
The Long-Term Outlook for Salmon Returns to Alaska

Milo D. Adkison and Bruce P. Finney

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ABSTRACT: With the exception of some western Alaska stocks, Alaska's salmon populations are numerically healthy. However, even fisheries on abundant stocks are suffering economically due to sharp declines in the value of the catch. The abundance of Alaskan salmon stocks has fluctuated greatly, both in modern times and prehistorically. These fluctuations are thought to be caused by multi-decadal changes in environmental conditions over large areas that affect many other species as well as salmon. Forecasts of salmon returns are not very reliable, and the potential for significant improvement in their accuracy is low in the short term. A viable fishing industry must be able to adapt to dramatic, persistent, and unanticipated changes in harvest levels. Nonetheless, Alaska's salmon stocks should continue to produce healthy harvests for the foreseeable future, barring significant damage to their habitat either via local activities or global warming.

CURRENT STATUS

Alaskan salmon returns are generally strong, with recent average statewide catches higher than in most previous decades (Figure 1). The major exception to the general pattern of healthy Pacific salmon *Oncorhynchus* spp. stocks is in western Alaska. This region's runs have been dismal for almost a decade, often dropping so low that no commercial fishing is permitted (Figure 2) and even subsistence fisheries are restricted. Nonetheless, in most regions of the state the perception that salmon runs are failing is not true (Baker et al. 1996; Halupka et al. 2000; Van Alen 2000).

Dramatic decreases in the prices paid for salmon due to the development of a large farmed salmon industry plus a weak Japanese economy have resulted in a steep drop in the value of catches (Figure 3) and severe hardship in most of the state's fisheries. In some areas, this decrease in prices is exacerbated by a reduction from recent record harvests. For example, Bristol Bay's sockeye salmon *O. nerka* runs have fallen from

their peak levels in recent decades of sometimes more than 60 million fish to just 16 million in 2002 (Figure 4). This remains at about the average seen in the 1960s and early 1970s, when runs of up to 60 million every five years were interspersed with much lower runs (only 3.3 million in 1973). The largest share of the reduction is the failure of the Kvichak River drainage, formerly the region's largest producer, to contribute appreciable runs during 6 of the last 7 years. Spawners in this system have not even been replacing themselves, in contrast to those in other drainages, including the adjacent Naknek River.

Most other regions in Alaska are suffering economically despite having biologically healthy stocks of the commercially important species. One example is the pink salmon *O. gorbuscha* fishery in Southeast Alaska. A near-record harvest in 1989 was followed by record-breaking harvests in 1991, 1996, and 1999, while the 2001 harvest was the second largest ever seen (Figure 5). Nonetheless, the value of the catch has been declining despite the increase in the number of fish caught (Figure 5).

Authors: MILO ADKISON is with the Juneau Center, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, 11120 Glacier Highway, Juneau, Alaska 99801. Email: Milo.Adkison@uaf.edu. BRUCE FINNEY is with the Institute of Marine Science, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, P.O. Box 757220, Fairbanks, Alaska 99801.

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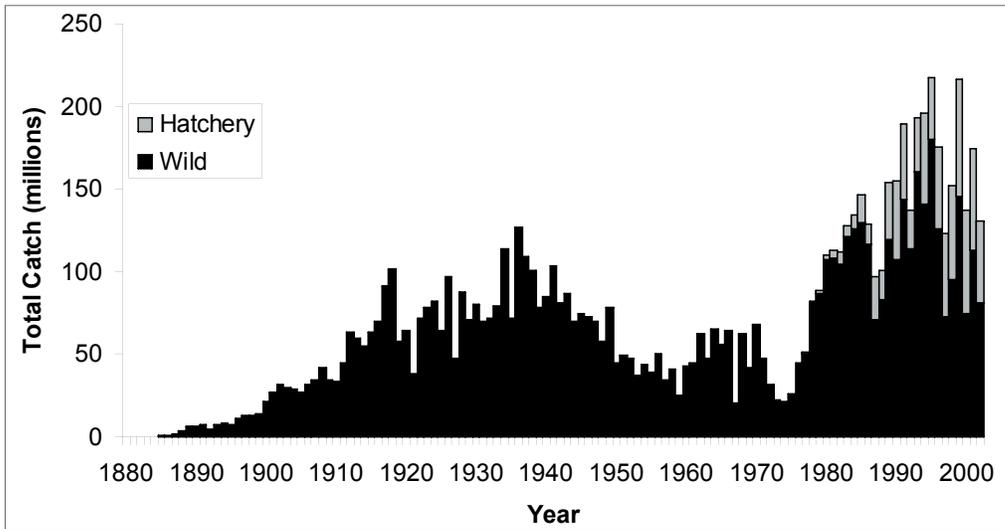


Figure 1. Catch of Alaska salmon, all species, in millions of fish, 1880–2002.

