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The Application of Farm Programs to Commercial Fisheries: The Case of Crop Insurance for the Bristol Bay Commercial Salmon Fisheries

Joshua A. Greenberg, Mark Herrmann, Hans Geier, and Charles Hamel

Under the direction of the Agricultural Risk Protection Act of 2000, the U.S. Congress proposed a crop insurance program for the Bristol Bay, Alaska, commercial salmon fishery. This study examines the feasibility of extending crop insurance to this commercial fishery. The specific focus of this analysis is on differences between this commercial capture fishery and agricultural enterprises in the context of property rights and producer control. Findings show that differences between this commercial fishery and agricultural enterprises would require substantial modifications to existing crop insurance programs. Furthermore, it is recommended that the consideration of extending crop insurance be delayed until this fishery is rationalized.

Key Words: Bristol Bay, commercial fisheries, crop insurance, farm programs, property rights, risk management, salmon

In light of recent poor fishing seasons in western Alaska from 1997 through 1999, and at the request of the U.S. Congress, the Risk Management Agency (RMA) of the U.S. Department of Agriculture (USDA) has proposed a pilot risk insurance program for wild salmon in Alaska. This request occurred through the enactment of the Agricultural Risk Protection Act of 2000, which directed the USDA's Risk Management Agency to develop and implement a pilot risk management program for the Bristol Bay commercial salmon fishery. This was the first time a USDA crop insurance program had been considered for a capture fishery.

Joshua A. Greenberg is associate professor, Department of Resources Management; Mark Herrmann is professor, Department of Economics; Hans Geier is research associate, Department of Resources Management; and Charles Hamel is research associate, Department of Economics, all at the University of Alaska, Fairbanks.

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The extension of a federal agricultural program to a commercial fishery may appear appropriate given similarities between the two industries.[1] Both fishing and farming represent natural resource based industries where resource productivity is affected not only by the choices of producers but also by numerous biophysical factors that are largely exogenous to producers. However, there are critical differences between these natural resource industries which need to be considered in an application of farm programs to commercial fisheries. For example, commercial fisheries often occur in complex ecosystems where factors affecting fishery productivity are not well documented or understood and are difficult to anticipate in advance. Also, unlike farmers who are able to increase area-wide farm production through employment of new technologies and prudent farming practices, fishermen in regulated, open-access commercial fisheries compete for a fixed harvest quota set by fishery managers in accordance with the overriding goal of stock protection. While coordinated efforts of the agriculture industry and technological advances can increase the overall production of farming, "in regulated, open-access fisheries, operators take control by adopting technology which facilitates winning the 'chase for fish' ..." (Anderson, 2002, p. 140). Accordingly, increased effort at the individual level does not affect industry-wide gains in production for capture fisheries.

This study focuses on the proposed extension of crop insurance programs to the Bristol Bay commercial sockeye salmon fishery by examining its structure and focusing on key characteristics that distinguish operations in this commercial fishery from those occurring in an agricultural setting. We examine the extent to which these differences can be accommodated in a proposed commercial fishery risk insurance program. Specifically, the concepts of producer control and property rights are utilized to examine three key elements of federal crop insurance—the definitions of peril, adverse selection, and moral hazard—in evaluating the feasibility of this farm program to the Bristol Bay commercial salmon fishery.

It should be noted that despite being directed by the Agricultural Risk Protection Act of 2000 to develop and implement a pilot risk management program for the Bristol Bay commercial salmon fishery, the RMA declined to introduce the program, and the Bristol Bay risk insurance program never proceeded beyond the initial feasibility study. This decision to abort the program prior to program design and implementation occurred despite considerable Congressional support and a federal appropriation which would have funded the pilot program. (The findings reported here may provide some clarification for the reasoning behind this decision.)

Industry Background

The Bristol Bay fishery occurs in the southeast portion of the Bering Sea, an area located in southwestern Alaska (figure 1). There are five large, geographically remote and dispersed fishing districts. The two principal staging areas for the fishery are the towns of Dillingham and Naknek, located over 300 miles from Anchorage, Alaska.

[1] Commercial fishery refers here to wild capture fishery, and is distinct from aquaculture enterprises.

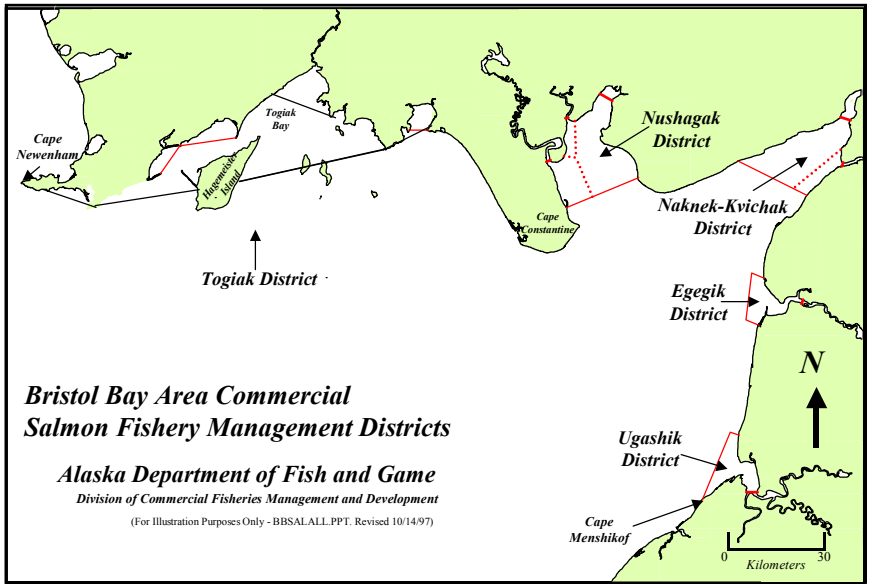

Figure 1. The five fishing districts of the Bristol Bay commercial salmon fishery

Most of the Bristol Bay commercial salmon fishing occurs in the months of June and July. Fishery harvest principally occurs in a two- to three-week period between the third week of June and mid-July. In the Bristol Bay fishery, unlike most other Alaska salmon fisheries, there is a single dominant species, sockeye.[2]

