Chaos on the Commons

Salmon and Such[1]

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ABSTRACT Garrett Hardin's 'Tragedy of the Commons,' assumes a stable biotic potential for any given set of common pool resources. This assumption leads fisheries managers to adopt policies of Maximum Sustained Yields, Limited Entry, and quotas. Because the universe is perceived as a finite, steady-state system, rational management employs allocative strategies intended to promote conservation. If Hardin is wrong, these policies may lead to the destruction of the managed resource. This world view is both culture bound and only partially correct. The same population formula employed in developing maximum sustained yields, can produce deterministic, probabilistic and chaotic models. Chaotic models, while causal, are non-linear and extremely sensitive to initial conditions. Tiny variations in inputs can lead to very different outcomes. Lacking perfect knowledge and control of all variables, regulatory interventions may produce unexpected results. Management policy which ignores the implications of chaos, is based upon theological, economic and philosophic myopia. 'Chaos on the Commons,' explores the relationship between aperiodic energy inputs, and how these inputs are translated through the reproductive strategies of salmon. It further touches upon the implications of managing a semi-chaotic system as if it were a deterministic model. Finally, it explores alternatives to the existing paradigm, and how the existence of chaos must ultimately alter our approaches to resource management.

Trivial Variant or Essential Component?

> ...population growth must eventually equal zero (*the case of perpetual wide fluctuations above and below zero is a trivial variant that need not be discussed*) (Hardin 1977:17, emphasis added).

Attempts to 'rationalize' the utilization of common pool resources are based upon the assumption that all such resources share certain salient characteristics. The most important of these is the fixed biological potential of any ecosystem. In avoiding a tragedy of the commons, management must reconcile the insatiable appetites of individual users with the stable productive abilities of the bio-system. The usual solutions include privatizing the commons, or conversely socializing the means of

production. In both cases the 'tragedy' is avoided by involving management's self interest in the preservation of the commons.

Analog models have great power. This is especially true if they are based upon cultural biases. Garrett Hardin's theoretical examination of the 'rational' dynamics underlying the use of British common pasturage ultimately rests upon such a bias. While extremely useful to the study of common pool resource problems, the analogy is both limited and limiting. In practical applications, this is quite literally the case.

After Hardin's work of 1968 was embraced by fisheries managers, Limited Entry programs for salmon and herring were adopted in Alaska, British Columbia, Washington State and elsewhere (Mundt 1974). By restricting access to the commons, bio-managers hoped to attain Maximum Sustained Yields while avoiding the problems of overuse. Other solutions included the assignment of individual quotas (New Zealand, and more recently the Pacific halibut fisheries). That these programs have at least partially failed in attaining their environmental and socio-economic goals lies in the misapplication of the model.

Hardin's model presupposes a stable environment in terms of pasturage, water availability and the like. The economic strategies of the herdsmen leads to an increase in cattle population which inevitably exceeds the Maximum Sustainable Yield (fixed biotic potential) of the commons. Overgrazing causes continued degradation of the local biosphere which reduces the carrying capacity of the system (Hardin 1977:16-29). In short, Hardin's model is as tame as the cattle he focuses upon.

Large scale maritime environments have not lent themselves to domestication. Because they inhabit an uncertain universe, many short lived marine species have adopted a radically different reproductive strategy than have their terrestrial counterparts. Their huge procreative potential produces extreme sensitivity to initial conditions. Seemingly minor variations in winter temperatures, rainfall, ocean currents, etc., result in large amplifications of fish populations. Many, if not most of these variables are beyond our ability to monitor let alone control.

As a result, fish populations and harvests often seem to defy 'rational' explanations. They are, however, in perfect conformity with the Malthusian population formula X (next) = XR (1-X), allowing for a variable environmental parameter. It is ironic that this equation lies at the heart of both Maximum Sustained Yield management strategy and chaos theory. The fact that bio-managers focus upon a single linear outcome space while ignoring aperiodic results, can only be explained in terms of philosophic prejudice.

If the maritime environment and its biotic potential can be even partially explained by the application of chaos theory, then management approaches rooted in Western theology must be re-examined. The attempt to control what is viewed as an orderly, predictable universe (implied by policies of Maximum Sustained Yields, Limited Entry and Quotas) must be abandoned in favor of more adaptive responses. In sacrificing the illusion of control we must redesign both allocative and utilization policies to conform with the inherent instability of fisheries outcomes.

Problems in Perception

> 'Truth' as preached by scientists often turns out to be no more than prejudice inspired by prevailing social and political beliefs (Gould 1977:44).

Hardin's cattle graze upon Newton's apples. Their pasturage is limited not only by geographic boundaries, but by philosophic ones as well. Temperature, sunlight, rainfall and the rate of vegetation growth apparently have been uniform in this acreage since 4004 BC. The cows are simply animated machines designed to translate this clockwork universe into meat and dairy products for human consumption. While the internal logic leads inevitably to the paradox of destruction, human actors retain control of environmental outcomes.

