting of mixed stocks, a definite no-no from the point of view of obtaining m.s.y. from each stock. The arguments for abstention were always a bit weakened if escapements were larger than was seen to be necessary, such as at Bristol Bay, but the country of origin idea and the minimizing of mixed fisheries were unassailable as principles of sound management.

The principles being sound, they had long since been recognized as applicable to the North American coast, where the United States and Canada traditionally had been involved in catching each other's fish, often doing the harvesting on mixed stocks. The first step in resolving the national disputes took about 30 years and culminated in the Convention establishing the International Pacific Salmon Fisheries Commission. Baldly stated, this arrangement gave one-half the permissible catch of Fraser River sockeye salmon to the United Staes in return for paying one-half the cost of rehabilitating and managing the stocks. It was obviously a good deal for the United States. In the mid 1950s, Canadian fishermen complained bitterly to their Minister of Fisheries that the United States fishermen were also catching large quantities of Fraser River pink salmon. The Minister suggested that they wipe their noses, pull up their socks, and catch a comparable number of Puget Sound pink salmon. And they did; and the Convention was subsequently amended to take pink salmon into account as well. This time the 50:50 split was a temporary measure pending detailed scientific investigation. On completion of the investigation, a new round of negotiations was to be scheduled.

From the beginning, these negotiations were estranged. A few years previous, the two countries had consulted on the subject of high seas salmon fisheries on mixed stocks and had decided to clean up their own acts, *vis-a-vis* the Japanese, by instituting the notion of surf lines. On leaving the negotiating table, they believed they understood each other. As it turned out, Canada and the United States south of 49° agreed, but Alaska had its own version of surf lines that were 4 miles farther to sea than everybody else's. Interceptions of Canada-bound fish in this Alaskan coastal zone were seen by Canadians as evidence of bad faith. The Canadians came to the bargaining table feeling bilious. The Americans were feeling bilious too, but for different reasons. First, there was an increasing troll fishery for salmon off the west coast of Vancouver Island, and it was suspected that many of the fish had originated in United States fish hatcheries. Second, the occurrence of unusual oceanographic conditions in 1958 diverted a large fraction of the Fraser River sockeye into the Johnstone Strait route, where the 50:50 rule didn't apply. To make matters completely reciprocal when it came to bile, the Canadians were upset by a somewhat similar oceanographic situation which diverted Skeena and Nass River sockeye closer to the surf line fishermen near Noyes Island at the south end of the Alaska panhandle.

The negotiations were not pleasant, and in an atmosphere of mounting hostility they were reconvened at roughly 6-month intervals, alternately in Canada and the United States. It was eventually agreed that what was needed was far more information on the total number of interceptions along the whole coast. The time had passed for settling the issues piecemeal.

There were some efforts made to plan the necessary investigations, but for a variety of reasons that are best described as rising pressures on other fronts, the large-scale study needed was never mounted. For the past 15 years

there have been several more contributions to the total picture, but it remains sketchy and incomplete. What is worse, much of the data has been kept locked up in files, ostensibly too important to release publicly and acquiring the status of fact even though it has yet to have public scrutiny. Also, since then, the two high contracting parties have met periodically to argue each other's interpretation of data, to reaffirm their basic agreement in principle, and to agree to disagree about the terms of a settlement.

One of the new features of the negotiations has been the consideration of economics which, predictably, has confused the issues. For purposes of negotiation, salmon caught by sports fishermen have a value close to infinity, while salmon caught commercially are worth what someone will pay for them. I once heard that after much bargaining the negotiations were within $5 million per year of reaching agreement. If that is true, it is scandalous that agreement wasn't reached. Consider, for example, that for the past 15 years the International Pacific Salmon Fisheries Commission has kept in mothballs plans for $11 million worth of salmon enhancement projects. The implementation of these projects alone would have already produced salmon worth far more per year than the $5 million gap in the negotiations. Regardless of monetary details, it is indeed true that Canada and the United States have together blocked an increase in the size of a pie because they couldn't agree on how to slice it.

As if all this wasn't enough, the establishment of 200-mile limits inevitably involved boundary questions, which the two countries had to discuss. As a result, the salmon questions became entangled with a number of other fisheries disputes.

In recent years I've lost interest in the United States/Canada negotiations, and I was surprised to realize how much I remembered when writing these remarks. I was also surprised to discover that I don't feel very hostile any more, and I wonder how many others feel the same way. In my view, it's time for a settlement. The two countries don't mean anything to the salmon, but the salmon mean a lot to the two countries. Looking to the future, then, I must, with great hope, predict an early resolution of our international differences. I once told Don McKernan that Americans were greedy, and he replied that he agreed and that Americans shared a lot of characteristics with Canadians. If that is indeed the case, we should be able to manage something that is responsive to our common failing.

