# AFA Pollock Fishery Data Collection and Salmon Bycatch Quota Program Analysis

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## *1. Introduction*

Following the recommendation of Amendment 91 to the Bering Sea and Aleutian Islands Fishery Management Plan in April 2009, the North Pacific Fishery Management Council (Council) asked the Alaska Fisheries Science Center (AFSC) to propose "a data collection program for the pollock fleet that would provide the information necessary to evaluate the salmon bycatch program to ensure that it is meeting the Council's intent." This paper presents a discussion of the types of analyses that could be conducted to evaluate the salmon bycatch program and the data necessary to conduct them.

Amendment 91 would establish an upper limit (hard cap) of 60,000 Chinook salmon caught per year for the Bering Sea pollock fishery (beginning in 2011), with the additional requirement that Chinook bycatch be below 47,591 in all but 2 years in any 7-year period (the "Performance Standard"). The bycatch quota would be allocated to sectors of the fleet proportional to both their pollock allocation and historic bycatch. The bycatch quota would then be allocated by cooperatives to individual vessels and would be transferable across the fleet and thus improve economic efficiency. The amendment would require 100% observer coverage for all vessels in the pollock fishery, which would affect vessels in the 60-125' length category which are currently required to have observers for 30% of their fishing days.

Limiting total Chinook salmon bycatch is expected to reduce the pollock fishery's impact on the number of Chinook returning to rivers. However, in periods of low salmon abundance a hard cap may be less effective since reaching the limit would be unlikely, although conserving bycatch may be most important at this time. For this reason, the Council explicitly required that vessel-level incentives to avoid bycatch be in place at all levels of abundance (the absence of such incentives will lead to a more restrictive hard cap). Incentive plans were developed by industry and refined with input from the Council's Scientific and Statistical Committee and AFSC economists. These plans will require further changes since the Council's approved motion includes a Performance Standard for vessels participating in what will now be designated as incentive plan agreements (IPA). IPA participants will be required to demonstrate to NMFS that their incentive plan will be compatible with the Council's motion, but the form of these plans and subsequent accountability measures are presently uncertain.

Given the various elements associated with Amendment 91 and the way in which they interact to influence salmon bycatch avoidance behavior, this discussion paper attempts

to explain what types of additional analysis can be undertaken to examine all major program elements. However, as evidenced by extensive comments on the salmon bycatch EIS and discussion during the April Council meeting, it is clear that the economic analyses conducted to date have provided a limited set of information from which to inform the Council on the benefits and costs associated with Amendment 91. Thus, we have proposed a range of potential analyses that can be conducted either with existing data or through enhanced economic data collection.

Given that data availability is often a constraining factor in the methods that can be utilized in economic analysis, we find that improved socio-economic data collection associated with Amendment 91 should provide for a considerable improvement in the analysis available to the Council. In particular, estimates of the benefits and costs associated with pollock fishing and salmon avoidance, respectively, can be observed or derived in various ways to help decision makers better understand whether they are commensurate with the magnitude of the incentives present in prospective IPAs. Additional data may also support an assessment of the industry costs associated with salmon avoidance actions and the hard cap on total bycatch.[1]

In Section 2 of this discussion paper, we lay out the key questions in which the Council may be interested to better understand the costs and effectiveness of its salmon bycatch actions. In Section 3, we discuss the general types of analysis that may be employed to address those questions and in Section 4 we discuss the extent to which each of the questions can be adequately analyzed based on a variety of data collection options. Section 5 provides a table to summarize the quality of the information that can be derived from the various data collection options given in Section 4. Section 6 discusses the relationship of this data collection with the Council's other economic data collection needs and programs. Section 7 discusses confidentiality and Section 8 summarizes key findings. Section 9 provides the References cited in the paper and Section 10 is an appendix with several additional data collection ideas that are beyond the core focus of this discussion paper.

## *2. Goals of Analysis*

Through Amendment 91 the Council has recognized the necessary trade-off between salmon conservation and the costs that the pollock fishery experiences in avoiding salmon. Regardless of which consideration one believes is paramount in this trade-off, it is in the public's interest to develop an efficient system that will allow pollock fishermen to incur the least costs possible for every salmon avoided.[2] This efficiency can be

1 New research on salmon genetics and population modeling, which are beyond the scope of this paper, may also better inform the Council about the magnitude of salmon population benefits of hard caps or other actions to reduce salmon bycatch.

2 Lower costs for the fleet may lead to lower prices for consumers and greater returns for pollock fishermen and crew, as well as their CDQ partners. This additional wealth in turn supports jobs in communities throughout the Northwest.

accomplished by allowing the salmon trades facilitated by Amendment 91 to occur between low-bycatch and high-bycatch vessels, or between vessels with high and low costs of producing pollock. Careful analysis of the salmon bycatch market and those participating in trades, and the market's interaction with IPA(s) can help the Council understand the extent to which Amendment 91 leads to greater salmon conservation at a lower cost than in the absence of such a system. Because of the innovative nature of Amendment 91's requirement that bycatch reduction incentives be in place at all levels of pollock and salmon abundance, economic analysis can help to ensure that gains in efficiency translate into both better conservation and economic outcomes.

Key questions that the Council may wish to examine when considering the effects of Amendment 91, and that can be illuminated to varying degrees depending on what data are collected, include:

1. How effective are the IPA incentives, the hard cap, and the Performance Standard in terms of reducing salmon bycatch?
2. How does the Council's action change where, when, and how pollock fishing and salmon bycatch occur?
3. How costly are the IPA(s), the hard cap, and the Performance Standard on all sectors of the pollock fishery (including CDQ)?
4. To what extent can vessels in the pollock fishery avoid salmon bycatch and what factors explain observed variation (e.g., heterogeneity of avoidance costs, skill in salmon avoidance, less avoidance effort exerted)?
5. What are the social and distributional implications of Amendment 91?
6. Is there any evidence of market power being exercised in the salmon quota market?

Answers to questions 1 – 6 above will inform a broad range of issues and concerns associated with salmon bycatch in general and Amendment 91 in particular. Specifically, information on the magnitude of the incentives for reducing salmon bycatch in the IPAs can be compared with the costs of salmon avoidance by estimating the increased fuel costs and changes in revenue earned by moving out of high-bycatch areas. This information would be used to examine whether the costs of catching additional salmon at different salmon encounter levels are sufficient to deter bycatch. The estimated costs of salmon avoidance can also be used to infer the costs of the salmon hard cap. Analysts will also be able to examine whether the intensity of fishing in high bycatch areas has abated relative to before the program and how such bycatch reduction efforts are related to seasonal fluctuations in bycatch rates and the price of pollock products. Collecting qualitative information on salmon bycatch reduction actions will help analysts better understand if observed changes in fishing location are pollock- or salmon-driven (or both), improving estimates of salmon bycatch abatement costs. Evaluating the redistribution of effort associated with increased salmon avoidance can also help examine if there has been a significant change in the spatial composition of salmon bycatch (potentially disproportionately affecting some salmon stocks more than others) relative to current patterns.