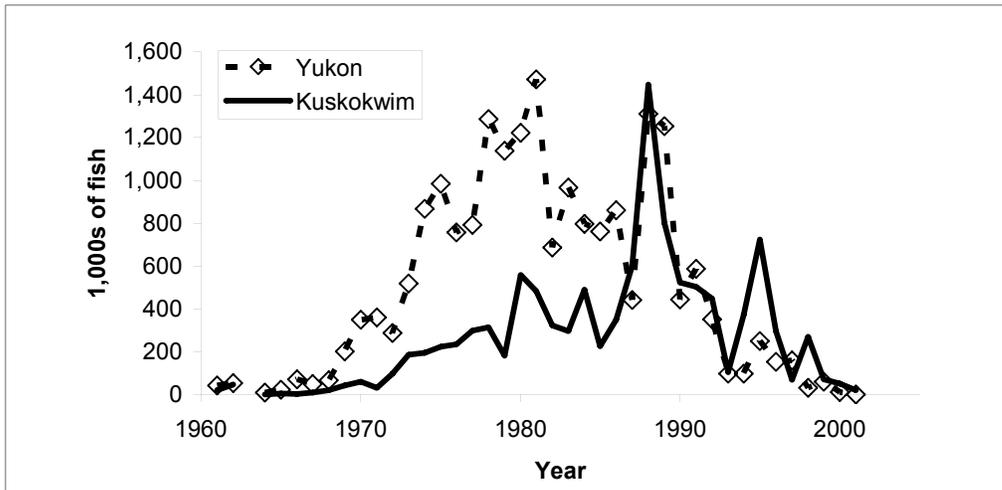


Figure 2. Catch of chum salmon from the Yukon and Kuskokwim Rivers in western Alaska, 1960–2002.

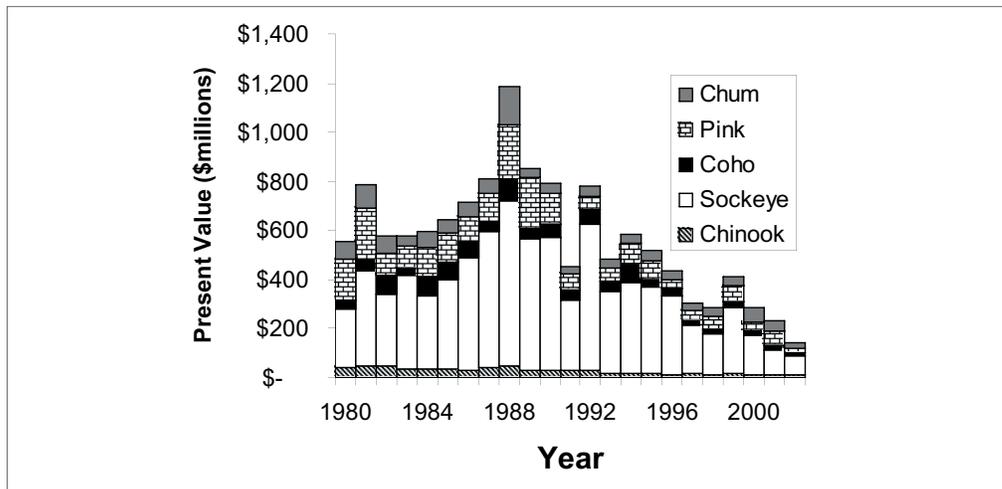


Figure 3. Value of Alaska's salmon harvests in present (2002) dollars, 1980–2002.

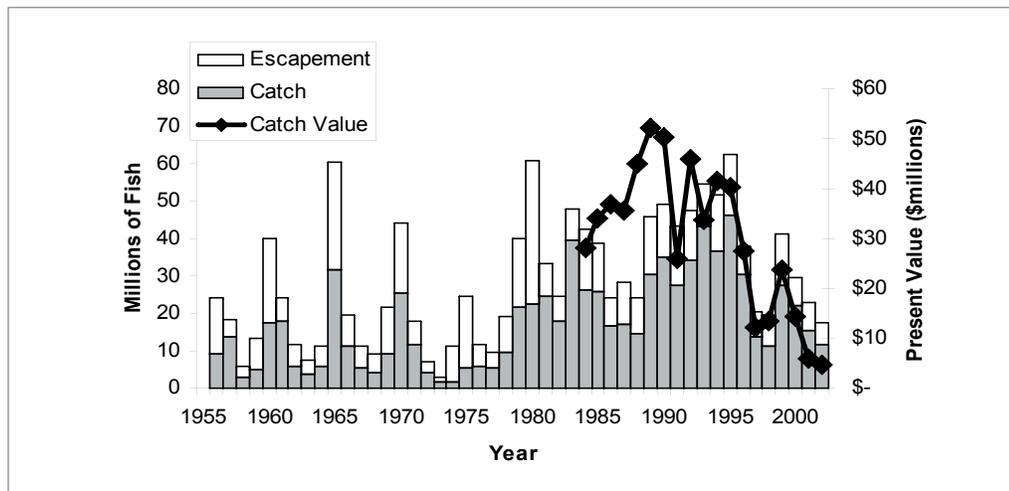


Figure 4. Escapement and catch of sockeye salmon in Bristol Bay Alaska, 1955–2002, and landed value of this catch in present dollars (2002), 1984–2002.