Bristol Bay is home to the largest sockeye salmon fishery in the world. For many years, the Bristol Bay sockeye fishery was also lucrative for its participants. In the late 1980s and early 1990s, during the height of the fishery, gross exvessel earnings exceeded $200 million. Prices paid to the fishermen (exvessel prices) peaked at $1.86/pound. This is in stark contrast to recent fishery performance, where landings, prices, and permit values have been in a steep decline. The 2001 and 2002 exvessel prices of $0.40/pound and $0.43/pound are the lowest since limited entry despite very weak runs. The estimated gross values of the 2001 and 2002 seasons were only $34 and $29 million, respectively [Alaska Commercial Fisheries Entry Commission (CFEC), 2003a, b]. The 2001 season was so poor that for the first time in history, a significant number of the Bristol Bay permit holders did not fish. Even fewer fishers participated in 2002. Industry consensus is that there is no price relief forthcoming in the near future.

The State of Alaska manages salmon fisheries under a limited-entry system, requiring harvesters to obtain region-specific permits for the areas in which they wish to

[2] Since 1990, the Bristol Bay sockeye salmon harvest comprised over 95.4% of total Bristol Bay salmon harvest by weight and 98.5% by value (Herrmann et al., 2004).

participate. While the permits convey a participation right and therefore limit the total number of participants, they do not allocate harvest, either by number, weight, or percentage, among permit holders as in the case of other fisheries managed under individual transferable quota programs (ITQs—such as the Alaska halibut and sablefish fisheries where percentage of total allowable quotas is allocated by a market mechanism).

There are two permit types in Bristol Bay, those that permit harvest by drift gill net and those that permit harvest by set gill net. The permits are transferable with certain restrictions, and an active market in Bristol Bay salmon permits has developed. Until 2001, the total number of permits for both segments of the fishery (drift net and set net) had been fairly constant throughout the years. However, permit prices have been highly variable, and severely depressed in recent years due to the poor economic performance of the fishery. For example, the drift gill net permit price peaked at $249,000 in 1989, but reached an all time low of just over $19,000 in 2002 (Alaska CFEC, 2003a; see figure 2).

Recent average gross revenues would have been even lower had many permit holders decided not to fish. The 2001 and 2002 seasons were the first since the advent of limited entry when many permit holders did not participate in the fishery. In 2002, only 63% of the Bristol Bay drift net salmon permit holders fished their permits (65% of set net permits), a record low level in the 24-year history of the limited-entry fishery [Alaska Department of Fish and Game (ADF&G), 2003; Alaska CFEC, 2003a]. The simultaneous occurrences of low landings and low exvessel price, as shown in figure 3, has led to back-to-back disaster declarations in western Alaska by the State of Alaska.

Today's Bristol Bay (and Alaska) salmon economic problems are extensive and not likely to improve anytime soon (Herrmann, 2002). Alaska sockeye exvessel prices are now largely unresponsive to harvest volume because of the domination of world salmon markets from farmed salmon production. With the dominance of farmed salmon well entrenched, increases in sockeye exvessel prices should not be expected to mitigate revenue decreases from poor landings.

The two Bristol Bay permit groups, drift net and set net, form two distinct harvesting sectors. Drift netters, in general, are able to fish in any of Bristol Bay's five districts. They will frequently change districts in-season, seeking the best fishing opportunities. In contrast, set net harvesters are tied to a specific geographic site both intra- and inter-seasonally. Set netters typically lease sites from the State that specify the geographic boundaries within which they have exclusive fishing rights. Set nets are set from shore, and captured fish are retrieved using small skiffs. Typical drift net operations are significantly more productive than typical set net operations, and the drift net fleet has historically accounted for 80%–90% of the bay-wide catch. Given its prominence, the drift net harvesting sector will be the focus of this analysis.[3]

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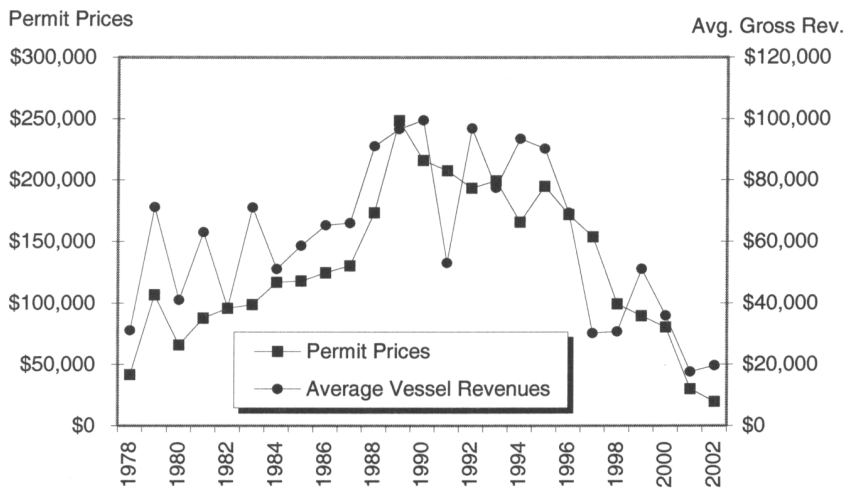
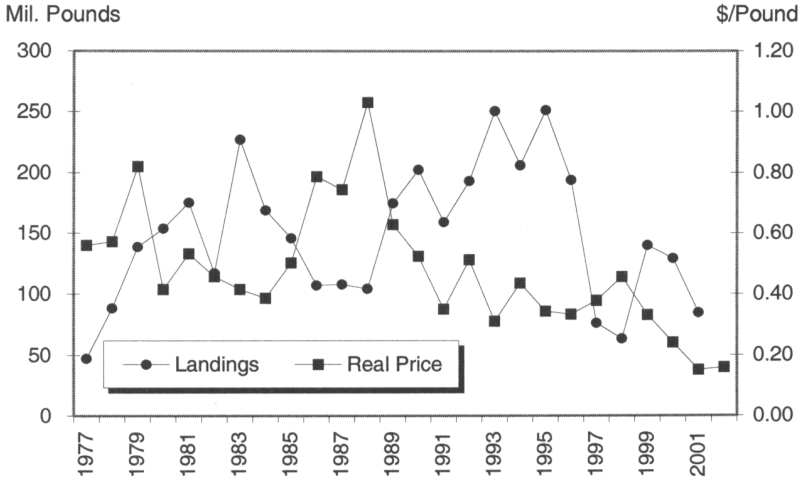
[3] For an application of risk insurance to the set gill net sector, the interested reader is referred to Greenberg et al. (2001).