Furthermore, with data on the operating costs and more temporally disaggregated revenues of the pollock fleet, analysts will be able to observe whether the heterogeneity we observe in salmon bycatch rates is tied to heterogeneity in net revenues[3] per trip, which in turn drive fishermen's decisions about whether to relocate to avoid salmon. Because CDQ groups would be impacted by Amendment 91 both through their commercial, subsistence and cultural ties to the salmon fisheries and through the CDQ groups' ownership share in the companies that target pollock, better understanding of how the net impacts of the program will flow to the CDQ groups warrants attention[4]. More broadly, however, likely impacts to fishermen and processors involved in the pollock fisheries, as a result of heightened bycatch avoidance, and the magnitude and distribution of those impacts may be of interest to the Council. Finally, one of the core principles in using a trade- or market-based mechanism to alleviate some of the costs of achieving any salmon bycatch target (by allowing lower-bycatch or more profitable vessels to prosecute the fishery) is that the market should be competitive and not susceptible to price manipulation. Evaluating the price, nature, and volume of trades for salmon bycatch will be a useful step toward evaluating how well the market is functioning.

## *3. Types of Analysis*

Before delving into how each of the key questions of interest may be analyzed and specifying the data required to address it, we will briefly introduce three general types of analysis that may be used to understand the impacts and effectiveness of the Council's salmon bycatch action. Each of the following types of analysis will be discussed in greater detail below and incorporated into the data options presented in Section 4:

- Mechanism design analysis – analysis of the IPA agreements and how these agreements work in conjunction with the hard cap and Performance Standard.
- Fishing choice and economic performance analysis – analysis of how fishing choices, costs, and benefits change after the implementation of Amendment 91.
- Market analysis – analysis of the transfers (and options for transfers) and prices of salmon and/or pollock allocations.

### Mechanism Design Analysis

Amendment 91 would require that any IPA submitted to NMFS must to be evaluated to assess whether it fulfills certain conditions laid out in the Council's April 2009 motion:

3 Here we define net revenues as quasi-rents, or total revenues less any variable costs, which are the relevant decision variables when out at sea.

4 This analysis has the potential to be very difficult, costly, and complicated, depending on how quantitative the assessment gets. For example, one could merely characterize CDQ involvement in salmon and within the pollock-based companies in which they share ownership to better frame the trade-offs we know exist. Or, one could go as far as attempting to derive the non-market monetary values for salmon and the market value of the directed salmon fishery with the value of salmon as bycatch in the pollock fishery.

- An IPA must describe incentive(s) for each vessel to avoid Chinook salmon bycatch under any condition of pollock and Chinook salmon abundance in all years.
- Incentive measures must describe rewards for Chinook salmon bycatch avoidance, penalties for failure to avoid Chinook salmon bycatch at the vessel level, or both.
- The IPA must specify how those incentives are expected to promote reductions in actual individual vessel bycatch rates relative to what would have occurred in absence of the incentive program. Incentive measures must promote Chinook salmon savings in any condition of pollock and Chinook salmon abundance, such that they are expected to influence operational decisions to avoid Chinook salmon bycatch.
- The IPA must describe how the IPA ensures each vessel will manage their bycatch to keep total bycatch below the sector level regulatory Performance Standard.

Further analysis of the incentive structure of the IPAs will allow analysts to describe the extent to which salmon avoidance behavior is likely to be altered in the presence of the IPAs, and whether the program internalizes the costs and benefits of salmon bycatch or avoidance efforts at the individual vessel level.[5]

In designing IPAs, the pollock industry has several decisions to make which have implications for what information the Council may wish to collect to understand the impact of proposed Amendment 91. For example, it is unclear how strong the incentives will be set to avoid salmon below the hard cap; the Council motion requires that there be incentives at all levels of abundance, but it does not require them to be of a particular magnitude. Thus, mechanism design analysis, in absence other information on the costs and benefits associated with pollock fishing, may be indeterminate depending on how the IPAs are defined.

Given that the current Council motion does not specify which IPAs will be proposed and implemented, we do not yet know the features of those programs and cannot state precisely what data one would need to conduct further mechanism design analysis after the IPAs are functioning in practice. However, we can surmise that any incentive program will provide costs and/or benefits connected to vessels' salmon bycatch, and the realization of these incentives within the functioning IPA can be quantified and compared to the costs and benefits of pollock fishing (assuming we collect the necessary data) to see if the incentives are large enough to alter fishing behavior. Without data on fishing costs, it will be very challenging to understand the degree to which the incentives in the IPAs affect fishery behavior. While analysts can assess the incentives in the IPAs and

5 Internalizing such costs and benefits eliminates "externalities" which lead to individuals' acting to maximize their self-interest while collectively generating a sub-optimal result (Samuelson 1954). Externalities occur when there are social costs (i.e., externalities) that are not paid by the individual making the choice. A classic example of an externality is an open-access or common-pool fishery in which a race-to-fish incentive leads to less profitable conditions for all (Gordon 1954).

observe behavior, it will be difficult to determine if movement is occurring because of the IPA incentives or changes in the abundance and location of pollock and salmon. If collected, cost and earnings data will allow analysts to compare the magnitude of the financial incentives from IPAs with fishery costs and revenues.

**Fishing Choice and Economic Performance Analysis**

A key aspect of understanding the impacts of Amendment 91 is to examine how it affects where and when vessels choose to fish and the benefits and costs associated with those efforts. Vessel operators often make these choices by speaking with others about fishing conditions in different areas, including information about roe recovery rates and the size of fish caught. With their knowledge of their own operational costs and the revenue that they expect to gain from fishing in different areas, skippers choose the location that they believe will be most profitable. One of the decision factors that will be given additional weight beginning in 2011 is the expected salmon bycatch in different areas. With accurate estimates of vessel costs and expected revenues, economic analysts can examine how all of the factors that we observe about vessels, areas, and bycatch affect the choices that different vessels make. These models build upon a robust literature in fisheries economics (e.g., Eales and Wilen 1986, Holland and Sutinen 2000, Smith and Wilen 2003, Smith 2005, Haynie 2005, Haynie and Layton 2009).

A broad range of factors drive such fishing location decisions. Heterogeneity in vessel characteristics, technology, and production goals play an integral role. One example of vessel heterogeneity that impacts bycatch behavior is that the cost for vessels to travel to more distant and cleaner locations is greater for some vessels than others. The relative value of products for different vessels/sectors (e.g., roe) will also impact their willingness to avoid salmon or to pay for additional salmon quota. The presence of salmon avoidance skills and the adoption of salmon excluder devices and other types of bycatch-reduction technologies will also vary within the pollock fishery. The quantity of information available on recent bycatch rates in different areas will also impact the likelihood of vessels being "unlucky" and getting a large tow of salmon, which will impact how willing vessels are to search for better pollock fishing conditions in areas that potentially have higher bycatch.