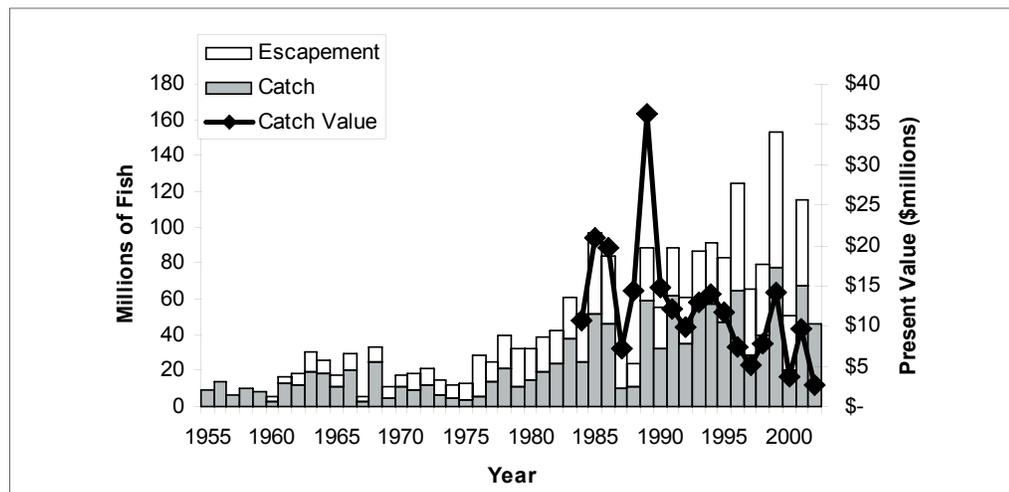


Figure 5. Escapement and catch of pink salmon in Southeast Alaska, 1955–2002, and landed value of this catch in present dollars (2002), 1984–2002.

RECENT FLUCTUATIONS AND THEIR CAUSES

Alaskan salmon catches have been recorded since before the turn of the century (Byerly et al. 1999); total abundance estimates for select stocks dates back to the middle of the century. Both types of data show pronounced fluctuations in abundance (Figure 1, Figure 4). Current thinking is that following the institution of strong conservation-oriented management in the 1950s (Cooley 1963), the major determinant of stock fluctuations has been environmental conditions (Van Alen 2000), although some stocks were affected by high seas interceptions into the 1970s (Eggers et al. 1983). Catch reductions in the first half of this cen-

tury are often attributed to overfishing (Cooley 1963; Royce 1989), although environmental fluctuations are also thought to have contributed (Hare et al. 1995; Mantua et al 1997).

Some regions have seen increased catches due to the addition of hatchery programs (Smoker et al. 2000), especially chum salmon *O. keta* in Southeast Alaska and pink salmon in Prince William Sound [see Hilborn and Eggers (2000, 2001) and Wertheimer et al. (2001) for a discussion of alternative interpretations]. Official estimates place the number of adult salmon produced at between 50 and 70 million during the last 5 years (Farrington 2002). In 2002, 23% of the commercial harvest was salmon of hatchery origin (Farrington 2002).

The environment has had a major effect on Alaskan salmon production in the last half of the century. Persistent environmental fluctuations, or *regime shifts* (Francis and Hare 1994; Steele 1996; Beamish et al. 1999), affected a variety of North Pacific fish species (Hollowed and Wooster 1992; Clark et al. 1999) as well as other taxa (Brodeur and Ware 1992; Anderson and Piatt 1999), and had a pronounced effect on Alaskan salmon. A regime shift in 1977 affected salmon stocks throughout Alaska (Beamish and Bouillon 1993; Hare and Francis 1995; Adkison et al. 1996; Downton and Miller 1998), while a 1989 shift has principally affected Western Alaska and British Columbia stocks (Brodeur et al. 1999b; Beamish et al. 1999; Hare and Mantua 2000). The 1977 shift manifested itself as a tendency for a more intense and easterly position of the wintertime Aleutian low-pressure system (Trenberth and Hurrell 1994; Miller et al. 1994; Polovina et al. 1994). Associated phenomena included more frequent winter storms, warmer coastal waters, and possibly increased upwelling and primary productivity (Francis et al. 1998; Brodeur et al. 1999a). Studies suggest that large scale shifts in ocean/atmosphere conditions over the North Pacific result in changes that are favorable for Alaskan sockeye, pink, coho, and chum salmon, and poor for Pacific Northwest chinook *O. tshawytscha* and coho salmon *O. kisutch*, and vice versa [*inverse production regimes* (Hare et al. 1999)].

Recent work suggests that the view of productivity fluctuations on a statewide level may be too simplistic. Peterman et al. (1998) showed that Bristol Bay sockeye salmon stocks had synchronous fluctuations in productivity, but the temporal pattern didn't extend to other Alaskan sockeye stocks. Pyper et al. (2001) showed that concordant fluctuations in pink salmon productivity occurred on a scale of less than 430 km, and were not as strong on larger spatial scales. Myers et al. (1997) found similarly restricted spatial scales of concordance in recruitment in an examination of a larger set of salmon stocks (and other fish species as well). Pyper et al. (2001) attributed previous findings of Gulf of Alaska-wide concordance in salmon production to the use of catch data, which can be increased both by higher escapements as well as higher survival. Higher escapement goals for many Alaskan stocks confound the effects of management with environmental influences (Van Alen 2000). Nonetheless, the synchronous and dramatic changes in abundance of many other marine species besides Pacific salmon (Brodeur and Ware 1992; Hollowed and Wooster 1992; Beamish 1993; Quinn et al. 1995; Anderson and Piatt 1999; Clark et al. 1999) is strong evidence for the validity of the regime concept.