Do we really occupy such an orderly universe? Was it created for the benefit of humanity? Does our species enjoy a special relationship with God that entitles it to a management role? If so, does 'efficiency' lie in the manipulation of the environment or in the adaptation of human appetites?

These issues are not new to the scientific community. Lyell's concept of uniformity was based upon the precept that natural laws were constant (uniform) in space and time. That if the past was capricious, and God was free to violate natural law at will, then science could not unravel history. While modern geologists accept the fact that both uniformism and Agassiz's catastrophism have played a part in shaping our planet, the uniformist argument has prevailed in cultural mythology (Gould 1977:150).

When Darwin introduced his concept of evolution he was forced to graft Adam Smith upon nature in order to explain his theory of natural selection within the existing socio-religious context. Each individual within a species, acting in its own selfish interest, contributed the necessary genetic materials that allowed for gradual adaptive change (Gould 1977:100). Herbert Spencer used this paradigm to justify the inequities of the economic status quo as being no more than 'the survival of the fittest.' The fact that the co-founder of evolutionary theory, Alfred Russell Wallace proposed a more rapid and cataclysmic evolutionary sequence, was largely ignored until the possibility of cosmic collisions was once again allowed into the scientific community.

The concept of an unchanging steady-state universe owes more to religion than it does to science. This is not to say that uniform processes are unimportant in nature, or that many if not most outcomes are the result of slow and predictable change. It does, however, raise the question of cultural bias in the application of 'scientific' fisheries policy.

William Blomquist, Edella Schlager and S.Y. Tang explore some important qualitative issues in their provocative paper 'All CPRs Are Not Created Equal' (1991). The two dimensions they focus upon are 'stationarity' and 'storage.' As they write, 'This typology classifies CPRs according to whether flow units are stationary and whether storage is feasible.'

		Flow Units	
		Fugitive	Stationary
Storage	Infeasible	fisheries	grazing areas
	Feasible	irrigation	groundwater

While such analysis clearly differentiates the common pool resources of fisheries from Hardin's grazing areas in terms of resource mobility, it does not examine the implications of reproductive strategies in maritime and terrestrial species. Neither does it raise the troubling possibility of a chaotic outcome space. The authors do note, however, 'If flow units are fugitive, variability in the flows available from one period to another is likely to be greater and more difficult for users to understand and anticipate.'

The power of Hardin's model lies in the paradox of rational self interest leading to collective irrationality. In this conflict, the stable productive abilities of a stationary biosphere are destroyed. By pointing out that fugitive common pool resources are more likely to vary in terms of availability, Blomquist and company have torn down the first cultural fence. Hardin's cattle are free to wander, and they belong to those who capture them.

In her article 'Chaos in Fisheries Management,' M. Estellie Smith has raised this issue more directly:

> There are, on the one hand, those who view Nature in classic Newtonian terms; on the other hand, there are those whose understanding of natural processes is strikingly parallel to the model being suggested by the newly emerging science of Chaos. Adherents of the first position model the world in terms of linear relationships; those of the second, in non-linear interweavings (1990:4).

Smith suggests that scientific, governmental and academic pressures require a 'scholarly' view of '...nature as (1) a system and (2) a system in which there is periodic order. (...) In such a system, one must monitor and measure within a context that stays constant from Time Measurement X1 to Time Measurement X2, X3, etc.' (ibid.). An orthodox belief in uniformity is extorted and becomes the standard of acceptance.

Members of Smith's second group, made up largely of fishermen, hold an axiomatic view of Nature as 'non-random but unpredictable.' Natural processes are complicated and dynamic and for all practical purposes aperiodic. While Smith focuses upon the conflict generated by these world views, she does not exclude the possibility that both may be partially correct.

In light of Alaska's experience with actual salmon production, it is surprising that 'chaotic' explanations have not been offered sooner. In 1974, the year Alaska's limited entry program was adopted, Dr. Dayton Alverson the director of the University of Washington's Northwest fisheries Center pointed out that in Bristol Bay 'the biological surpluses can vary by a factor of 30 from year to year' (Mundt 1974:78). This has been underscored by numerous unanticipated fluctuations in Alaskan salmon production.

Predator-Prey Relationships

Hardin's model is both culture bound and anthropocentric. The 'tragedy' would seem to lie in the loss of potential collective profits. Were the cattle to enjoy an isolated steady-state pasture, free of predators, they would soon overgraze the area and produce the same results Hardin laments. This would not be described as 'tragic,' but rather as a manifestation of 'the balance of nature.'

Were wolves (cooperative predators) introduced into the system, the cattle population would be constrained, the grasses recover, and the herd's population would stabilize at a higher level than in a system lacking predators. The wolf population would eventually mirror that of its prey. This too would be seen as a natural balance.