As we will discuss further in Section 4, additional information will be required to adequately account for these factors in future analyses. These analyses of fishing choices and the associated costs and benefits are important pieces of information required to understand the impacts of the Council's salmon bycatch action.

**Market Analysis**

Amendment 91 would create a framework for the development of a market for salmon bycatch allocations, through which salmon bycatch privileges may be traded, sold, or potentially saved for future years (through an appropriate IPA mechanism). There are many possibilities for how this market may develop and for the types of transactions that

will occur. At one end of the spectrum, in-kind trades may occur between jointly- owned vessels in which any reported transaction price is merely an artifact of the exchange and may not reflect the value of salmon bycatch in pollock fishing. At the other end of the spectrum, "arm's length cash" transactions reflecting the actual market value of the privileges may be made between unaffiliated vessels. There may also be a number of transactions that lie in-between these polar extremes in which other non-monetary considerations play a role in the agreed-upon price, in turn diluting the value of the price signal in reported transactions. In some years with low bycatch levels, it's possible that there may be no transactions at all.

Of these types of trades, arm's length cash transactions provide the single most valuable piece of information for the Council to understand the value of salmon in the production of pollock and in turn, the costs of salmon avoidance. Specifically, the market price of salmon bycatch represents the marginal value of one more salmon as bycatch in the pollock fishery. The information contained within this price signal is somewhat analogous to what is reflected in the prices of assets traded in the stock market. Specifically, the stock price reflects the present value of the earnings that are expected to be distributed to shareholders based upon the profitability of the company. In a sense, the stock price is a "sufficient statistic" representing the value of an asset whose profitability depends upon many factors, but has been distilled down into a reduced-form representation. Should we observe unbiased transaction prices associated with salmon bycatch quota, we can use that information directly to quantify the value of salmon in pollock fishing, rather than having to rely strictly on estimates of that value through statistical modeling of the relationship between economic returns and the level of salmon caught. With this information in hand, the Council can weigh those values against what it knows about the value of salmon in the directed commercial, recreational and subsistence fisheries.

Regardless of the market mechanism that materializes, it is worth emphasizing the importance of collecting data on both the price and nature (e.g., arm's length or not) of individual transactions if one's goal in collecting market information is to estimate the value of salmon bycatch in pollock fishing. The cost of salmon avoidance will differ from vessel to vessel as well as within different times of the year, which suggests that transaction-level accounting is required to adequately understand the context underlying the reported prices from salmon transactions and the heterogeneity in salmon bycatch avoidance costs. It is the presence of such heterogeneity and the potential for trade that creates the potential for large cost savings in achieving a given salmon bycatch target or limit. By examining the volume of salmon trades and the characteristics of the vessels partaking in such trades (e.g., historic bycatch rates or estimated bycatch abatement costs), one can address whether the program is facilitating a reduction in salmon bycatch avoidance costs. Furthermore, market analysis of salmon bycatch transactions will allow one to investigate whether market power or price manipulation is present in the salmon bycatch quota market and if the market appears to be "well-functioning" according to criteria developed in the economics literature (e.g., Newell et al. 2005, Newell et al. 2007).

## *4. Data Collection Options*

Ultimately, data availability drives one's ability to analyze the impacts of Amendment 91. Below we discuss six alternative economic data collection options, each of which collects different types of information that can be combined together to facilitate a desired level of analytical ability. As mentioned earlier, biological data on salmon genetics and population dynamics are also important in evaluating impacts and effectiveness of the IPA incentives. However, those collections are beyond the scope of this paper. We also address which of the key questions 1 – 6 from Section 2 can be addressed using the data collected under each option and consider the collection costs or reporting burden associated with each.

### 1. Status quo data collection + 100% observer program

The Council's April 2009 motion recommends extended observer coverage to 100 percent of days at sea. Thus the key data that are currently available for analysis include:

- Observer & VMS data characterizing spatial behavior and catch and bycatch per haul (CP/MS) and catch and bycatch per trip (CV)
- Price data from Commercial Operators Annual Report (COAR) and Commercial Fisheries Entry Commission (CFEC) fish tickets
- Weekly production data for all processors
- Salmon bycatch quota transactions from NMFS
- Any IPAs submitted to NMFS
- Annual reports to the Council, which according to the April 2009 Council motion must include:
    - "a comprehensive explanation of incentive measures in effect in the previous year,
    - how incentive measures affected individual vessels, and
    - evaluation of whether incentive measures were effective in achieving salmon savings beyond levels that would have been achieved in absence of the measures."

With no additional data collection the effectiveness of the IPAs can be estimated to varying degrees of accuracy depending on the nature of the IPAs and whether the incentives are explicitly quantified in the agreements. Even if the incentives are explicitly quantified, without information on the net revenues earned in pollock fishing it may still prove difficult to estimate which consideration will drive behavior.

Federal observer data exist to address the degree to which salmon bycatch is reduced, potential avoidance efforts are undertaken, and how pollock fishing activity may be affected by Amendment 91. Spatial data on fishing patterns responses to SeaState closures can be used to infer salmon bycatch avoidance actions, although it will remain difficult to understand whether observed changes in spatial locations are driven by salmon bycatch, pollock returns or both. Without additional data on the costs of relocating and the benefits from pollock fishing (which may be characterized by fish size

and roe bonuses based upon the quality and quantity of the roe being derived from a given area, both of which are currently not reported), the analysis will be not fully incorporate the information needed to account for vessel behavior.

It will not be possible to estimate the costs of the IPA without knowing the travel costs associated with relocating to different areas or the way in which operating costs may differ under different pollock catch rates or levels of abundance. Similarly, the cost of the hard cap to the fleet will not be estimable in absence of more detailed cost data or observations on the value of salmon bycatch in arm's-length transactions. Even in years where salmon bycatch rates are sufficiently low throughout the entire season so that most vessel operators likely assume that the cap will not bind and purchases of salmon quota are not necessary to stay under the cap, banking or incentive aspects of the IPA may dictate that abatement costs are still incurred.

Under the status quo it will be difficult to accurately estimate the extent to which different vessels can avoid salmon bycatch because we will not know how the costs of salmon avoidance are internalized by the incentives present in the IPAs or associated net revenues from pollock fishing. Differences in salmon bycatch rates will likely exist in the observer data but as with our current state of knowledge, we will not be able to discern whether such differences reflect heterogeneity of avoidance costs, skill in salmon avoidance, differential values of pollock products, or less avoidance effort exerted.

In addition to direct salmon avoidance costs discussed above, industry has incurred additional costs (and will likely continue to do so) through their efforts to develop and maintain the SeaState/VRHS program and the inter-cooperative agreements. Those activities are not costless and the information needed to assess these costs, such as attorney fees and contracted bycatch monitoring fees, are proprietary and have not been provided by industry. Finally, costs have also been incurred to develop salmon excluder devices; however, such devices are in experimental stage of development and it is not presently clear how effective they will be, how may vessel operators will voluntarily use them, and what reduction in bycatch might be brought about via their adoption. Thus, without additional information on these types of expenditures the full cost of salmon bycatch reduction activities cannot be estimated.