Several lines of evidence suggest that marine conditions are important in regulating these changes in salmon abundance. Synchronous regional changes in abundance of multiple salmon species and other marine organisms, and similar temporal patterns in salmon species with short freshwater rearing times (e.g., pink salmon) and longer freshwater residence (e.g., sockeye salmon), point to controls in the marine environment. The early ocean stage is considered to be a time of high salmon mortality (Groot and Margolis 1991), and thus spring to early summer conditions in coastal regions may be a key link between climatic change and salmon abundance (Pyper et al. 2001). Most hypotheses consider food (e.g., Cooney 1993) or predation (e.g., Willette 2001) to be more important than purely physical conditions such as direct effects due to temperature. There is, however, very little observational data to directly assess how factors such as coastal zooplankton abundance and productivity (e.g., Brodeur et al. 1999a) are related to salmon mortality or abundance.

PREHISTORIC PATTERNS

Recently, methods have been developed to infer past levels of salmon from sediment core analysis (Finney 1998; Schmidt et al. 1998; Finney et al. 2000). These methods have been applied to sockeye salmon systems, because lake sediments are suitable for these paleolimnological methods, and the natural history of sockeye salmon generally requires lake habitat. Standard methods are used to obtain and date sediment cores. Past salmon abundance is reconstructed from $\delta^{15}\text{N}$ analysis, based on the observation that salmon deliver significant quantities of nutrients, including nitrogen, to fresh waters when they return to spawn and die. Because salmon carcasses are enriched in $\delta^{15}\text{N}$ relative to other nitrogen sources, $\delta^{15}\text{N}$ is a proxy for past levels of salmon-derived nutrients and hence abundance. These long-term estimates of salmon abundance reflect escapement for times since the development of commercial fisheries, and total adult runs prior to this time.

The paleo-records provide new insight into salmon population dynamics, because they reveal variability over time scales much longer than provided by historical records, for a period not complicated by significant human impacts (Figure 6). The similar patterns in reconstructed trends for a given region provide strong evidence that large-scale climatic changes are a persistent factor controlling salmon population variability (Finney et al. 2000, 2002). This variability occurs over