Population dynamics can be viewed as a problem in energy flows. Grasses convert solar inputs into calories that cattle can utilize. Cattle convert these to the protein form that wolves require. At each stage of the food chain there is a 'loss' in terms of this closed model. The grasses are more efficient in terms of 'usable' conversion than are the cattle, the cattle more efficient than the wolves.

Reproductive strategies reflect a species ability to respond to energy fluctuations. Annual grasses produce a prodigious amount of seed, which allow them to survive adverse conditions, and prosper during good times. Breeding cattle produce a single offspring every year, heavily weighted towards females. While far more fertile than wolves, the cattle cannot advantage themselves quickly of the annual fluctuations in grass production. In terms of input-grass-cattle-wolves, much of the energy is wasted, and large differences in input are manifested in such slight wolf population variance that the system appears stable.

The food chain can be thought of as a biological storage battery wherein fugitive flow units (solar energy) are captured and converted to usable forms. Inputs vary over time and season. Arctic and sub-arctic environments are subject to greater fluctuations than temperate and equatorial environments. In all cases the lower links of the food chain adopt strategies that are based upon efficient utilization of these inputs, and their populations demonstrate a high degree of instability. At each stage

of energy conversion there is both storage and loss, which dampens the amplitude manifested in the next stage.

Many maritime species employ a reproductive strategy of extreme fecundity. This allows them the potential of more accurately reflecting the variance in energy inputs. Since these inputs ultimately depend upon both weather and oceanic conversions and distributions of solar energy, and since both weather (Lorenz) and hydrodynamics (Swinney) exemplify non-periodic systems: the populations manifest a high degree of non-linearity (Gleick 1987:105). Predator populations that base their reproductive strategy upon low potential-high survival, cannot quickly respond to these fluctuations in energy input. Because energy is dissipated in each link of the food chain, climax predator populations appear nearly steady-state.

Prey Species Reproductive Strategies

> Nature it seems is the popular name for milliards and milliards and milliards of particles playing their infinite game of billiards and billiards and billiards (Hein 1966:24).

Salmon, like most other fish, base their reproductive strategies upon an uncertain future. A spawning pair of pink salmon may account for 3,000 fertilized eggs. Simple replacement requires that .067% survive. Obviously, small differences in this survival rate can lead to huge returns or disastrous failures. A mere 1% increase would lead to a return 16 times larger than the parental population.

Since salmon inhabit a universe that is affected by many variables, (winter temperature, fresh water flows, food availability, etc.), their biological response has been to adopt a strategy of extreme fecundity and geographic-genetic diversity. Each spawning system can be expected to produce unique annual conditions which will result in localized 'booms' and 'busts.' Should the entire region enjoy favorable conditions, and the oceanic environment allow, extreme amplification can occur. Systemic failures are equally possible.

This aperiodicity may be both the result and a component of the survival strategy. Since predator populations are dependent upon prey availability, regularity encourages predator tracking. Some species, such as cicadas, employ the dual technique of predator satiation (extreme fertility), and a reproductive cycle based on large prime numbers (to discourage predator adaptation) (Gould 1977:97). Non-linear population cycles would seem to serve a similar purpose. If so, human predators must recognize these fluctuations for what they are.

Hardin's model does not include predators, but rather sets humanity apart from nature. Since biotic potential is constant in terms of annual output, he implicitly endorses rational exploitation. But salmon are not cattle, and the oceans are not

English countryside. It is not clear that a fugitive, semi-aperiodic species can sustain the industrial model we have long sought to impose upon it.

Predator Species Utilization Strategy

> It is the purpose of this chapter to promote the conservation and sustained yield management of Alaska's fishery resource and the economic health and stability of commercial fishing in Alaska by regulating and controlling entry into the commercial fisheries in the public interest and without unjust discrimination (AS Sec 16.43.010).