The social and distributional implications of Amendment 91 cannot be estimated under the status quo because we will not know the costs of salmon avoidance and how those costs differ among vessels and between sectors. We also do not know the net revenues earned by the vessels and distributed to crews. Analysis of potential employment effects is problematic for several reasons. First, employment data for pollock harvesting sectors is not systematically collected. Thus, it is not possible, with presently available data, to use potentially forgone revenue estimates to generate harvest employment impacts. Second, there is no systematic data collection underway to document shoreside expenditures in the support sectors. Thus, it is not possible to use estimated potentially forgone revenue to generate estimated effects on shoreside expenditures and subsequent effects on the services and support sectors. Third, employment in shoreside plants, though estimated by ADOL, is not reported specifically for pollock processing. Thus, it is

difficult to determine the level of employment effects that might occur from potential contraction or concentration of the pollock fishery, should the cap have such an effect.

It will also be difficult to discuss the economic impacts on CDQ groups, which are of particular interest given that some are heavily vested in the pollock fishery. Until 2006, NMFS received detailed annual financial audits from each CDQ entity (for 2005 and previous years). The audits included detailed revenue information and royalties paid, by species or species group, for the CDQ allocations. NMFS has not been authorized to require financial audits since the 2006 amendments to the Magnuson-Stevens Fishery Conservation and Management Act. Therefore, we now rely on information from the CDQ entities publicly available annual reports prepared primarily for residents of the member communities. Some of the CDQ entities choose to include specific information on revenue sources and investments, while others choose not to provide this level of detail in their annual reports. Thus, any analysis of CDQ impacts is likely to be incomplete under the status quo.

Finally, without any information on salmon bycatch transactions we cannot assess whether the market is competitive, functioning properly, or subject to distortions.

The additional costs associated with the status quo include the costs of deploying 100% observer coverage. However, given that this change is mandated by Amendment 91 and is not a new data collection option proposed within the context of this discussion paper, the costs of the observer coverage do not vary according to each data collection option we discuss.

**2a. Record all salmon transaction data**

In addition to data available in status quo, the following data on vessel-level quota transactions would be collected under this option:

- Price of salmon quota transaction
- Date of salmon quota transaction
- Parties of salmon quota transaction
- Nature of transaction (arm's length or not)

This option will potentially allow for a significant amount of market analysis to be conducted, depending on the proportion of "arm's length cash" transactions reported in the data. In arm's-length cash transactions, the transactions represent the real market value of salmon in the pollock fishery (i.e., the benefit of not having to incur salmon avoidance costs) and thus would be a major contribution towards assessing the impact of Amendment 91 on the fishery and will provide valuable information into many of the questions introduced in Section 2.

However, at this point it is unclear how many of the salmon transactions will meet this criteria. Salmon trade prices may be skewed to reflect personal relationships, tax advantages, or other factors. For example, one individual may give a fellow cooperative

member a relatively low price for salmon quota because he hopes to get the same consideration in the following year. Or, members of the cooperative may be part of a vertically integrated company, wherein salmon trades may be undertaken to help keep pollock catch flowing to a processor, facilitating a smooth operation and higher prices for products. For salmon trade data to have practical utility in deriving an accurate measure of the value of salmon it is important to account for the nature of the transaction and to ensure that all forms of compensation or value associated with the trade be noted. It may be difficult to derive a collection mechanism that is brief, yet can still definitively distinguish real market transactions from in-kind trades. However, the CFEC has developed a set of criteria for use in permit transfers, some of which may be useful in this context.[6]

In addition to examining the nature of the transaction, having information on the date of transactions will also allow insight into how well the market is working and whether or not there should be efforts to build better markets to improve "thickness", or a consistent market with sufficient buyers and sellers (Roth 2008). Tracking the parties to transactions will in itself allow for the assessment of whether market power is being exercised in the quota market.

There may be potentially significant limitations of collecting these data without also collecting additional data on simultaneous pollock transactions. For example, if a given quantity of pollock and salmon is sold together for a single price and the pollock transaction is not tracked, then the value assigned to salmon in transaction records may be arbitrarily or strategically reported. This will lead to inconsistency in data quality and the price may not accurately reflect the market value of salmon to the pollock fishery.

We envision that the costs of this program will include i) burden hours for those pollock fishery participants who partake in salmon bycatch transactions (approximately 5 – 10 minutes per transaction); and ii) administrative costs for NMFS staff to enter the data into an electronic database ($10K). We do not envision this data collection to be required in real time to facilitate the trades, and it may be the case that final settlement prices for salmon quota may not be available at the time of the transfer. Therefore, if these data are collected at the end of the season in one comprehensive report the details should be finalized and there will be a minimal amount of effort required to follow up with clarifying questions about the specific elements of the transaction.

**2b. Record all salmon and pollock transaction data**

Under this option, individual transactions involving pollock quota would also be recorded in order to prevent the potential implications and shortcoming associated with salmon bycatch quota transfer data discussed in detail under Option 2a. In short, collecting information on pollock transfers will provide greater assurance that observed salmon quota transactions reflect the actual value of the quota. Additionally, tracking the value

6 The CFEC has attempted to collect this type of information in their permit transfer request form available at http://www.cfec.state.ak.us/forms/Request_for_Permanent_Transfer_of_Entry_Permit.pdf

of pollock quota over time will enable the Council to observe how salmon bycatch levels and restrictions impact the value of pollock. The information will also help the Council monitor the extent to which pollock quota is moving to/from certain vessels or companies as a result of salmon bycatch quota limitations, which will better inform the Council about the distributional impacts of its action.

One limitation of collecting only pollock and salmon quota transaction data without additional cost and earnings data (as discussed in Option 3 below) is that analysts will not be able to characterize the extent to which the market may be functioning, for example, to facilitate trades of salmon bycatch between high- and low-cost vessels. A persistent difference in salmon avoidance costs or skill indicates the presence of potential arbitrage opportunities that can be exploited to decrease the industry costs of meeting a particular salmon bycatch target. Once differences in operational costs are considered, along with the explicit outlays for salmon bycatch quota, one would expect the market to result in an equilibrium in which these total costs converge among vessels within the fleet.

We envision the costs of this program to be similar in nature to those of 2a, but burden hours (minutes) will be slightly larger for each transaction because of the additional details required for pollock.