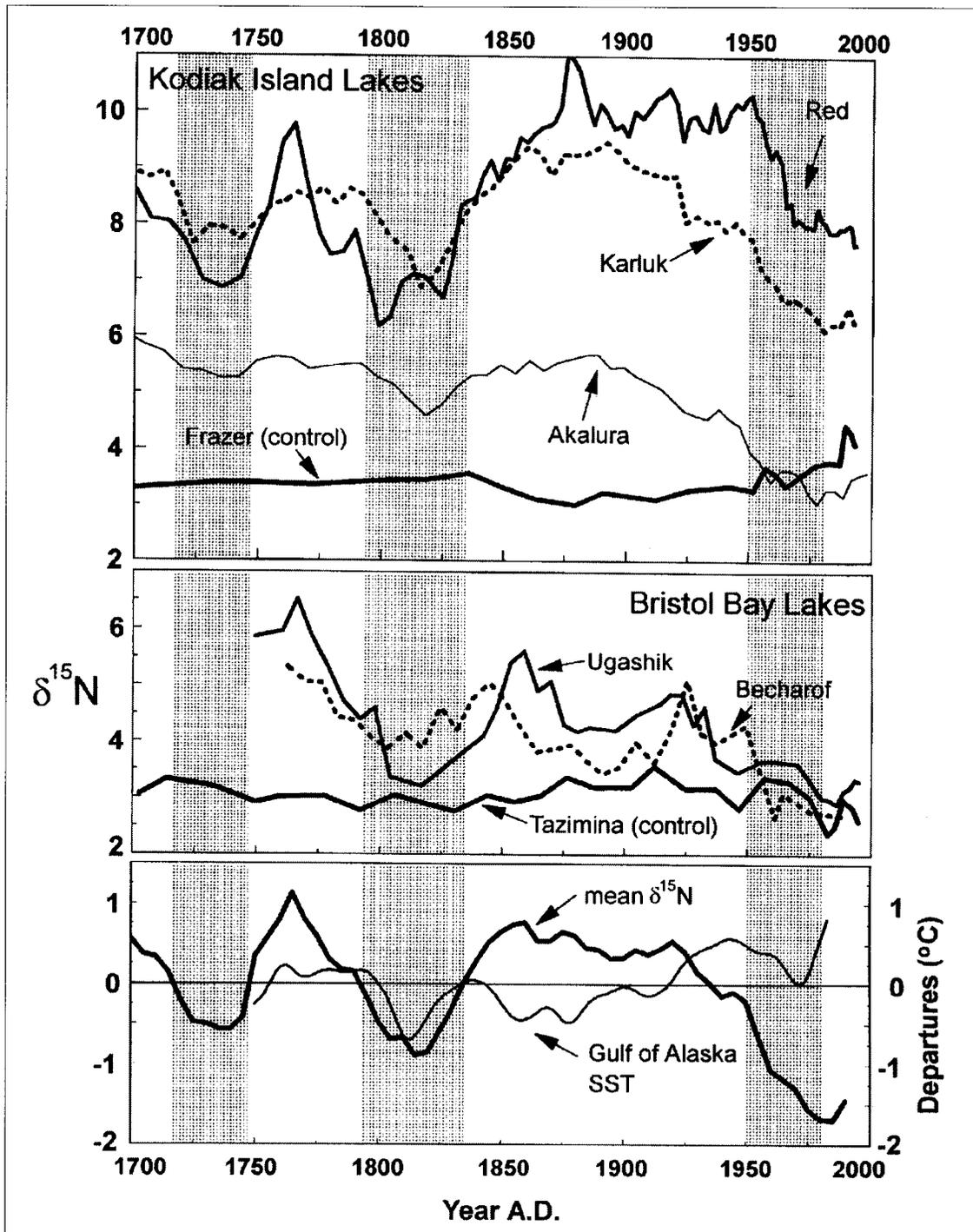


Figure 6. Sedimentary $\delta^{15}N$ profiles from lakes on (a) Kodiak Island, and (b) Bristol Bay, Alaska. Increases in $\delta^{15}N$, which has a higher ratio in salmon relative to the level in a lake's baseline source, indicate an increase in sockeye salmon carcasses. Panel (c) compares a composite $\delta^{15}N$ time series to Gulf of Alaska sea surface temperature anomalies. Reprinted with permission from Finney, B. P., Gregory-Eaves, I., Sweetman, J., Douglas, M. S. V. and Smol, J. 2000. Impacts of Climatic Change and Fishing on Pacific Salmon Abundance Over the Past 300 Years. *Science* 290:795–799. Copyright 2000 American Association for the Advancement of Science.