Source: Alaska Commercial Fisheries Entry Commission, 2003a.

Figure 2. Bristol Bay drift net nominal permit prices and nominal average gross revenues, 1978–2002



Sources: Alaska Department of Fish and Game, 2003; Alaska Commercial Fisheries Entry Commission, 2003a.

Note: Real prices are based on the U.S. Consumer Price Index for food and are nominal in 1977.

Figure 3. Bristol Bay real exvessel price and landings, 1977–2002

The management goal for the Alaska salmon fisheries is to allow a proportion of a given salmon run to escape capture that is consistent with achieving the desired sustainable yield. Any salmon in excess of the desired escapement goal is then allocated to the commercial, sports, subsistence, and personal use fisheries. To achieve the escapement goal, Bristol Bay managers limit the amount of time the fishery is open. Fishery openers for as little as six hours may be staggered throughout the week, as sockeye runs first arrive in Bristol Bay. As salmon escapement moves closer to the desired target, fishery openers may be lengthened. Fishery managers also utilize various input controls to limit fleet fishing power. Among the most notable controls are a 32-foot size limit on vessel length, and limits on net length and mesh size. Also, harvesting methods other than drift and set nets are banned from the commercial fishery.

Drift net harvesters have responded to the regulatory requirements and extreme conditions of Bristol Bay by developing a highly specialized fleet of fishing boats. Harvesters have compensated for the 32-foot vessel size restriction, potentially limiting fish hold capacity, by building unusually wide vessels or cutting away the bow of their existing vessel. These modifications compromise vessel speed and maneuverability. Bristol Bay vessels are also built with shallow drafts. This design feature accommodates the area's severe tidal fluctuations which frequently require boats to fish in shallow waters. The reduced stability of Bristol Bay salmon vessels makes them unsuitable for open-sea travel beyond Bristol Bay. Accordingly, vessels are dry-docked in the boatyards of Naknek and Dillingham during the off-season (some harvesters also participate in Bristol Bay herring fisheries).

The purchase and maintenance costs of a competitive Bristol Bay salmon boat dwarf drift net vessels in other Alaska salmon fisheries, making these among the most expensive commercial fishing craft for their size. There is a high variation in vessel costs, reflecting differences in hull type, engine type, gear, electronics, and hydraulics. A top-of-the-line fully outfitted aluminum vessel may cost well in excess of $150,000. Alternatively, a lower performing fully outfitted vessel can be purchased for under $40,000.

Agriculture versus Commercial Fisheries

Under the auspices of the Agricultural Risk Protection Act of 2002, the U.S. Congress requested that crop insurance be extended to the Bristol Bay commercial salmon fishery. If adopted, it would have represented the first extension of USDA agricultural support programs to a commercial fishery. Crop insurance has become one of the principal federal programs for U.S. agricultural producers. The USDA's Risk Management Agency in 1999 provided crop insurance for over 100 crops, with 1.85 million policies for crops valued at $31 billion and covering 194 million acres. In 2003, the program was projected to provide $38 billion in risk protection for approximately 208 million acres representing more than 100 crops, or 80% of the nation's planted acres for principal crops (Davidson, 2003; USDA/RMA, 2003).

As noted earlier, the concept of applying agricultural programs to commercial fisheries may appear to be a natural extension of federal assistance. Both agriculture and commercial fisheries are primary industries. Producers in both industries are subject to high risks associated with production vulnerabilities from environmental conditions and biophysical parameters that are beyond the control of the producers. Accordingly, enterprises in both agricultural and fishery settings can experience wide earning fluctuations caused, in part, by production variability that is exogenous to the producer. Finally, production failures from natural events in both settings commonly affect producers throughout entire geographic regions, rather than being restricted to a specific firm(s).

Nevertheless, there are important differences between agricultural and commercial fishery settings that serve to distinguish these two natural resource based industries. In comparing commercial fisheries and aquaculture enterprises, Asche and Tveteras (2002) and Anderson (2002) provide a useful framework for examining these differences which can be extended to our analysis of risk insurance programs in Bristol Bay. Anderson points to property rights as the mechanism conferring varying degrees of control on what, where, when, and how much is produced. As property rights increase, the degree of control increases. Anderson notes there is not a clear distinction between aquaculture and wild fisheries with respect to property rights, but rather, the difference exists in accordance with the amount of control held by individuals, groups, communities, and cooperatives over the fishery. While aquaculture ventures, similar to other agricultural enterprises, commonly have considerable control over production, market development, costs, innovations, and investment, some capture fisheries have developed an institutional framework that has led to some degree of property rights. Capture fisheries with a higher degree of property rights (though still lower than most aquaculture ventures) include those organized under individual transferable quotas and cooperatives. Salmon ranching fisheries including cost-recovery hatcheries have a higher degree of property rights than those fisheries with no production control.

In contrast, relatively weak property rights and lack of producer control over production characterize Alaska's salmon fisheries. Weak producer control is evident in the fishery's performance in an index constructed by Anderson (2002) in which aquaculture and capture fisheries are positioned on opposite ends of a spectrum. The index is composed of the following five factors: (*a*) dependence on wild fish stock for brood stock or juveniles, (*b*) degree of dependence on wild fish stock for feed, (*c*) degree of confinement, (*d*) degree of control of the environment/habitat, and (*e*) degree of harvest and market management. The Bristol Bay sockeye run size is determined by factors exogenous to producers. The fish stocks are completely dependent on wild feed sources exogenous to producers. The fishery resource is unconfined throughout its life cycle. There is very little control over the sockeye's environment. Finally, harvesters have almost no control over the timing of harvest and sale of raw product.