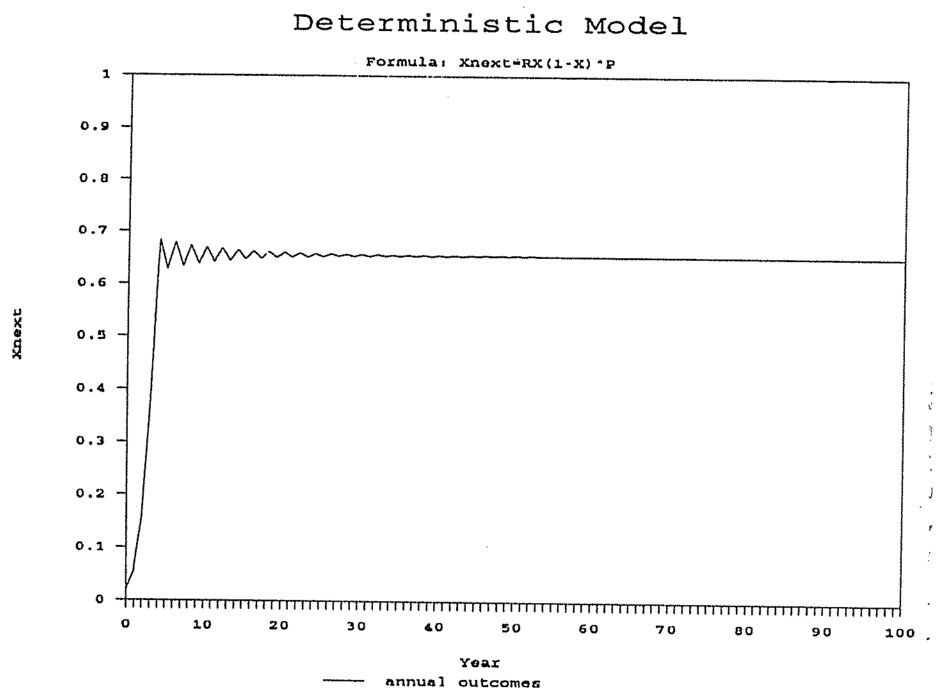

Figure 1.

The concept of Maximum Sustained Yields, whether applied to cattle or fish populations, assumes the existence of a stable environment. As stated in the *Integrated System Plan for Salmon and Steelhead Production in the Columbia River Basin*,

> ...any environment ... can support only a limited number of fish. As the population approaches the maximum, the rate of population increase will decline... The point where the number of surplus fish is the greatest is termed the point of maximum sustained yield (MSY). This point usually occurs at one half to two thirds the maximum population size (1990:14).

In computing MSYs, bio-managers employ a Malthusian population formula labeled the logistic difference equation. X (next) = XR (1-X). Future population (X next), is a function of present population (X) and the environmental growth parameter (R). The last item (1-X) is simply a mathematical constraint which allows the projected population to be stated in numeric values ranging from 1 (extreme overpopulation) to 0 (extinction) (Gleick 1987:70).

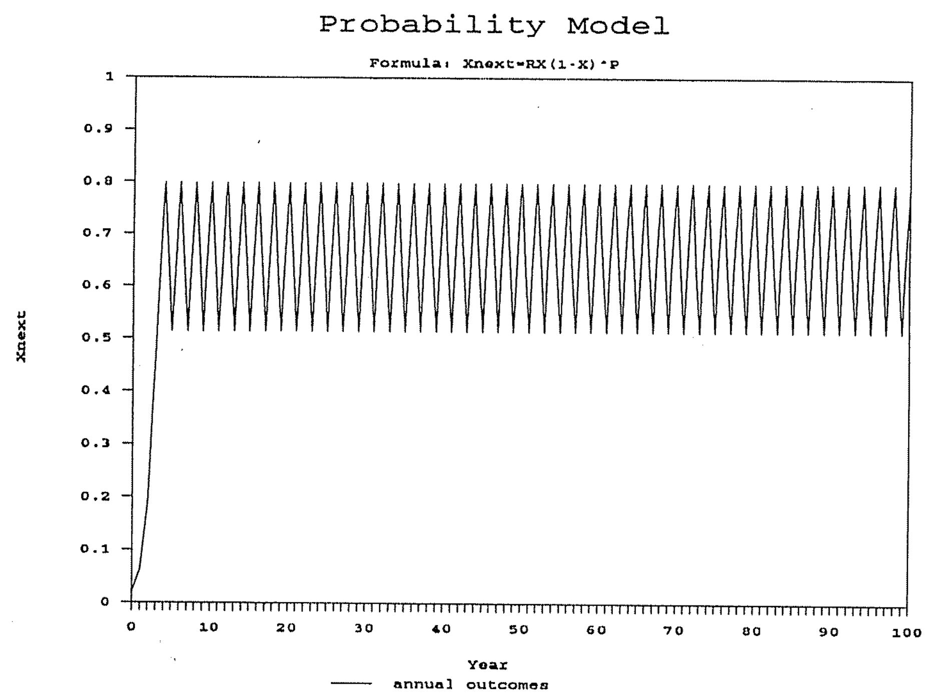

Figure 2.

This equation, which ultimately describes all bio-systems, can produce outcome patterns that appear to describe deterministic systems, probabilistic systems, or non-periodic 'chaotic' systems. The value ascribed to the environmental growth parameter (R) is the critical factor. Bio-managers who employ MSY models assume that the value of R is fixed at the artificial value of approximately 2.7. (This is the point where populations overshoot a stable sustainable level, and if unmolested fall back to that level.)

If the biological potential of a fisheries is constrained by a stable environment (R), then policies which limit access or assign individual quotas can be employed to avoid overutilization. Since the spawning population (X), is the only determining factor in establishing returns (X next), bio-managers need only concern themselves with escapement levels. In theory, this will lead to a stable productive model with catches at or fluctuating around the point of equilibrium.