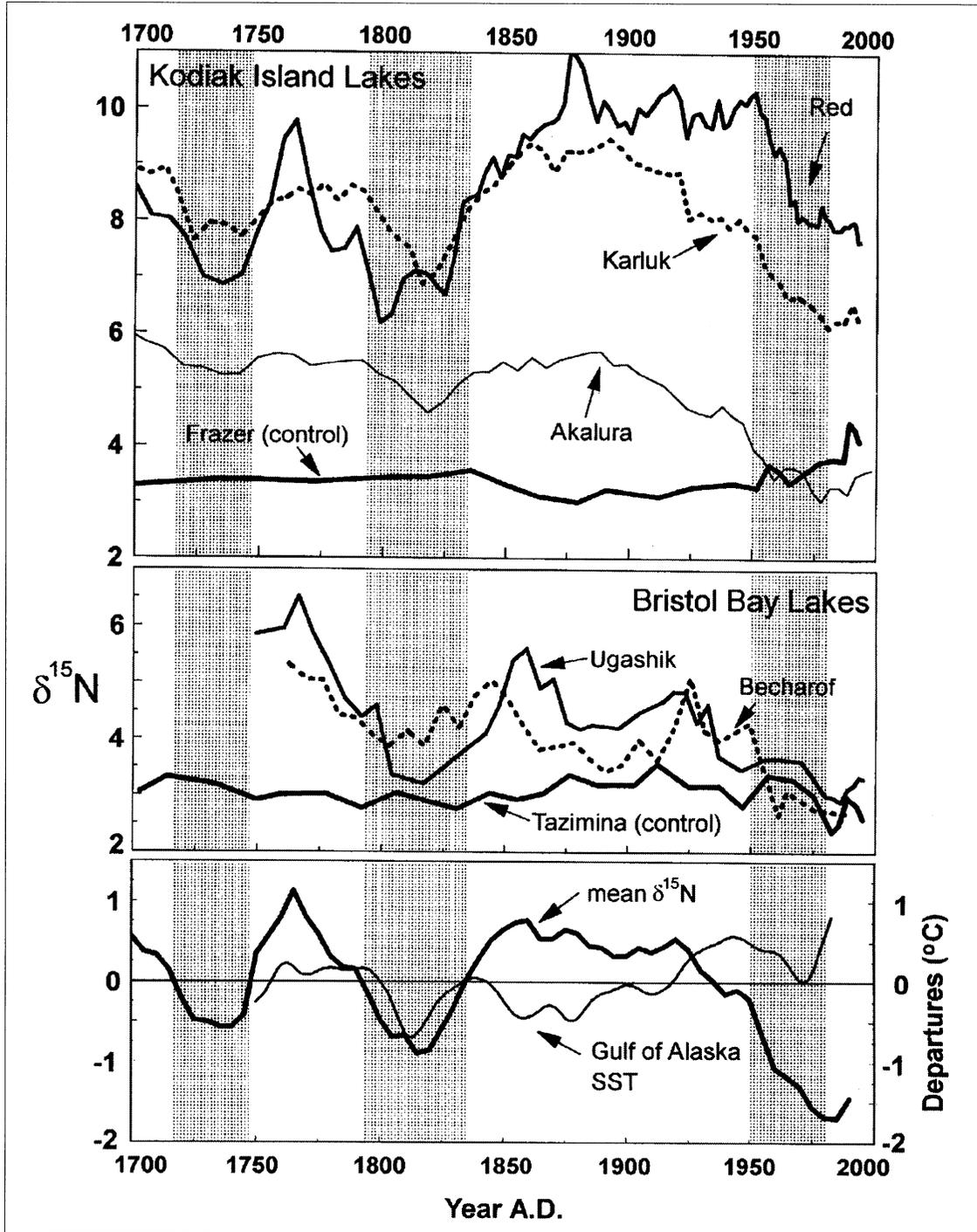


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a range of time scales. There is evidence for regimes lasting on the order of several decades—similar to historical records—as well as regimes lasting for several centuries (Finney et al. 2002). Interestingly, these long-term records do not suggest a regular cyclicality. A subtle difference in trends between Bristol Bay and Kodiak Island systems for the interval between the late 1800s and the early 1900s (Finney et al. 2000) coincides with a period of climatic change where North Pacific temperature patterns are different than those observed in the 20th century (i.e., a non Pacific Interdecadal Oscillation state; Finney 1998; Gedalof and Smith 2001). This indicates that some North Pacific climate states may result in responses by salmon stocks that vary regionally within Alaska. While the timing of changes in these long-term records generally coincides with times of change in paleoclimatic records, the relationships are complex. Historically, Alaska salmon are generally more abundant during periods of warm climate. This pattern is sometimes, but not always, followed in the sedimentary records. This suggests that conditions experienced since written records have been kept are not representative of the full range of states of the North Pacific.

Paleoecological data from freshwater sockeye salmon lakes demonstrates the potential importance of nutrients derived from salmon carcasses to freshwater ecosystems, which has implications for management and long-term sustainability. In systems where salmon-derived nutrients are a significant proportion of annual nutrient loadings, there are strong positive correlations between escapement, lake nutrient level, primary productivity, and zooplankton productivity (Finney et al. 2000; Gregory-Eaves et al. 2003). Thus, lake carrying capacity for juvenile sockeye salmon is not constant, and there may be a positive feedback between salmon-derived nutrients and carrying capacity. However, in lakes less dependent on salmon-derived nutrients, lake carrying capacity may not be sensitive to escapement (Finney et al. 2000). Similarly, it has become increasingly recognized through contemporary studies that salmon-derived nutrients may be an important component of salmon habitat in riverine systems, and thus have the potential to influence the productivity of all salmon species (Bilby et al. 1996; Cederholm et al. 1999; Naiman et al. 2002; Wipfli et al. 1998). The importance of salmon-derived nutrients needs to be assessed for individual systems, but may be difficult to determine from short-term data on altered or depressed systems.

PERFORMANCE OF FORECASTS

Forecasts of salmon runs are important planning tools for processors, fishermen, and managers. Unfortunately, forecasts are often unreliable. Forecast models are generally based on a stock-recruitment relationship, usually the Ricker function (Fried and Yuen 1987). These models are modified by including various sorts of auxiliary information. Smolt counts are used where available, although these data are expensive and thus rarely collected. Where sibling returns (returns of a portion of a cohort the previous year) are available this information is also used. Environmental indices may be used to adjust expected survival rates up or down (Rogers 1988; Hofmeister 1994), and sometimes indices of fish condition such as juvenile size or growth rate (Courtney 1997; Adkison 2002) are used as well. These methods all rely on the semi-mechanistic assumptions that the number of parents determines the initial number of offspring, but that survival of these offspring is affected by changes in environmental conditions. However, the mechanisms affecting survival are rarely specified; rather, an empirical relationship is estimated from salmon production data.

Purely empirical time series models are commonly used for forecasting in systems where the mechanisms are poorly understood (Wei and Reilly 1990). The potential of this statistical methodology for salmon stocks has been explored by several researchers (Farley and Murphy 1997; Quinn and Marshall 1989; Noakes and Welch 1990). Most of these authors have used time series methods to forecast only one year into the future. Klyashtorin (2001) used time series models to make forecasts for several fish stocks, including Pacific salmon, up to 60 years into the future. These forecasts depend on the existence of strong and regular cycles of fixed period (as opposed to fluctuations that endure for long but irregular periods) in salmon abundance, driven by environmental conditions that are themselves cyclic. However, we find the evidence for fixed-period cycles in salmon unconvincing.

Adkison and Peterman (1999) attempted to forecast Bristol Bay sockeye salmon runs a more modest 1 to 4 years into the future using models with time series components. Unfortunately, the accuracy of these forecasts was low. Worse yet, the most recent forecasts appeared to be biased upwards. This suggests that even the detailed records for the best-studied stocks may be insufficient for constructing reliable empirical models. The 30 to 40 years of data available may not span environmental conditions similar enough to the current state so that future runs can be predicted from past behavior.

When the uncertainty of salmon forecasts is examined, the results are discouraging. Noakes and Welch (1990) used a cross-validation approach to compare the performance of several models for forecasting Fraser River, British Columbia sockeye salmon returns. They found that even the best models averaged a 35% error. Adkison and Peterman (1999) examined the performance of forecasts of Bristol Bay sockeye salmon stocks. They presented their results somewhat differently, as 80% confidence intervals, but the outcome was similarly poor. Runs ranging from ½ to 2 times the forecast were quite likely. Bayesian forecasts of salmon runs give similar uncertainty estimates; Adkison (2002) gave 80% credible intervals for Southeast Alaska pink salmon runs that spanned almost a three-fold range, and hind-casting showed that this wide range correctly reflected the uncertainty.