As noted above, federal crop insurance to date has been available only in agricultural settings, including limited applications to aquaculture where producers have

considerable control over production as conveyed by the opportunities for strong property rights. However, the characteristics of the Alaska salmon fisheries have particular implication relative to several of the conditions of insurability which may interfere with the application of crop insurance in this commercial fishery setting. As reported by Rejda (2001), the conditions for risk to be insurable are: (*a*) there must be numerous exposure units, (*b*) the loss is accidental and unintentional, (*c*) the loss must be determinable and measurable, (*d*) the loss should not be catastrophic, (*e*) the chance of loss must be calculable, and (*f*) the premium must be economically feasible. In the remainder of this paper, we apply the concepts of property rights and producer control to evaluate the insurability of risk in the Bristol Bay salmon fishery through three key elements of federal crop insurance—the definitions of peril, adverse selection, and moral hazard.

Peril

A starting point for our discussion is the concept of peril. Peril is defined here as an event or element that introduces risk into the production process. The types of insured perils for agriculture vary by crop insurance program, but commonly include the following:

> (a) adverse weather conditions; (b) fire; (c) insects, but exclusive of damages due to improper/inadequate pest control measures; (d) plant disease, but not damage due to improper/inadequate plant care measures; (e) wildlife; (f) earthquake; (g) volcanic eruption, or (h) failure of the irrigation water supply if due to an unavoidable cause of loss occurring within the insurance period [Frerichs, 2001, online].

As revealed by an examination of the above list, peril has been defined as a specific set of unanticipated/unavoidable events which affect some outcome, such as low yields. This definition of peril acknowledges that despite considerable producer control over production, there are events beyond the producer's control which will occur periodically and lead to production failures (often affecting all producers in a region). In this definition of peril, it is assumed these events outside of producers' control can be readily distinguished from those events producers could avoid if "best farming practices" are followed. The set of "best farming practices," as specified in crop insurance programs, represents agreements between producers and insurers with respect to specific production practices a prudent farmer would follow.

This approach to defining peril must be altered in the case of the Bristol Bay commercial salmon fishery due to producers having weak production control. In the case of this fishery (and many commercial fisheries), it is difficult (or perhaps impossible) to determine the contribution of various natural factors and harvester-induced factors to both fishery-wide and harvester-specific performance. Numerous natural events may influence run strength at various temporal points from when salmon hatch, through their migration, and when they return to Bristol Bay three to four years later. Insufficient information is available to assign specific impacts to

these various factors. Furthermore, the salmon population is not confined, and is unobserved except upon its return to Bristol Bay.

It is even more problematic to link the behaviors of individual fishermen to fishing performance. Similar practices among individual farmers in a given county would be expected to yield similar rates of productivity, ceteris paribus. Furthermore, changes in productivity of one agricultural producer do not affect the productivity of other agricultural producers. However, in Bristol Bay, the zero-sum nature of commercial fishing results in an added element of divisibility in production and a further weakening of producer control: each fish of the total allowable catch harvested by fisherman *A* is one less fish available for capture by fishermen *B* and *C*. Here, even if we were to assume homogeneity in capital and skill levels, a disproportionate distribution of productivity among individual fishers would still be expected, favoring those who happen to reach the fish first. The open-access nature of the resource and the absence of nonattenuated property rights lead to a direct interdependency between fishermen performance that would not otherwise be present.

When other sources of variability, such as skill level, are added to the natural variability inherent in the race for fish, it is easier to understand the variability in fishing performance that exists across drift net fishermen in Bristol Bay (table 1). For example, in 1999, the mean harvest for the drift net fleet was 61,000 pounds, with a standard deviation in excess of 26,000 pounds and coefficient of variation (standard deviation divided by the mean) of 44%. Historically (between 1980 and 1999), the coefficient of variation ranged between 40% and 80%, with a mean of 54%. The heavy reliance on a biological determined fish run contrasts with the typical agricultural scenario in which a guideline set of prudent and enforceable farming practices is expected to result in more similar yields across individual farmers, holding all other variables constant.

In addition to the problematic nature of determining the cause of an individual harvest failure, the insurance of an outcome rather than an event has other important implications in the design of a commercial fishery risk insurance program. In typical agriculture crop insurance programs, occurrences of the defined perils are largely independent events across time. For example, a flood in county x in year y is likely not to change the probability of hail in county x in year $y+1$. However, salmon run sizes across time are not independent events, but rather biological outcomes that are linked together by common biological responses to shared phenomena or events. For instance, a water temperature event (a change in water temperature from the norm) may affect siblings within a cohort that return in different years and/or affect sockeye populations across several cohorts.

From the perspective of a risk insurance program, the key issue is whether this correlation can be exploited by the potential insurance purchasers (the producers) to successfully determine whether the upcoming season's fishery performance will be above or below historical fishery performance (harvest in the case of a production-based program and revenue in a revenue-based program), and hence whether there is a good chance an insurable event will occur. Fishermen may form an expectation of the upcoming season's performance based on their knowledge of recent

Table 1. Summary Statistics for Bristol Bay Drift Net Landings

Year[a]	Total Landing (lbs.)	Average Vessel Landings (lbs.)	Median Vessel Landings (lbs.)	Standard Deviation of Vessel Landings (lbs.)	Coefficient of Variation for Vessel Landings (%)
1980	132,998,302	74,844	69,862	41,765	56%
1981	148,570,193	82,769	76,649	43,568	53%
1982	101,319,801	56,446	44,072	44,065	78%
1983	203,045,585	112,678	108,193	53,353	47%
1984	150,277,450	83,072	78,986	44,323	53%
1985	131,460,701	68,900	61,433	44,959	65%
1986	91,578,350	49,798	47,935	28,060	56%
1988	87,989,905	47,614	42,249	23,720	50%
1989	149,107,543	79,865	75,867	34,050	43%
1990	175,491,384	93,446	88,829	40,358	43%
1991	136,433,355	72,111	63,658	39,857	55%
1992	167,624,605	88,597	78,581	47,146	53%
1993	218,385,808	116,101	109,841	51,283	44%
1994	180,890,003	95,658	90,972	44,851	47%
1995	218,591,747	111,356	104,564	53,768	48%
1996	166,867,213	88,057	83,056	35,538	40%
1997	62,776,331	33,338	30,166	26,634	80%
1998	51,133,668	27,418	25,663	18,517	68%
1999	113,887,423	61,131	57,980	26,619	44%
Average	141,496,282	75,958	70,450	39,075	54%

Source: Alaska Commercial Fisheries Entry Commission, 2003b.