Policies which restrict participation or assign individual quotas are designed to limit collective appetites. They usually fail to do so because individual fishermen attempt to increase their 'share' through overcapitalization in technological innovation. Moreover, processors who possess much political influence, require a minimal level of annual production that often exceeds the reproductive potential of actual returns.

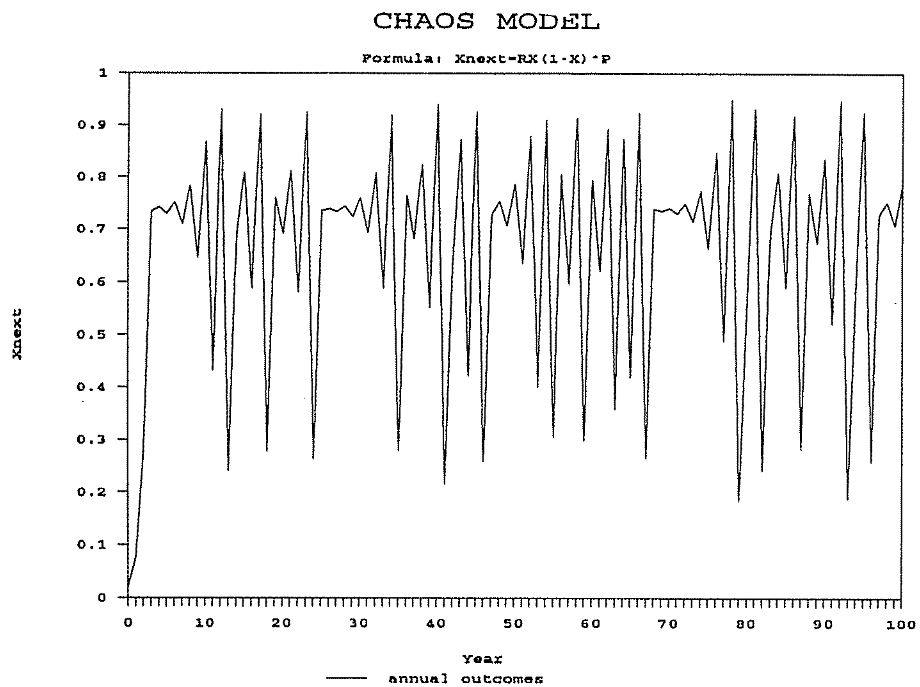

Figure 3.

'Rational' allocative policies have the added benefit of assumed economic viability. An ongoing fisheries will result in a constant annual harvest to be divided among a fixed number of users. Since production is constant, and the worldwide population of consumers is growing, the value of the harvest should increase over time.

The problem is that reality does not always conform with the limited interpretation of the model. The reproductive strategy employed by salmon is instructive. Tiny alterations in survival rates lead to huge amplifications in populations. To admit that rainfall varies from year to year, as does winter temperature, spawning acreage, plankton blooms, ocean currents, predator populations etc., is to allow for the possibility of a variable environment. In terms of our model, this would result in a movable value for (R).

If this is the case, the concept of Maximum Sustained Yields is meaningless. While each year, or spawning cycle would represent a unique biotic potential, slight variations in environmental parameters could result in stable, periodic, or aperiodic patterns as well as unpredictable amplifications of population. Fisheries production would at times seem to conform to deterministic, probabilistic and chaotic explanations.

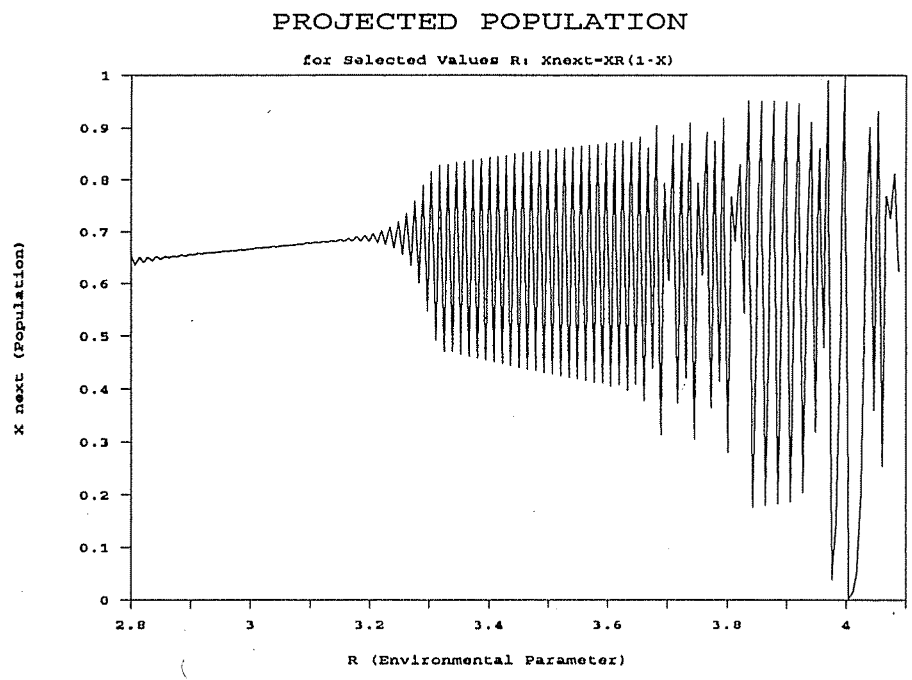

Figure 4.