Recent publications (Hare and Mantua 2000; Taylor et al. 2002) suggest that synchronous shifts in the biota of an ecosystem are a much more reliable indicator of a climate shift than are the climatic or oceanographic variables themselves. It is possible that monitoring several biotic components of the marine ecosystem could improve our ability to detect ecosystem shifts affecting salmon productivity soon after they occur. At-sea direct measurements of salmon abundance and growth might improve forecasts even more, particularly if coupled with good stock identification techniques (Hilborn et al. 1999; Adkison 2002). However, the logistics of such a program would be daunting. Nearshore studies of juvenile growth and survival (Orsi et al. 2000; Willette et al. 2001) are potentially a cheaper alternative. As a better understanding evolves regarding the mechanisms controlling relationships between environmental change and salmon abundance, monitoring programs can be designed to measure key variables that may help with forecasts, such as determining zooplankton biomass at key localities and times.

FUTURE ALASKA SALMON RETURNS

With the exception of some marked examples of overfishing early in this century, fluctuations in the production of Alaskan salmon appear to be primarily climate driven. The effects of climate operate on spatial scales that range from a few hundred miles to as large as the entire Gulf of Alaska. These effects operate at many time scales: strong year-to-year fluctuations affect most stocks, major decadal-scale changes in production have strongly affected recent runs, and the

historical record indicates that century-scale highs and lows can also occur.

Such fluctuations can be expected to repeat in the future. Being able to predict average salmon harvests for the next decade could be very valuable to harvesters, processors, managers, and rural communities, who often incur great economic losses when returns fail to meet expectations. However, we are not yet able to predict when a major change in climate-ocean conditions or salmon productivity will occur. Forecasting next year's salmon run is difficult enough. Reliable forecasts of salmon runs far into the future would require a better understanding of the specifics of the effects of the meteorological, oceanographic, and biotic components of the ecosystem on salmon survival, plus the ability to forecast future trends in these critical ecosystem components.

Even detecting that a shift to a new productive regime has occurred is difficult. The normal large variability in salmon runs from one year to the next masks longer-term shifts in average production, or causes erroneous speculation that a shift is occurring. The mid 1970s shift in the Gulf of Alaska ecosystem wasn't widely appreciated for at least a decade. An apparent 1989 shift in conditions affecting the Bering Sea and British Columbia is still somewhat subject to dispute (Hare and Mantua 2000). In the last 15 years, we have seen numerous dates proposed as the beginning of a major shift in salmon production; so far, the bulk of these warnings of collapse in Alaska's salmon runs have failed to materialize. Future shifts in salmon production are inevitable, but we must expect that these changes will be unexpected. However, it is important to distinguish between climate induced and human induced causes during low productivity phases, and to not use climate as a scapegoat, because negative human impacts can be corrected.

The health of Alaska's salmon runs depends on maintaining its conservation oriented management policy (Royce 1989). A widely-accepted goal of meeting escapement objectives coupled with intensive in-season management has helped to maintain the health of salmon stocks for decades, even through dramatic declines in abundance such as occurred in the early 1970s. Nonetheless, there are some threats that are beyond the purview of the Alaska Department of Fish and Game.

The first major long-term threat to Alaskan salmon populations is global climate change. A scientific consensus has emerged that global warming is occurring and human activity is a major cause (IPCC 2001). The effects of global warming on specific regions are difficult to forecast with any certainty, but many

models suggest that northern latitudes will experience significant temperature increases (IPCC 2001). Despite this uncertainty, it is likely that within the next century Alaskan salmon will experience environmental conditions unique relative to the previous century. Ocean circulation has been dramatically altered during past warming regimes, sometimes quite suddenly (Broecker and Denton 1990; Dansgaard et al. 1993; Taylor 1999; Ganapolski and Rohmstorf 2001). While beneficial effects are possible, changes in ocean temperatures or circulation would probably detrimentally affect Alaska's salmon populations (Welch et al. 1995; Ingraham et al. 1998). There is perhaps little Alaskans can do to forestall global warming other than to press for changes in policy and try not to contribute to the problem.

The second long-term threat is within the power of Alaskans to prevent. The major cause of the loss and degradation of salmon populations elsewhere is the destruction of their habitat (Nasaka 1988; Lichatowich 1999; Langer et al. 2000). When rivers are dammed or re-channeled, when lakes are polluted or become eutrophic, when logging roads or agricultural activities erode sediment into streams, when the riparian zone is paved over, then salmon inevitably disappear. In many cases, salmon populations have been destroyed slowly, with a thousand small but cumulatively significant insults to their habitat. Alaska has many statutory protections for salmon streams (Holmes and Burkett 1996), but a major reason our stocks are generally so healthy is the low density of humans near productive watersheds. Preserving our salmon will take constant vigilance, and the resolve to not allow habitat destruction for short-term economic benefits.

Pacific salmon have evolved and survived during a period of dramatic climatic and environmental variability over the last ca. 7 million years. This great potential for adaptability is due in large part to the high genetic biodiversity of salmon. Fish managed as a single stock often are actually an aggregate of locally adapted populations (Blair et al. 1993; Gharrett and Smoker 1993; Woody et al. 2000), and thus excessive harvest of any component can reduce future production (Royce 1989). Management practices such as spreading catch throughout the period of salmon returns reduce the risks of overfishing distinct substocks within a system. Monitoring all such stock components is difficult. Nonetheless, maintaining biodiversity will be key to the continued health of Alaska's salmon.