[a] No statistics are provided for 1987 because the individual catch data were considered unreliable for this year.

fishery history or on forecasts derived from more complex fishery modeling such as those provided by the Alaska Department of Fish and Game (ADF&G) and the Fishery Research Institute, University of Washington (FRI-UW). If potential insurance purchasers, such as fishermen, have a good ability to predict the relative strength of the upcoming season vis-à-vis historical fishery performance, then it should be expected they would commonly adopt a strategy of purchasing insurance only in those years considered likely to qualify as disasters. This point is discussed in greater detail in the context of adverse selection, below.

Adverse Selection (*Against the Insurance Provider*)

Adverse selection generally exists when the insured party has better knowledge of the relative risk of a particular situation than does the insurance provider. The relevance of this issue to a Bristol Bay risk insurance program was raised in the prior section where peril, due to weak producer control over total fishery output and individual harvests, was defined as an outcome—fishery harvest. Since fishery harvest

is dependent on run strength, which may be correlated and predictable over time, fishermen may be able to successfully anticipate when an insurable event will occur. In our case then, adverse selection refers to the potential ability of fishermen to "outguess the insurance policy," i.e., adopt a strategy of purchasing insurance only when there is a good chance of insurance payout. This strategy would severely compromise the ability to implement an actuarially sound insurance program. Under these circumstances, participation in the insurance program would be expected to be low in those years when it is unlikely an insurable event would occur, and high when poor seasons are probable. Consequently, the insurance provider would be faced with the daunting challenge of developing a program whereby receipts in nondisaster years are sufficient to offset payouts from years in which insurable events do occur.

Fishermen may base their expectation of future harvest on factors such as their own past harvest history or readily available preseason forecasts of run size and harvest levels from ADF&G and FRI-UW. Both the ADF&G and FRI-UW preseason forecasts have been highly errant in the past, and the errors appear to have a strong unsystematic component. This is not unexpected, given the limited understanding of salmon population dynamics and the numerous potential influences on run strength for which data are unavailable or incomplete. For example, between 1990 and 2001, the percentage deviation between actual run size and the ADF&G and FRI-UW forecasts ranged from !106% to +56%, and from !135% to +43%, respectively (table 2). Despite the inaccuracies, fishermen and processors utilize these forecasts as planning tools in making large capital investment decisions.

Although forecasts are highly errant, this does not diminish their potential role for aiding fishermen in "outguessing the insurance." A more important consideration within the context of risk insurance is whether a fisherman can predict if harvest (or revenue) levels will be better or worse than normal for the upcoming season. Typically, in crop insurance programs, expected production is defined as an average of historic production. The time periods included in this calculation vary across programs, and various types of averages are employed. Expected production, however it is defined, serves as the benchmark to which current year performance is compared in the determination of whether an insurable event is triggered. Accordingly, with respect to a risk insurance program, it is not important to harvesters that they be able to predict the absolute value of the upcoming season's harvest (or revenue). Rather, it is sufficient to simply predict whether production in the upcoming season will be greater or less than the expected level adjusted by the chosen coverage level, as defined in the insurance program. This is a much less rigorous requirement of the fishery forecast than predicting the absolute value of next season's production. These predictions become the relevant concern to harvesters, particularly if they have chosen a 100% coverage level.

Similar analyses could be calculated to provide measures of the forecasts' success for various coverage levels. Table 3 presents a comparison of the success of the ADF&G and FRI-UW forecasts as well as a naïve forecast in predicting whether harvest will exceed expected harvest. The naïve forecast represents the upcoming season's harvest as equal to that of the previous season. This latter forecast is included

Table 2. ADF&G and FRI-UW Forecasts of Harvestable Bristol Bay Sockeye and Actual Run Size, 1985–2001 (million fish)

		ADF&G Forecasts			FRI-UW Forecasts		
Year	Actual Run Size (mil. fish)	ADF&G Forecast Run Size (mil. fish)	Deviation: Actual Less Projected (mil. fish)	Actual Deviation (%)	FRI-UW Forecast Run Size (mil. fish)	Deviation: Actual Less Projected (mil. fish)	Actual Deviation (%)
1985	23.7	20.3	!3.4	!14.3%	—	—	—
1986	15.8	13.3	!2.5	!15.8%	—	—	—
1987	16.1	9.3	!6.8	!42.2%	12.4	!3.7	!12.0%
1988	14.0	16.8	2.8	20.0%	20.8	6.8	48.6%
1989	28.7	16.2	!12.5	!43.6%	25.4	!3.3	!11.5%
1990	33.5	14.7	!18.8	!56.1%	19.0	!14.5	!43.3%
1991	25.8	21.2	!4.6	!17.8%	25.0	!0.8	!3.1%
1992	31.9	26.3	!5.6	!17.6%	22.0	!9.9	!31.0%
1993	40.5	32.0	!8.5	!21.0%	31.9	!8.6	!21.2%
1994	35.6	39.6	4.0	11.2%	34.1	!1.5	!4.2%
1995	44.4	40.3	!4.1	!9.2%	34.4	!10.0	!22.5%
1996	29.7	34.6	4.9	16.5%	33.4	3.7	12.5%
1997	12.2	24.8	12.6	103.3%	25.4	13.2	108.2%
1998	10.0	20.6	10.6	106.0%	23.5	13.5	135.0%
1999	26.1	13.8	!12.3	!47.1%	21.2	!4.9	!18.8%
2000	20.5	22.3	1.8	8.8%	24.4	3.9	19.0%
2001	14.0	15.6	1.6	11.4%	13.8	!0.2	!1.4%

Sources: Rogers et al., 1991; Rogers, Lew, and Hilborn, 2000.