While the model describing MSYs assumes a stable universe, and deterministic outcomes, most bio-managers allow themselves a degree of flexibility. That is, by assuming an 'average' case for the environment, they move their predictive models into the realm of probability. A certain spawning population will lead to a return that falls within a normal distribution, (fluctuates around a point of equilibrium). This compounds the problem of identifying 'chaotic' outcomes.

Most population outcomes of a 'chaotic' R value (over 3.7), fall within the range described by probabilistic models. Managers dealing with such results accept them as normal and supportive of policies based upon probabilistic assumptions. The higher than chance frequency of inexplicably poor outcomes, usually results in blame being placed upon some previously unidentified 'causal' factor and is often accompanied by requests for increased funding. The higher frequency of unexpectedly favorable outcomes is always attributed to 'good management.' In short, any 'chaotic' outcome can be interpreted as supportive of existing policies and preconceptions.

Scientific governmental agencies have generally refused to incorporate the implications of chaos theory into their management models. This may have more to do with the cultural need for 'control' and the requirement of legitimacy than it does with existential reality. Were a scientific-cum-bureaucratic agency to admit the possibility of a partially chaotic system, much of its social justification (to attain predictable outcomes) would fall away. Such attitudes are rooted in a cultural complex which ignores the policy implications adhering to interactive rather than control systems.

One Creature's X is Another Creature's R

In divorcing themselves from nature humans have assumed a property settlement that may yet be contested. The earth has been defined as and divided into separate sets of 'resources,' each of which is subject to human control. Because the universe is both orderly and stable, it is best understood in terms of simplified systems analysis. 'Unimportant' relationships are discarded.

Resource management incorporates this species specific approach. The Tongass National Forest covers most of southeast Alaska and is harvested under the supervision of a Forest Service intent upon providing a MSY in terms of timber production. Rivers are calibrated in terms of sustainable hydro potential by the Army Corps of Engineers. The Alaska Department of Fish and Game attempts tc attain its steady state goal through management of spawning populations.

In this industrial compartmentalization of 'resources,' the interdependency of periodic and aperiodic manifestations is ignored. The fact that forests provide essential salmon habitat may be acknowledged by timber producers, but their success can be quantified in terms of total annual cut. Less recognized is the fact that the aperiodic salmon represent a means of transporting oceanic energy in terms

of nutrients to the longer term storage system of forests. It is as if the wolves have taken to eating the grass upon which the cattle depend and even the soil which nurtures the grass.

In defining the natural world as a discrete set of deterministic relationships, Western science has set a course which will inevitably lead to the exhaustion of the very resources upon which it depends. This is 'tragic' only if one views the collapse from the perspective of a species which will be eliminated or reduced to an impoverished existence. Whether the would be managers will be among those species remains to be seen.

Managing Chaos

If the natural world allows for chaotic outcomes but management models do not, then the universe must be altered to conform with the model or the model must be made congruent with the universe. This is a simple choice between control and adaptation. There is little doubt that a culture which denies and fears the existence of chaos will adopt the former strategy.

The last two decades have witnessed the development of two alternative methods to wild salmon management. Aquaculture or ocean ranching allows for selective breeding and partial environmental control. Pen rearing or 'farming' allows for total environmental control. Both pose dangers to the continued existence of wild stock fisheries. It is not the fact that either of these methods are more efficient in terms of biological production or cost effectiveness, but rather that they conform to the philosophical norms of modern society.

Rationality In Phase Space

A final analogy may be useful. It involves a roulette wheel. In the first instance, the wheel has a single slot into which the ball may fall. There is no gamble, and one's winnings simply depend upon one's investment. The initial 'bet' results in a known return. This is the universe represented in deterministic models.

If the game is now changed to a normal wheel lacking only the outcomes 0, and 00, one can play a probabilistic strategy by betting red-black, odd-even. Since an honest wheel will produce each color 50% of the time, a betting strategy of red, red, red... will allow one to finish exactly even. Insurance companies base corporate profits on such calculated odds.

Finally, if the wheel is changed to include only the thirty two numbers, a many pockets strategy must be employed. That is, by covering every number on the table, one can insure a pay-off that allows one to stay even. If all numbers are not covered, big wins will be offset by big losses in a random fashion.

Strategies in Fishery Management

> Not to encumber the earth – No pathetic Excelsior, but just this: not to encumber the earth (Hammarskjold 1966:66).