**3. Collect trip- or haul-level revenue data for all vessels**

To understand the economic repercussions of changing fishing locations to avoid salmon bycatch, or predict whether a fishermen is likely to make such a decision, one needs to compare the costs and benefits (revenues) of fishing in each area. From observer, fish ticket, and weekly processor report data we have information on the volume of fish caught during a trip but we do not know the product value.[7] Because the price per metric ton varies significantly based on roe content, product output, and product recovery, price data currently available at the annual level does not capture the temporal or spatial variation in value that occurs from fishing in one place versus another. Thus, we are do not have data on potentially large intra-seasonal revenue differentials that exist in different locations and often dictate observed fishing choices. As such, haul-level earnings data would provide the most valuable information for understanding the actual revenue that vessels receive from fishing in one area versus another with a different Chinook bycatch level. Depending on the heterogeneity in fish size and roe maturity, as well as the number of statistical areas in which a vessel fishes in a trip, trip level revenue data can also provide a reliable means for understanding the observed trade-offs in fishing.

For inshore catcher vessels, hauls are not separated from one another in terms of roe content (or salmon bycatch), implying that only trip-level revenue data could be collected. For catcher processors and motherships this limitation does not apply, and it is our understanding that many vessels internally track the recovery of roe and value of

7 For historical data, we have observer data for only larger vessels but with the program implementation these data will exist for all vessels.

product at the haul level (sometimes with price averaging over a trip or lot). Because catcher processors and motherships take trips that are several weeks in duration, trip-level data would blend values across a relatively long time-period and spatial locations and could significantly diminish the resolution of the price signals dictating observed site choices. In this case, recording the quantities of row per-haul along with the value per-trip would provide analysts more accurate data to use evaluate how vessels trade of expected revenues with salmon bycatch.

We envision that the costs of this program would include i) the burden hours for industry to record information on revenue for each haul or trip (approximately 5 minutes per observation); and ii) administrative costs for NMFS staff to structure and maintain the data provided by respondents in an electronic database ($10K). If data are recorded at the haul level for catcher processors and motherships, they will have a greater number of transactions to report than under a trip-level scenario and their burden hours may exceed those of catcher vessels.

**4a. Collect annual cost data for all vessels**

We currently collect no data on the operating costs of pollock vessels. The primary vessel costs that may be affected by Amendment 91 relate to salmon bycatch reduction efforts, including the variable costs of relocating from one site to another and having to fish and/or process for a longer period of time to catch a given level of quota (if one moves out of "prime" pollock areas).

To quantify the changes in variable costs one would need to collect data on fuel consumption and prices, as well as other expenditures associated with harvesting and processing. The expenses to be tracked would include fuel and lube, labor costs, salmon bycatch quota purchases, observer fees, gear expenses, insurance, repair and maintenance, salmon excluders or other equipment directly designed to limit bycatch, and potentially new investments in technology that are adopted to help find pollock and avoid salmon.

Fortunately, much of this information is readily obtainable from already compiled industry records. Vessel operators typically have a good sense of their fuel consumption (often in gallons/hour) and track their costs on an annual level. We can combine these annual variable cost data with information captured by VMS tracks and the observer program on total travel distance to develop cost-per-mile estimates. This will allow analysts to estimate the relative cost of going to one area versus another for different vessels, to compare whether observable vessel characteristics impact vessel bycatch rates, whether higher-cost vessels may be less willing or able to avoid bycatch, and whether there are patterns of behavior that can be identified and potentially altered to reduce bycatch.

It should be noted, however, that even if the information requested in the cost survey is collected or tracked by industry, data quality problems can arise when the specific form

of the information requested in the survey is misunderstood by respondents or differs somewhat from the way in which they keep their records. It may be the case that a respondent's expenditure records included purchases that reflect activity in more than just pollock fishing, making it difficult to derive a pollock-specific cost for certain items. In other situations, the nature of a transaction may involve in-kind considerations which cause the reported cost of an item to not reflect its true cost, and the survey instrument may not be sophisticated or flexible enough to account for such factors. In short, it is likely that the data collected within the first year or two under this Option would be subject to measurement error that would decrease over time as respondents learn to understand exactly what information is being requested and modify their record-keeping practices to better track what is requested. Data quality problems can be mitigated up front by conducting industry focus groups and refining the survey to reflect any detected misinterpretations, but there will still likely be an evolution in the quality of the data collected.

One of the primary cost categories that is commonly tracked accurately in detail by industry is crew costs.[8] As a result, the impact of changes in costs on crew employment and earnings (labor costs) can also be evaluated under this option. While we do not know the extent to which the additional fishing costs associated with Amendment 91 will be passed on to crew, we do know that many of the expenses directly associated with at-sea costs are shared by the crew. We may observe that the costs of salmon bycatch reduction are borne more heavily by certain vessels, which in turn may have a similar disproportionate effect on crew earnings. Because we have no baseline data on crew earnings it will not be possible to observe how crew income changes with the introduction of Amendment 91, but it may be possible to see how crew earnings and employment levels vary over time as salmon bycatch rates vary. In order to parse out effects of Amendment 91, however, one would need a clear understanding of the way in which crew are compensated (e.g., share- or wage-based) and what expenses are shared between vessel and crew. In some situations these conditions are fluid depending product prices and fuel prices and would need to be updated annually in the cost survey.

If annual cost data are collected without trip and/or haul level revenue data (see discussion above), our understanding of vessel opportunities and choices will be incomplete. From observer data, we observe the amount of pollock caught and CPUE in different areas, but we do not observe the revenue earned in those areas. The implication of this is that we do not know if people are moving from one area to another with a lower catch rate because of salmon bycatch avoidance or to capture higher roe content or product value.

Vessel operators possess a breadth of information about their activities that would be very useful to the analysis of fishery behavior and especially valuable in properly contextualizing any data provided through new cost data collections. For example,

8 Crew typically receive detailed settlement sheets showing how their total earnings were derived from the gross earnings less any deductions for fuel, quota acquisitions, groceries, etc. Vessel owners can thus rely upon settlement sheets to readily provide information on crew payments.

knowing that fishing was bad in certain areas during certain months or how fishermen respond to congestion would both improve analysis of the impact of Amendment 91 on the fishery and improve our ability to explain the costs of the salmon bycatch program. We propose that an additional series of questions be included in any cost survey to elicit vessel operator input on important factors that impacted the vessel's performance during the year; such questions could be developed in consultation with industry once the specific questions to be posed in the cost survey are defined and nuances of the data that must be considered to properly use the reported data are discussed. Even if cost data are not collected to evaluate the effects of the program, such information could be used to better explain the location choices that can be observed in federal observer data.

While members of the fleet have been very willing to provide this type of qualitative information through informal discussion, it would be more useful to collect this information in a systematic manner that would help to ensure that anecdotal information (that may not fully reflect the participation by all sectors of the pollock fishery) would be considered in the proper context by NMFS and the Council. Any information submitted on fishing details in conjunction with the annual cost survey would also be provided greater confidentiality protection as part of a mandatory data collection program.