Table 3. Percentage of Time the ADF&G, FRI-UW, and Naïve Forecasts Correctly Predicted Whether a Harvest Will Be Less Than or Greater Than the Expected Harvest, Based on 4-, 8-, and 12-Year Averages

Forecast	4-Year Simple Average	8-Year Simple Average	12-Year Simple Average
ADF&G	73%	73%	91%
FRI-UW	80%	80%	91%
Naïve [a]	73%	87%	91%

[a] Naïve forecasts for 4-year average harvest are for 1983–2001, for 8-year average harvest are for 1987–2001, and for 12-year average harvest are for 1991–2001.

because recent fishery performance provides another indicator to fishery participants of what to expect in the coming season. Three alternative expected harvests are examined in table 3, representing normal harvests defined as simple 4-, 8-, and 12-year averages of historic harvests.

Even if a forecast has no predictive power, it should, on average, correctly predict whether harvest would be above or below the calculated normal harvest approximately 50% of the time in repeated samples. Inspection of table 3 reveals that each

of the forecasts significantly exceeds this level of predictive power. The ADF&G, FRI-UW, and naïve forecasts successfully predict 91% of the time the relative position of next season's harvest in comparison to the 12-year average harvest. As would be expected, the predictive powers of the forecasts are diminished as the time period used in calculating normal harvest is shortened. Nevertheless, the forecasts continue to display significant predictive powers. The success rates in the case of an 8-year simple average are 73%, 80%, and 87% for the ADF&G, FRI-UW, and naïve forecasts, respectively. Similarly, in the case of a normal harvest based on a 4-year average, the success rates are 73% for the ADF&G and naïve forecasts and 80% for the FRI-UW forecast. A surprising outcome is that the naïve forecast performs comparably well to the ADF&G and FRI-UW forecasts in predicting whether harvest will exceed expected harvest.[4]

The potential problems in delivery of an insurance program caused by the availability of ADF&G and FRI-UW forecasts could be offset by requiring that the insurance purchase occur prior to the forecasts' public release dates. However, the predictive power of the naïve forecast is more problematic. This forecast (or some variant of the naïve forecast presented here) can easily be derived by fishery participants. Fishery participants are well aware of their collective performance history, and would be expected to apply this knowledge in forming their risk insurance purchasing strategy.

Moral Hazard

Moral hazard for agriculture is defined here as an action taken by producers to maximize joint returns from the insurance product and productive activities by limiting their production of the insured crop. There are numerous potential moral hazards in commercial fisheries. Principal concerns in evaluating moral hazards specifically revolve around (*a*) introducing incentives for harvesters to "fish" the insurance, and (*b*) creating major structural changes to the way the fishery operates.

It is common in the discussion of agricultural risk insurance programs to refer to the potential problem of farmers "farming" the insurance. In point (*a*) above, we adapt this term to the commercial fisheries. For either farmers or fishermen, this refers to the case where the producers can increase their return by organizing their activities toward maximizing joint returns from the insurance product and productive activities. One obvious application to the commercial fisheries would be a harvester who decreases fishing effort in anticipation of insurance payouts exceeding any decline in harvesting revenue. For example, in the case where an insurance trigger is based on an individual harvester's historic average performance, a harvester could restrict effort in order to trigger insurance payout. In the Bristol Bay salmon fishery, this could take the form of participating in fewer fishery openers or even limiting the number of crew employed or the use of other capital inputs. Given the size and scope

[4] We are not suggesting here that the naïve forecast is as useful as the ADF&G and FRI-UW forecasts. In contrast to these other two forecasts, a naïve forecast will never foresee turning points and is of little value in projecting the longer run outlook for the fishery.

of the commercial fishery, the setting in which the fishery occurs, and the wide divergence in vessels and vessel performance, it would be very difficult to develop an enforceable mechanism for identifying these types of practices as the cause of poor performance. Accordingly, in this setting, asymmetric information is a prominent feature whereby it would be difficult for the insurer to uncover all of the actions of the harvester, and only the harvester knows the actual motives for his or her fishing actions and whether any particular action is inconsistent with best fishery practices.

This discussion underscores two basic problems in applying crop insurance to commercial fisheries. As noted, it is virtually impossible to precisely identify the causes of weak fishery runs. The population dynamics of anadromous fish stocks are generally poorly understood. Furthermore, data on contributing factors are frequently lacking or incomplete. This greatly compromises the ability to accurately estimate the average frequency and severity of future fishery losses.

Second, unlike agriculture, it is difficult to conceive of a set of "best practices" that would be required of harvesters. This is a consequence of commercial fishing and agriculture occurring within very different institutional and competitive settings. In agriculture, a farmer applies productive inputs to land either owned or leased and has exclusive rights to all associated output. In contrast, regulated, open-access fisheries are prosecuted under a competitive, but zero-sum setting. Harvesters do not own fish until capture, and engage in an inefficient race against one another to catch the seasonal allocation. The suboptimal performance of derby-style fisheries is the primary impetus for rationalization efforts in fisheries management. There are numerous strategic decisions harvesters make in regulated open-access which are behaviorally related to an absence of nonattenuated property rights. They must try to anticipate the response of all other harvesters in planning their own harvesting strategy. They must also anticipate what the run size will be in various locations and at various times. For example, the determination of where and when to participate is going to depend on a harvester's assessment of run strengths at various locations and the number of other participating vessels. It may be reasonable for harvesters to opt out of participating in a given fishing period, or to choose one location to fish over another, even if in hindsight these decisions turn out to be incorrect. Furthermore, harvesters' actions are constrained by fishery managers who control where and when fishing will be allowed and which productive inputs may be employed. Given weak producer control over harvest and the absence of nonattenuated property rights, we are uncertain how an insurance provider would determine the true motivation for a particular action by a harvester and differentiate between those activities which, from an insurance standpoint, are considered legitimate, and those that are not.