Determinism

If deterministic results are to be obtained from a program of fisheries management, the managers must control both the initial population (X) and all the variables contained in the environmental growth parameter (R). The universe must be privatized, simplified, and subject to manipulation. Salmon farming, as introduced by the Norwegians over a decade ago meets all these requirements.

In addition, the ability of managers to control for size, freshness, year round availability and quality control, would seem to conform to the requirements of the modern market place. These factors have seen worldwide production of farmed salmon increase from 15.7 million pounds in 1980 to 596 million pounds ~~in~~ 1991. This represents over one quarter of the total world supply (Knapp 1991:1-4).

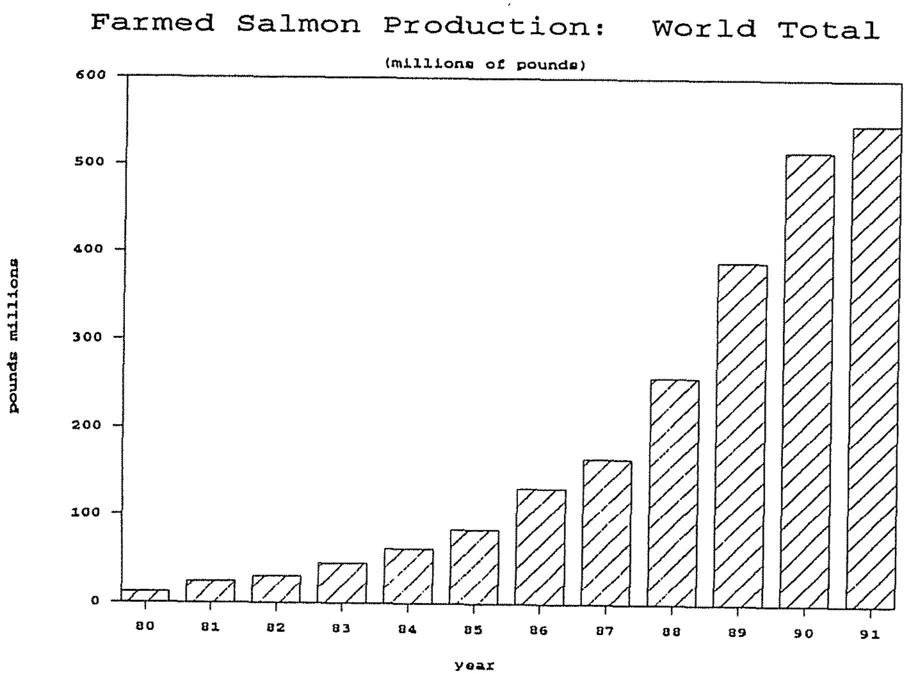

Figure 5.

This increase in production has undermined the economic assumptions used to justify limited entry programs in the wild salmon fisheries. Since farmed fish are now contributing to a worldwide surplus, commercial fishermen have seen their production severed from expected economic returns.

If this trend continues, farmed salmon will replace natural stock fisheries. When this happens, the cattle will have been put back in the pen, the commons privatized, and the universe of salmon made to conform to our standards of predictability.

Probabilism

While greed may be an individually adaptive trait in a universe characterized by stability, cooperation is a rational response to uncertainty. The maritime origins of the insurance industry was a reaction to this problem. By spreading the risks of vessel losses, La Rochelle wine merchants assured themselves of good profits while avoiding the harsh consequences that the probabilistic maritime environment eventually extorts (Morison 1971:265).

Acting upon the same motivation, Alaska's salmon fishermen instituted a series of collective aquaculture programs nearly two decades ago. These hatcheries were initially funded by a self imposed tax upon fishing receipts during a period of severely depressed salmon returns. They now account for over 10% of the salmon harvested in Southeast Alaska and over 50% of the Prince William Sound harvest (Pinkerton 1993:4-6).

Managers of the aquaculture associations enjoy a higher degree of control than do wild stock managers. That is, they not only control the initial population (X), but control all aspects of the environment (R) for the critical first year. The survival rate of hatchery reared fish is considerably higher than that of wild stocks. Returns do seem to oscillate around a point of equilibrium, and usually fall within the predicted range.

Unfortunately, these fish compete with wild stock runs (and become part of an altered systemic R). Some fear that the advantages enjoyed by hatchery reared salmon will result in a diminished gene pool. Quasi-Natural selection will inevitably lead to a variation in Gresham's Law: the bad (hatchery reared) fish will drive out the good (native).

Since the economic imperative which led to these programs (scarcity) has now reversed itself to a point where the wisdom of producing more salmon has been called into question, (supply and demand), the future is unclear. Should farmed production continue to displace wild salmon in the market place, an ever larger percentage of hatchery surpluses will be harvested by aquaculture managers in order to cover production costs. This will result in diminished returns to shareholders and at best as self-supporting semi-public bureaucracy.