The costs of this option would include direct costs for NMFS staff to develop and implement an annual variable cost survey and, preferably, additional expenses associated with having the survey data verified by a third party. The costs of these two elements would likely be around $60K for 0.5 NMFS FTE to oversee the data collection, $50K for a contractor to provide data entry, database design, and support services for respondents, and another $60K for data verification by a certified public accountant. There would also be burden hours imposed upon industry respondents. It is likely that approximately 8 – 10 hours would be required from all pollock fishermen to pull and organize documentation and fill out the annual cost survey, and an additional 2 – 8 burden hours for the subset of individuals subject to data verification audits.[9] We would anticipate fielding this survey to all participants in the pollock fishery.

4b. **Collect Trip-level cost data for all vessels**

Under this option the same cost elements reported under Option 4a would be recorded, but those that could be recorded at the end of each trip would be entered into a mechanism such as an economic logbook. To the degree that annual costs can be accurately apportioned to each trip based upon some factor such as miles traveled or pounds caught, this option may not dramatically improve the quality of data available to analysts. Although many of the expenditures captured under this option vary according

9 The time it takes to complete a data verification audit will depend upon whether the individual providing the data has relied upon actual financial documents or receipts and kept them available in case of an audit. If so, providing this information to the auditor should require minimal effort and time. However, individuals who hastily estimate their reported values and have no documents from which to validate these values may spend considerable time deriving actual, accurate values or attempting to explain and recreate the values they originally reported.

to trip length or pounds caught (see Option 4a above), it might be the case that asking respondents to attribute costs that are incurred once per year to specific trips could be confusing and possibly degrade data quality.

If, however, cost data can be recorded accurately at the trip level, the increased resolution would allow a better understanding of how costs vary among different trips, including, for example, those trips in which salmon bycatch led to rolling hotspot closures and subsequent relocations. This degree of resolution would also allow observations of how costs and behavior change in the face of intra-seasonal changes in fuel prices, market prices, or other costs affecting fishing behavior.

If data were collected at this level, a short vessel-operator survey or logbook add-on could be completed by vessels operators, potentially while at sea. This would allow an avenue for vessel operators to express valuable but less quantitative information about measures that vessel operators take to avoid salmon. It is often the case that vessel operators may not know all of the expenses incurred by the vessel (and to be reported under Option 4a), as some are incurred before or after fishing takes place. Therefore, trip-level economic data is often supplemented with annual data surveys to fill in the gaps.

The costs of this option would include many of the same costs identified in Option 4a. Therefore, there would be direct costs for NMFS staff to develop and implement an annual survey and, preferably, additional costs for having the data verified by a third party. The costs of these two elements would likely be around $60K for 0.5 NMFS FTE to oversee the data collection, $50K for a contractor to provide data entry, database design, and support services for respondents, and another $60K for data verification by a certified public accountant. There would also be burden hours imposed upon industry respondents. It is likely that approximately one hour per trip would be required to provide the trip-level data, and 4 – 6 hours would be required to pull and organize documentation and fill out the supplemental annual cost survey. An additional 2 – 8 burden hours would also exist for the subset of individuals subject to data verification audits. We would anticipate fielding this survey to all participants in the pollock fishery.

5. **Ownership data**

During the April 2009 Council meeting, several council members expressed concern that the Council's action would place an excessive burden on vessels with a very small salmon quota. If the Council were provided with data on vessel ownership it could examine whether systematic changes in vessel ownership arise after Amendment 91 is implemented. Additionally, this information could be used in conjunction with salmon market transactions to monitor the level of quota consolidation and to ensure that the market does not become excessively concentrated.

The U.S. Maritime Administration (MARAD) collects vessel ownership data to determine whether vessel owners are in compliance with the 75 percent U.S. ownership

requirement of the American Fisheries Act. Information collected by MARAD is considered confidential but may be released to NMFS under specific circumstances. MARAD data are not organized in a format that will allow analysts to make a determination of whether the fishery becomes more concentrated subsequent to Amendment 91, but these data could be used as a foundation for improved analysis of vessel ownership.

Should the Council express interest in acquiring more information on vessel ownership, staff could invest some time to better ascertain exactly what information can be obtained from MARAD and thus what additional information NMFS may need to collect to facilitate Council goals. It should be noted, however, that vessel ownership data are dynamic in nature and tend to become "stale" if not updated at regular intervals. For the reasons stated above, at this time we cannot provide reliable estimates of the cost of providing the Council with improved ownership data, but we do know that a considerable amount of effort by NMFS staff (disproportionately high compared to the effort required by industry to report the data) may be required to piece together the ownership data and characterize discernible trends.

## *5. Comparison of different collection protocols*

The following table displays the contribution of each of the data collection options described in Section 4, along with groups of options that may potentially be selected by the Council. Note that while data collection Option 5, ownership data, is listed as an independent option, it is not listed as part of the combination packages for the sake of simplicity. Section 4.5 discusses the value and costs associated with collecting ownership data and these data could potentially be collected in conjunction with any of the other packages.

Table 1: Comparison of Different Economic Data Collection Options

| | **Analysis Goal** | | | | | |
|---|---|---|---|---|---|---|
| **Data collection option** | 1. How effective is the Action? | 2. How does pollock fishing change? | 3. How costly is the action? | 4. What explains bycatch variation among fleet? | 5. What are social and distributional impacts? | 6. Is there market power in the bycatch market? |
| 1. Status Quo | FAIR | FAIR | POOR | FAIR | POOR | POOR |
| 2a. Salmon transactions | GOOD* | FAIR* | FAIR/GOOD* | FAIR* | FAIR* | FAIR* |
| 2b.Salmon & pollock transactions | FAIR | GOOD | FAIR/GOOD | FAIR | FAIR | GOOD |
| 3. Haul-level revenues | FAIR/GOOD | FAIR/GOOD | FAIR | FAIR/GOOD | POOR | POOR |
| 4a. Annual costs | FAIR | GOOD | GOOD | GOOD | GOOD | POOR |
| 4b. Trip/haul costs | GOOD | GOOD | GOOD | GOOD | GOOD | POOR |
| 5. Ownership | FAIR | FAIR | FAIR | FAIR | FAIR | GOOD |
| Market, revenue, & cost options | | | | | | |
| 2a + 3 + 4 | GOOD* | EXCELLENT* | GOOD* | EXCELLENT* | EXCELLENT* | GOOD* |
| 2b + 3 + 4 | EXCELLENT | EXCELLENT | EXCELLENT | EXCELLENT | EXCELLENT | GOOD |
| Market + revenue options | | | | | | |
| 2a + 3 | FAIR* | GOOD* | GOOD* | GOOD* | GOOD* | FAIR* |
| 2b + 3 | GOOD | GOOD | GOOD | GOOD | GOOD | GOOD |
| Market + cost options | | | | | | |
| 2a + 4 | FAIR* | GOOD* | GOOD* | GOOD* | GOOD* | FAIR* |
| 2b + 4 | GOOD | GOOD | GOOD | GOOD | GOOD | GOOD |
| Revenue, & cost options | | | | | | |
| 3 + 4 | GOOD | EXCELLENT | GOOD | EXCELLENT | EXCELLENT | FAIR |

* The data quality of 2a and the options involving 2a is unknown. The ratings here assume that the data collected are not systematically biased or severely limited.