The second moral hazard refers to the possibility that introduction of the crop insurance program will be detrimental to the industry. Introduction of a risk insurance program could encourage fishery participation by harvesters who otherwise would have remained idle for a given season. Such an outcome in the Bristol Bay commercial salmon fishery would not be in the joint interest of fishery participants, fishery

managers, or the State of Alaska. In fact, it is exactly the type of behavior that should be discouraged from the standpoint of economic efficiency. The Bristol Bay commercial salmon fishery, like so many other regulated open-access fisheries worldwide, suffers from overcapitalization with too many boats chasing too few fish. Historically, encouraging additional participation to the fishery would not have been of concern. A cap on the total number of fishery participants is set by the limited-entry system, and this cap was achieved year-in and year-out, through the 2000 season, as virtually every permit was fished (the sole exception was 1991, when fishermen engaged in a work stoppage to protest low price offers from processors). However, as noted earlier, in the 2001 and 2002 seasons, many permits in Bristol Bay were not fished due to the combination of low expected harvests and exvessel prices. This lower participation has a positive effect on efficiency by reducing overall fishing costs, thereby increasing the average catch and net revenue of the remaining fleet. This outcome helps offset the negative impacts of poor runs and/or prices to those fishermen who choose to participate in the fishery.

A risk insurance program could interfere with logical reductions in participation in years of low performance expectations. This is a consequence of fishery participation being required to be eligible for indemnity payments, particularly in years which are expected to qualify as a disaster. The incentive to participate would be further enhanced if permit holders believed that nonparticipation would be detrimental to their historic catch and/or revenue history which is used to calculate future indemnity.

Discussion

In the consideration of extending the USDA crop insurance program to a wild fishery, it is important to examine the significant differences between agriculture (including aquaculture) and a capture fishery, and the implications of these differences for the insurability of the risk. Perhaps the most important difference arises from the need to define the "peril" as an outcome, rather than an event. Given this definition of peril, all instances of low harvests or low revenues, no matter what the underlying reason, would become candidates for consideration as a disaster if the insurance guarantee were based on individual performances. An obvious incentive would be introduced for fishermen to attribute all harvest problems to an absence of fish or other insurable causes when it may just be the random variation inherent in the zero-sum nature of fishery landings. A commercial fishery equivalent to "best agricultural practices" is not apparent for this fishery, and we do not foresee how a loss adjuster could be employed at season's end to determine the causes of low catches and appropriately weight all possible contributing factors. In the absence of having an observer onboard all relevant vessels (a very expensive proposition), it would be difficult or impossible to appropriately separate out those claims that are legitimate from those not deserving indemnification.

Because of these reasons, an insurable event in the Bristol Bay sockeye fishery would have to be defined as a harvest failure on a group guarantee basis rather than an individual basis. In typical crop insurance programs, a group guarantee basis is

accompanied by a group indemnity basis. That is, the group's harvest (or revenues) is used to determine whether a disaster has occurred, and identical payouts to farmers (on an acre basis) are based on a group's "average farmer." For example, under a Group Risk Program (GRP), the guarantee and indemnity function is defined as:

$$(1) \qquad \begin{aligned} & y^g = \theta y^e = \theta y^{AGH}, \\ & I = \max\{0, (y^g - y^c)P^g\}, \end{aligned}$$

where y^g is the guaranteed yield that triggers the insurance, y^e is the expected yield, y^{AGH} is the average production history for a group of producers (such as a county in an agricultural setting), y^c is the group average yield, θ is the chosen coverage level, I is the indemnity payment, and P^g is the guaranteed price. The guaranteed yield is estimated based on past group yield histories (see Makki and Somwaru, 2001). In the case of the Bristol Bay salmon fishery, harvest would replace yield as the relevant production measure.

The above example may be appropriate in an agricultural setting where a guideline set of prudent and enforceable farming practices is expected to result in similar yields across individual farmers, holding all other variables constant, but it does not characterize the Bristol Bay fishery where judgment, skill, experience, capitalization, labor employment, and other factors contribute to extreme catch differentials even among harvesters with similar fishing opportunities. In commercial fishery settings, it is common for there to be a group of harvesters—referred to as highliners—who are consistently much more productive than the rest of the fleet. The catch variability among harvesters in Bristol Bay was previously reported in table 1, which provides the coefficient of variation of vessel landings. This variability is further documented in table 4, which shows that for the 1995–1999 period, both the most productive 5% and 10% of producers outperformed the fleet average by a ratio greater than 2:1. In contrast, the less productive producers significantly underperformed the fleet average. An insurance product such as GRP, with a group indemnity, has been cited as being unsuitable for producers whose production does not follow the group (county) yields (Edward, 2003; Stokes et al., 1999). A GRP type program may be unattractive to the more productive "highliners," while being very attractive to low-end producers. This outcome could severely compromise the ability to establish a successful insurance program.

Accordingly, characteristics of the fishery would require consideration of a hybrid risk insurance product that has a group guarantee basis and an individual indemnity basis. Specifically, while a disaster is based on the entire group's performance, payouts are based on a producer's past history. An example of one specification a hybrid program could take is presented below:

$$(2) \qquad \begin{aligned} & y^g = \theta y^e = \theta y^{AGH}, \\ & \delta = (y^g - y^c)/y^g, \\ & I = \max\{0, \delta(\theta y^{APH} - y^a)P^g\}, \end{aligned}$$

Table 4. Bristol Bay Salmon Fishery Drift Net Harvest Performance Measures for the Entire Fleet and for the Top 5%, Top 10%, and Lower 50% of the Fleet by Landings (by permit)