Chaos

The underlying assumption of Maximum Sustained Yield management, (a stable environmental parameter) may not be applicable to wild stock fisheries. If this is the case, the derivative policies of Limited Entry and Individual quotas, will also prove non-functional. By focusing upon escapement requirements (X), managers ignore the far more important consideration of environmental constraints (R). In terms of Hardin's model, bio-managers are culling the cattle while ignoring the pasture and water requirements of their charges.

Managers of industrial resources are not exempt from political pressures. The history of the Alaskan and Canadian salmon industry underscores this fact. When the old instruments of near corporate monopoly (traps, exclusive areas, fishing license assignment) gave way to the reforms of limited entry, they were welcomed as steps towards a more equitable distribution of benefits. The twenty years which have followed the introduction of these policies have witnessed an ongoing transfer of both Canadian and Alaskan salmon from the independent small boat (gillnet) sector, to the corporate dominated industrial sector of purse seining (Gilbertsen 1990).

In terms of rational response, a many pockets strategy would seem preferable to policies which result in concentrations of production. Diversification, however, cannot be encouraged by a management agency dedicated to corporate profits as a measure of its own success.

Alternatives

> ....there is no technical solution to the problem (Hardin 1977:17).

Alaska's native peoples adopted a cultural mechanism to deal with the uncertainties of maritime existence. The potlatch served a redistributional function, which allowed temporarily prosperous groups to acquire status and prestige through competitive generosity. Since the group receiving the gifts was obligated to eventually respond or to suffer extreme loss of face, the ceremony can be regarded as an investment designed to offset the instability of fisheries. This would appear to incorporate elements of both insurance and a 'many pockets' strategy. By ameliorating the peaks and valleys inherent in the chaotic systems of local salmon returns, the potlatch provided a measure of economic stability to the region. Unlike 'technical solutions' that objectify nature and attempt the imposition of control, it was a social solution based upon human adaptation.

Northwest Coast culture did not impose the wrenching dichotomy of humanity isolated from nature. While Pinkerton, Knutson and others describe indigenous fishery management techniques as deliberately 'conservationist,' this may be an imposition of modern management conceptions (Knutson 1989; Pinkerton 1989). In point of fact, Haida, Tlingit, Tsimptsian and other Northwest Coast tribes did not 'manage' nature, but accepted their position as an integral part thereof. Salmon, which provided the chief economic basis for NW culture, would only return so long as the people did not offend the spirits governing them.

In accepting their role as an integral part of an interwoven natural system, and by designing social institutions that provided a means of redistributing aperiodic acquisitions of wealth, Northwest Coast society engineered a successful predator-prey relationship. This was not only 'wasteful' to European eyes, but constituted a heretical threat to a Western philosophy based on the 'rational' principles of individual greed, and environmental control.

The potlatch was outlawed by European settlers convinced of the superiority of their own productive and distributional models. Native culture, impacted by disease and displacement, suffered a collapse of confidence. The salmon and their habitat, which had provided an economic base for a thousand years, were 'offended,' as the trees, minerals and fish themselves were redefined as 'property.'

Conclusion

> A man must have chaos within him to be able to give birth to a dancing star (Nietzsche in Schuman 1991:141).

It may be that 'rational' solutions do not obtain in a chaotic universe, but rather that wisdom lies in insecurity. In adopting the non-management philosophy of indigenous fishers, we must also accept our role as interactive agents; responsible not only to ourselves, but to the other creatures and spirits that interact with us.

'The case of perpetual wide fluctuations above and below zero,' would seem to be the norm in a healthy biosphere. Such fluctuations of energy input are stored by species whose reproductive strategies accommodate aperiodicity. While each link on the food chain tends to dampen amplitude, the assumption of a steady state natural universe is a dangerous folly.

A philosophic bias which assumes such order and predictability, generates demands for manipulation. When a culture discards its strategy of cooperative predation, and assumes the role of manager, it simplifies and reduces the storage capacity of the system.

Salmon would seem to represent an aperiodic interface between the maritime and terrestrial energy systems. As such, they are an indicator species which reflect the functioning of both. When the storage capacity of forests and watersheds are reduced, they cannot utilize the oceanic nutrients which salmon carry. Since the energy stored in the terrestrial system is reduced, salmon populations must decline and in so doing carry fewer calories back to the maritime system.

What Hardin describes is indeed a tragedy, but not for the reasons he asserts. The growth or disappearance of a single species is of little consequence to a dynamic universe. Perhaps the great extinction which industrial society is currently inflicting upon the planet is of similar unimportance. The 'tragedy' lies only in the fact that we as a choreographic species have forgotten how to dance with stars.

Note

1. This article is a revised version of a paper delivered at the International Arctic Social Science Association First International Congress of Arctic Social Science, Université Laval, Ste-Foy, Quebec, Canada, 1992.

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