On the wider international scene, it is interesting to speculate on what the 200-mile limit eventually will mean. At present it is an exclusive fishing zone. But the biology of the animals demands something more sophisticated. The potential for feeding young fish is the real oceanic resource. Salmon of Japanese and Russian origin feed extensively within the chain of 200-mile limits that encircle each of the Aleutian Islands. Canadian salmon feed extensively within 200 miles of the Alaskan coast, and Washington and Oregon salmon certainly feed within Canadian 200-mile limits. Can each country lay claim to exclusive grazing rights for its portions of the ocean pasture? Let us suppose, for a moment, that a brilliant Canadian scientist breeds a particularly virulent strain of sockeye that intimidates the sockeye of Bristol Bay. Bred in the millions, these super sockeye take over the Gulf of Alaska and Aleutian Islands rearing areas, returning with their ill-gotten gains to Rivers

Inlet, far from where American fishermen can catch them. Will this be considered fair play?

In addition, salmon go well beyond 200-mile limits. Who has the grazing rights there? Can Switzerland and Uganda, as landlocked states, claim a share of grazing rights beyond 200 miles? Should they be collecting part of the fees we should be paying for grazing our salmon in the community pastures?

These are difficult questions, and they relate centrally to some of the unresolved matters in the Law of the Sea Conference. Unfortunately, for those who like simple answers, the world's oceans are complex global systems. I doubt it would take Warren Wooster more than 20 minutes to prove that physical circulation and resultant productivity within the 200-mile zones of the North Pacific is related in part to events in the South China Sea and partly to events in mid-Pacific beyond all 200-mile limits. So who has grazing rights? Though it may all seem farfetched at the moment, these are the types of questions we may well be asking in the middle of the next century, if not well before.

This leads me naturally into what I see as the great hope for the future, based on the great accomplishments of the past. Many of you here will remember that in 1950 we knew very little about the oceanography of the North Pacific and virtually nothing of the seaward migrations of Pacific salmon. As a consequence of the investigations conducted under the rubric of the International North Pacific Fisheries Commission, we greatly enhanced our understandings, and the magnificence of the natural spectacle of Pacific salmon migrations began to unfold. Since 1965, or perhaps, to be charitable, 1970, we have added little new. The scale, scope and intensity of international cooperation has faded rather than grown. For many years Japan, Canada and the United States cooperated in INPFC enterprises, while Japan and the USSR annually negotiated the high seas catches of Asian stocks. From time to time there have been visitors from the USSR to North America, and vice versa, but only rarely have the four countries collaborated on large-scale scientific studies. For reasons that I would personally summarize as a lack of imagination and enterprise at the highest levels of government, we have collectively failed to pursue the great promise of joint international undertakings.

It is my passionate hope that the next two decades will be characterized by new and exciting international investigations that will bring our knowledge of Pacific salmon and of the North Pacific Ocean to levels of understanding that would be enriching to all mankind.

If he had heard that, Don McKernan would have said, "Peter, let me buy you a drink!"

Peter Larkin

Peter Larkin, dean of the Graduate School at the University of British Columbia, is an internationally known fisheries biologist whose research efforts have resulted in more than 100 scientific papers. In 1965 he was named a Fellow of the Royal Society of Canada, and he is the recipient of numerous other honors, including the 1977 Queen's Jubilee Medal, the Fry Medal conferred by the Canadian Society of Zoologists, and 1979 Canadian Sports Fishing Institute Award.

Dr. Larkin is a graduate of the University of Saskatchewan and Oxford University. He served as chief fisheries biologist for the Game Commission of British Columbia from 1948-55. In the years 1955-63, he was director of the Institute for Fisheries and professor of zoology at the University of British Columbia. From 1963-66, he was director of the Biological Station of the Fisheries Research Board of Canada at Nanaimo. He returned to the University of British Columbia in 1966 and in 1975 was named to his present position as dean of the Faculty of Graduate Studies. He is also professor in the Institute of Animal Resource Ecology.

Since 1974, Dr. Larkin has served as advisor to the Salmonid Enhancement Program of the Canadian Department of Fisheries & Oceans and currently is the Canadian participant on the steering committee of PICES—the International Council for Scientific Investigations of the North Pacific.