	No. of Permits				Average Landings				% of Total Landings		
Year	Top 5%	Top 10%	Lower 50%	Entire Fleet	Top 5%	Top 10%	Lower 50%	Entire Fleet	Top 5%	Top 10%	Lower 50%
1999	93	186	932	1,863	126,159	113,689	40,788	61,131	10%	19%	33%
1998	94	187	933	1,865	63,290	54,725	17,410	27,418	12%	20%	32%
1997	94	188	942	1,883	96,602	83,279	13,805	33,338	14%	25%	21%
1996	95	190	948	1,895	178,516	160,253	60,829	88,057	10%	18%	35%
1995	98	196	982	1,963	255,397	223,746	72,284	111,356	11%	20%	32%

Source: Alaska Commercial Fisheries Entry Commission, 2003b.

where δ is the payment calculation factor, y^{APH} is average production history for a producer, y^{a} is the actual producer's yield, and all other variables are as previously defined. In this case, an insurable disaster would be triggered only if the average group yield were below the group-based guaranteed yield. However, the indemnity payment would be based on both the percentage by which the group yield is under the guaranteed yield (the payment calculation factor, δ) and the difference between the individual producer's yield and the producer's average production history adjusted by the chosen coverage level. Payment to a producer would occur only if both the actual group yield falls below the average group production history adjusted by the coverage level and the actual producer's yield falls below the producer's average production history adjusted by the coverage level. [For a further discussion of this hybrid program, see Greenberg et al. (2001).]

An additional modification may be necessary for a risk insurance product in Bristol Bay to avoid the problem of adverse selection. Fishery harvests are dependent on run strength, which is a biological phenomenon. Therefore, run strength over time may be correlated, and to a certain extent predictable. As a result, fishermen may be able to successfully anticipate whether an insurable event will occur in the coming season, and thereby adopt a strategy of purchasing insurance only when insurable events are likely. This would severely compromise an insurer's ability to implement an actuarially sound risk insurance program. One possible remedy would be to create a multiple-year insurance product, whereby policyholders would agree to insure their operation for consecutive periods.

Even with these program modifications, however, the question of the appropriateness of risk insurance to this fishery remains. A major restructuring of the Alaska salmon industry appears to be imminent. This risk insurance discussion is unfolding against a backdrop of rationalization efforts in Alaska's salmon fisheries following successful management approaches to rationalize halibut, sablefish, and other groundfish, as well as similar ongoing efforts in the crab fisheries. As noted by Anderson (2002), a fishery co-op was formed for the Chignik, Alaska, salmon fishery (a small-

scale Alaska salmon fishery located off the Aleutian peninsula), providing producers with greater production control. Similar measures are likely to be adopted in other Alaska salmon fisheries over time. The objective of fishery rationalization is to rectify problems caused by regulated, open-access treatment of the fishery resource through respecification of property rights in a manner which provides greater producer control over where, when, and how much is produced, and the timing of harvest. A key feature of fishery rationalization is the reduction of competitive effort on the fishing grounds. An important consideration of the extension of a risk insurance program to a wild fishery such as the Bristol Bay area is whether the program would interfere with the exit of capital from this oversubscribed fishery, and thereby seriously harm fishery rationalization efforts. This concern alone casts serious doubt over the merits of such a program.

Following the rationalization of the Alaska salmon fisheries, salmon harvesters will have obtained a greater degree of property rights to fishery harvest and increased producer control. At this point, many of the existing significant obstacles of the crop insurance extension to the Bristol Bay, and other Alaska salmon fisheries, will have been mitigated—although other obstacles may arise.

For example, should the rationalization process in the Bristol Bay salmon fishery follow some form similar to that introduced in the Alaska halibut and sablefish fisheries, then harvesters would be able to acquire transferable harvest quota shares. Transferable quota shares represent a harvester right (privilege) to a certain percentage of total fishery harvest. The presence of transferable quota shares introduces into the fishery a productive unit which, for insurance purposes, is in many ways analogous to land in an agricultural setting. Harvesters, rather than being engaged in a race-for-fish, are able to employ labor and capital so as to minimize the cost of catching their assigned harvest share. Harvesters are able to adjust their production by buying and selling quota shares rather than through the more uncertain process of open competition on the fishing grounds.

The relevant production unit in the insurance setting would change from total producer harvest to yield per unit of quota share, which is similar to the measure of yield per acre found in agricultural crop insurance programs. The insurance product could guarantee the harvester some historical average yield per quota share (adjusted by coverage level), with the assumption that it is the responsibility of the harvesters to catch the share of the total fishery harvest determined by their total quota shares. This group-based average yield per quota share would be based on average production history (APH), which would also serve as the basis for determining indemnity payments. Since the insurance guarantee and indemnity are group based, it is no longer important for the insurer to know all the actions undertaken by individual harvesters, the motives for these actions, and whether these actions are consistent with best fishery practices. This greatly mitigates problems caused by asymmetric information, which were introduced in the discussion of moral hazard. A more traditional group-based risk insurance product could be employed in the fishery, such as a GRP program.

Consequently, it may be prudent after salmon rationalization has been implemented, and the fishery under these conditions has matured, to revisit the idea of insuring the Alaska salmon fishery. Nevertheless, even with these structural changes to fishery management, major challenges remain in developing a risk insurance product for the fishery. The assignment of property rights does not eliminate the potential for intertemporal adverse selection—although, as noted, this problem may be addressed by requiring insurance buyers to purchase a multi-year product. More importantly, the introduction of a property rights based management system into the fishery does not improve producer control over total fishery harvest. Total fishery harvest remains a function of total fishery run size, a biological event that is exogenous to producers. Accordingly, peril would continue to be defined as an outcome, i.e., low fishery harvest, rather than as a specific set of events.

The current array of risk management tools offered by the RMA relies upon basic actuarial information in order to provide actuarially sound resources and programs. In the case of the Bristol Bay commercial salmon fishery, acquiring this information would be problematic since the population dynamics of wild salmon are poorly understood. It is simply not possible to definitively identify the causes of periodic run failures. In order to be effective, "crop insurance" programs, as currently offered by the RMA, rely on probabilistic determination of the frequency and severity of loss. Given the aforementioned fishery feature, it would be hard to establish either of these factors to a degree of accuracy consistent with current RMA requirements.

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