Other possible threats to the future of Alaska salmon include factors such as new diseases (Tompkins and Wilson 1998), invasions from other species that use or affect salmon habitats [e.g., Atlantic Salmon

(ADF&G 2002)], and contaminants. It is difficult to predict or assess the severity of future impacts from factors such as diseases and invading species. Generally, contaminant levels in adult salmon are low (Ewald et al. 1998), though the magnitude of salmon runs suggests a possible contaminant vector to freshwater ecosystems. Ewald et al. (1998) found that levels of organic pollutants were higher in a sockeye salmon nursery lake than a nearby lake that salmon could not access, and suggested that the difference could be explained by biotransport contaminants of oceanic origin by adult salmon. More obvious sources of contaminants include motor vehicles, mining, and urban runoff. Few systematic studies have been done to assess contaminant levels and their possible effects in Alaska salmon ecosystems (but see Heintz et al. 1999; Wertheimer et al. 2000; Krümmel et al. 2003).

Regional and statewide changes in salmon production, both positive and negative, are inevitable. The viability of Alaska's salmon fisheries depends on how we react to these changes. The salmon industry developed in the face of large year-to-year fluctuations in harvests, and processors and harvesters have developed methods of coping with this type of variability. Fluctuations that persist for a decade or more are more difficult to prepare for, and have usually resulted in economic hardship. The decline in fish value has exacerbated the effects of below-average runs of some stocks, and has even disrupted fisheries with abundant runs. Alaska's salmon fisheries urgently need some new approaches.

Government institutions that develop and implement fisheries management schemes must ensure that these do not hinder the ability of the fishing industry to accommodate themselves to future changes in salmon abundance and value. Regulations, statute, and even the Alaska constitution prescribe in detail how salmon will be harvested. The number of fishermen, the length of vessels, and the gear employed are regulated in great detail. These regulations were in large part the result of a policy of maximizing rural employment. In the current environment of cheap and abundant farmed salmon, the economic inefficiency resulting from the large number of harvesters, vessels and gear unsuitable for other uses, and excessive investments in fishing power as a result of "the race for fish" is insupportable. While rural employment should be protected to the extent possible, harvesting costs must decrease if the fishery is to remain viable. Various groups, such as the Bristol Bay Economic Development Corporation (Link et al. 2003) and the Alaska State Legislature, have been studying ways to achieve this. Part of any solution must be to minimize restrictions on harvest methodolo-

gies to allow the fishing industry to develop methods of harvesting that suit the economic climate.

Harvest regulations must be designed to provide an incentive for the fishing industry to harvest in an economically efficient manner. The current strategy of letting fishermen compete for the available fish rewards those who invest large sums in harvesting power such as large fast vessels and large crews, and penalizes those who take the time to ensure their catch is kept in good condition. An alternative, one version of which has been tried in Chignik (Knapp et al. 2002), is to allocate a fixed amount of fish to each fisherman. This changes the economic incentives, rewarding harvesting fish as cheaply as possible and carefully handling each fish to generate as much value as possible.

The Chignik experiment consists of allocating a proportion of the catch to a cooperative of fishermen. These fishermen have harvested their joint quota using only a fraction of the vessels and crew they formerly used, realizing substantial cost reductions. Economically, this experiment has been successful. Unfortunately, this model results in non-participating parties owning a transferable quota of fish. This could lead to a substantial flight of the economic benefits of fisheries away from rural communities and even out of state.

Alaska's salmon harvest levels are set based on the sustainable salmon fisheries policy (Mundy 1998) that emphasizes maximum sustained yield. Managers adjust fishing periods to obtain escapement goals and ensure that the surplus is harvested. Economic considerations coupled with fluctuations in abundance may require different management strategies. In years of high abundance, markets may not be able to absorb all

of the available fish, particularly for low value species such as pink salmon. Managers should be prepared for periodic overescapement. While there are indications that in some systems large escapements can reduce future production (e.g., Kyle et al. 1988), there are many other reasons to think overescapement is generally not a serious problem.

The fishing industry may desire to minimize costs by harvesting in a short period, or harvest in a small area that either has high quality fish or is adjacent to processing facilities. Alternatively, the industry might want to increase quality with a protracted season so that harvests never exceed the capacity of plants to ensure a quality product. Successful management will have to balance these economic considerations against the conservation costs of differential harvest of substocks that these sorts of fisheries entail.

Although Alaska regulates hatchery siting and operations to minimize the effects of hatcheries on wild stocks (Ulmer 2000), some detrimental effects undoubtedly occur. Hatcheries provide significant economic benefits to regional fisheries, but may through competition reduce benefits received by fishermen in other parts of the state. Hatchery production levels need continuous review and oversight to ensure their benefits are commensurate with their costs.

The fish will come and go. While these natural fluctuations are inevitable and, for the short term at least, unpredictable, the outlook for the biological health of Alaska's salmon stocks is good. Our present crisis is largely economic, and requires economically-oriented solutions. However, any successful solutions must necessarily take into account the inconstant nature of our salmon resources.

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