## *6. Other analyses that can be conducted with these data*

While the primary purpose of this discussion paper is to describe the analyses and data collection needed to analyze various aspects of Amendment 91, we should note that additional analyses (some salmon-related, some not) can be facilitated by the information gained within many of the data collection options presented in Section 4.

In particular, additional pollock fishery salmon-related research can be undertaken to examine or quantify the economic impacts of selecting the specific hard cap of 60K Chinook, or other hard cap levels, should the Council consider modifying the cap in the future. This work could be conducted if either transaction-level salmon trade data are collected, or if cost and earnings data are collected.[10] With respect to the former, trade data on arm's-length transactions can be isolated to provide "reduced form" estimates of the value of salmon bycatch throughout the season, potentially during periods of both salmon scarcity and abundance, and inform a reasonable range of salmon bycatch values. This information can be utilized to estimate the value gained or lost by the pollock fishery from changing the salmon cap. The marginal value of changes in the cap are likely to be non-linear in that one cannot assume the observed bycatch values will remain constant over all ranges of the cap, but for relatively minor changes in the cap the fleet-wide average price in the most recent year is likely to be a good approximation. For larger changes in the cap the full range of salmon bycatch prices observed within past years can be employed to bound the likely impacts of the change.

Cost and earnings data can also be used to develop "structural" estimates of the value of salmon bycatch by modeling or comparing the relationship between salmon bycatch levels and net revenues associated with site choices during the season. If both salmon transaction data and cost and earnings data are collected, the reduced-form and structural estimates of salmon bycatch values can be compared and corroborated to validate empirical models or to investigate the veracity of reported salmon bycatch prices.

If the Council was instead interested in how changes in the structure of an IPA would impact salmon bycatch levels or avoidance behavior, transaction level salmon trade data collected under any Option, or the cost and earnings data collected under Options 3 or 4, could be particularly useful. While IPAs may change significantly because of the Performance Standard contained in Amendment 91, the general way in which the incentives of the heretofore developed incentive plans work is by allowing i) vessel owners to "bank" salmon bycatch and use it at a later date by keeping bycatch levels below a specified threshold in each year; or ii) by rewarding low-bycatch levels in a

10 As discussed in greater detail earlier in the paper, more temporally disaggregated cost and earnings data will provide successively heightened accuracy in estimating the value of salmon bycatch. Differences in analytic precision arise because the value of salmon bycatch is directly related to the costs of moving out of one area into another and the revenue derived from fishing in the two locations. The relevant choice sets for fishing location and the associated costs and revenues change throughout the year so more disaggregated data will provide a more realistic set of trade-offs that can be evaluated to estimate the value of salmon bycatch.

given year with a relatively large share of a financial "ante" pool. Should i) be modified in the future to either allow for changes in how much salmon can be banked, or how long banked salmon can be utilized, estimates of salmon bycatch values can be used to estimate how changes in access to those valuable salmon privileges would impact the parties governed by the IPA. Changes to ii) could similarly be evaluated by comparing the size of the new "antes" one could earn in the IPA with the salmon bycatch value estimates to evaluate whether behavior could be markedly impacted by the changes.

In addition to facilitating potential follow-up analyses of salmon-related questions, the information collected under many of the data collection options could also be quite useful for analysts tasked with answering other questions pertaining to the pollock fishery[11]. For example, there are other current and possible future spatial regulations that govern where and when pollock fishing can be undertaken, including Steller sea lion protection mechanisms, essential fish habitat designations, and general marine protected areas which could be enacted to provide protection for other species of concern. To effectively analyze the effect of such regulations one must have knowledge of the costs associated with traveling to alternative fishing sites as well as the net revenues earned in these locations. The cost and earnings data collected under Options 3 and 4 would provide the data required to address the aforementioned questions (again, with increasing levels of precision depending on the degree of temporal disaggregation in the reporting frequency).

More generally, those same data could be utilized to calculate estimates of producer surplus (quasi-rents) for the pollock fishery, which is useful in answering a variety of common questions that arise:

- How do the net benefits derived from the pollock fishery compare with estimated benefits of protecting marine mammals that also reside on the fishing grounds?
- To what extent are post-seasonal revenue payments and roe bonuses incorporated in fish tickets and COAR data? Are annual prices for pollock sufficient to capture the broad distribution of observed landings prices, and more generally, are our revenue data reliable?
- How does a change in the pollock TAC affect the costs and revenues, and thus net benefits, generated from the fishery?
- How would changes in the harvesting or processing caps or annual TACs affect estimated economies of scale, and how would this affect average production costs?
- How much wealth is generated though the sale or lease of pollock and salmon quota? When combined with cost data one can estimate the net benefits of idling vessels and potentially consolidating fishing aboard larger, newer, and safer vessels (if future legislation allows this).
- What is the interstate and international ownership structure of entities in the processing sector and where do fishery benefits flow?

11 In fact, the cost and earnings data collected under Options 3, 4, and 5, are strikingly similar to the data that is currently being considered for collection from all fleets by the Council-appointed Comprehensive Economic Data Collection Committee.

## *7. Confidentiality*

Protecting the confidentiality of any economic data collected to analyze Amendment 91 is a very high priority for the management agencies and the industry. Since the data would be collected under the authority of the MSA, the substantial protections provided by the Act will be maintained for all data. To protect the industry, procedures were included to protect the data from being released for reasons other than the purposes for which it was collected. Some members of the fishing industry have stated that, in the past, data have been provided to agencies on a voluntary basis. Those data were then forced to be released, through court proceedings, and used in lawsuits against the companies that provided the data. Because of such incidents, it is imperative that regulations preclude the data from being used, either by individuals that are not intended to have access to the data, or for purposes in which the data are not intended. Authorized agency staff members from NMFS, ADF&G, and NPFMC are currently defined as the potential users of such data. Other users could include individuals that are contractors of the above agencies that are conducting research associated with the program and its fisheries. Examples include agencies like AKFIN or PSMFC that are involved in maintaining and supplying data to other agencies. University faculty conducting research for one of the above agencies would also be envisioned as users that would be given access to these data. The release of these data outside of the primary users or for other purposes would be strictly regulated. NMFS has stated that protecting the confidentiality of the data will be one of its highest priorities. At a minimum, all are sworn, under penalty of law, to protect the confidentiality and use of the data.

## *8. Discussion and Key Findings*

In this discussion paper, we have attempted to provide an assessment of what analysis can be done to better inform the Council about the impacts of Amendment 91 on salmon bycatch avoidance and its relation to the way in which the pollock fishery is executed. Many of the most germane questions relating to Amendment 91 cannot be answered satisfactorily with the current economic data available to analysts. In developing alternative data collection options we have identified the types of information that could be expected to be obtained through three general types of analysis (mechanism design analysis, fishing choice and economic performance analysis, and market analysis). Collecting more information will clearly increase the costs to both industry and NMFS, but will lead to a substantially better set of economic data with which to analyze Amendment 91 and upon which to base any subsequent actions.

Key findings of this discussion paper include:

- Status quo data collection will not provide sufficient information upon which to develop reliable conclusions about the impact of Amendment 91.

- Data on salmon and pollock markets will substantially inform the Council on the value of salmon bycatch to the pollock fishery, with the caveat that data on these transactions are susceptible to misreporting and misinterpretation, and data should be collected in such a ways as to maximize their quality.

- Trip-level product prices (e.g., roe) are essential for characterizing the spatial trade-offs between pollock fishing and salmon bycatch avoidance and in turn, determining the financial impacts of proposed Amendment 91.

- When combined with trip-level revenue data, cost data will allow analysts to examine how differences in vessel net revenues affect participation in salmon bycatch markets and avoidance behavior. The information can also be used to examine changes in crew employment and earnings. Whether annual cost data can be accurately and consistently apportioned for trip-level analyses, or if trip-level reporting is crucial for some input costs, should be determined in consultation with the Council's Comprehensive Economic Data Collection Committee and industry.

- Revenue, cost, and trade data together allow for the most thorough analysis of the Council's actions. Information from the market data can be integrated with cost and revenue data and analysis of the IPAs to provide the greatest understanding of how Amendment 91 affects fishing behavior and how the salmon bycatch quota market functions.

- Ownership and employment data will allow further distribution of impacts of distributional impacts of Amendment 91.

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# *10. **Appendix***

In developing this discussion paper we considered additional data collection possibilities that may be useful for informing the Council about the impacts of Amendment 91 but were not included in the main discussion i) because they may not be feasible in the time frame the Council has set; or ii) due to the significant regulatory complexities involved. Rather than omit these ideas we have included them in this Appendix to provide potential "food for thought" in enhancing or developing this and other data collection programs in the future.

One such idea was to develop an auction market for a portion of the salmon bycatch quota in order to increase the number of observations with which one can estimate a true "market" price. Depending on the number of true arms-length cash transactions reported in the transactions for salmon and/or pollock, and the period of the season in which they arise, it may be difficult to derive a representative market value indicating the value of salmon bycatch throughout the year. In Options 2a and 2b above, we discuss the value and limitations of these data.

If *a priori* expectations are that insufficient arms-length transactions are likely to exist under a salmon bycatch quota market, auction mechanisms can be used to construct a series of price data from which to derive a more defensible measure of the value of salmon bycatch. Conducting an auction for some portion of the quota would not require a diminution of the quota available to the fishery. Rather, there are a number of ways that such an auction could be conducted in which any sales revenue earned in the auction is returned to the quota contributor. For example, some percentage of each vessel's quota (e.g., 20%) could be added to a pot of quota that would be auctioned off at one or more points during the season. A blind bidding process would take place and the prices would be recorded. The revenue from the auction would be returned to the contributors of the quota in proportion to their contribution.

An extensive literature on developing efficient, fair, and transparent auctions exists (e.g., Klemperer 2002, Cramton 2007, Crampton 2009, Roth 2008) and can be drawn upon to develop a mechanism for transparent resource pricing in an uncertain environment (Cramton 2009). Auctions can readily be conducted through the internet with minimal transaction costs and in a manner compatible with potential bidders who may be spread across the Bering Sea. Should an auction system be desired, a range of considerations could be included to structure the auction to meet the Council's informational needs. An additional advantage of this option would be that it could be utilized to mitigate potential issues of market power at the end of the season, in which individuals could hoard quota and extract monopoly rents from others who have no option but to purchase salmon to fish their pollock quota or potentially comply with (currently unknown) IPA provisions.

A second data collection option that we considered but did not present in the main body of the paper was to collect fixed costs in addition to variable costs in Options 4a and 4b. Although the primary vessel costs that may be affected by Amendment 91 relate to the variable costs of relocating from one site to another and having to fish and/or process for

a longer period of time to catch a given level of quota, the degree to which fixed costs (e.g., capital expenditures on vessel improvements; vessel maintenance and haulouts; overhead including office space, administrative staff and sales personnel; legal and administrative fees associated with cooperative agreements and vessel associations) incurred by pollock fishery participants will also be affected by Amendment 91 is uncertain. Clearly any expenditures on salmon IPA development and administration will represent new fixed costs, but whether companies' overall profits will affected to the point that fixed costs such as capital improvements or investments may be diminished is unknown.

However, we should point out that even if one is able to precisely estimate the changes in variable costs associated with Amendment 91, without a full accounting of all the costs (fixed and variable) and revenues of each company, one cannot state whether the cost of Amendment 91 is significant relative to the profits being earned. Put another way, a cost impact of $1 million per year will have markedly different impacts on a company depending on whether it earns $1 million or $100 million in profits. Without that context it may be difficult for the Council to judge whether the costs imposed by Amendment 91 are disproportionately large.

Defining the profits earned by a company is a very complicated and potentially subjective process (subject to advanced accounting and tax practices), and is out of the scope of expertise of AFSC staff. Thus, should all of the fixed and variable costs associated with a vessel be collected, with the aim of deriving profit estimates, one would have to do so at a company level; a vessel-level approach would be difficult and/or misleading because company-level overhead costs may not be accurately apportioned to a single vessel for a multi-vessel company. Linking individual vessels to companies would also require detailed ownership data on all vessels (discussed in Option 5 of Section 4, above). The expertise of certified public accountants would also be required once ownership patterns were defined in order to derive profit measures for each company. This process would be more difficult for some companies than for others. Some companies have considered going public and as such have detailed profit records available. All companies are required to report profits to the Internal Revenue Service, but such information includes all aspects of their business operations, which may include endeavors outside of pollock fishing. If one's goal was to derive measures of profit derived from pollock fishing these financial documents would need to be reworked for companies engaged in other business activities. In sum, collecting all fixed and variable costs for a vessel with the goal of defining profits would be a challenging and costly task requiring a significant investment in time to plan and coordinate a proper study.

Finally, although collecting data on revenues and costs received after the implementation of Amendment 91 will help analysts better understand spatial fishing decisions going forward, it may also be informative to collect such data from the past, should it be available from industry. The additional information and observations indicating past years' site-specific financial returns can be used in conjunction with records of spatial fishing patterns to help make models of future fishing behavior more robust and to facilitate comparisons of how salmon avoidance costs may change under Amendment 91. For the first year or two under the program there will be a relatively small number of

observations from which to examine and model economic returns and fishing choices, making analysis of program impacts challenging. The availability of historic data would increase the number of observations available for statistical models, increasing the degrees of freedom and improving the accuracy of parameter estimates.