The FishSource Method for Scoring Salmon Fisheries

A statistical approach for aligning the FishSource salmon fishery assessment method with Marine Stewardship Council ratings

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Executive Summary

The world of seafood sustainability ratings is becoming increasingly complex due to the multiplicity of involved organizations and ratings schemes that target various audiences (e.g., consumers, retailers, suppliers, etc.). One new development is the appearance of assessment method versions tailored to suit the specificities of a particular seafood commodity (e.g., a species group). Amidst the various organization- and species-specific rating schemes, it is important to develop means of comparison between assessment methods in order to foster a better understanding of what the ratings signify. This report describes analyses applied to Marine Stewardship Council (MSC) ratings of Pacific salmon fisheries in 2007–2013, including an exploratory and inferential statistical approach. Results were used in the effort to align Sustainable Fisheries Partnership's FishSource (www.fishsource.com) salmon-specific assessment method with MSC's ratings of salmon fisheries, but the approach also has broader applications for improving the quality of seafood sustainability ratings.

1. Introduction

Sustainable Fisheries Partnership (SFP) is a business-focused NGO that is reshaping the world of corporate responsibility in the seafood industry through the creation of powerful information tools and a methodology that allows companies to directly engage with suppliers of natural resources. SFP is currently playing a key role in the sustainable seafood movement by providing seafood retailers with actionable information that can be used in order to catalyze improvements (through the inception and implementation of Fishery Improvement Projects) in their supply chains (Bush et al. 2013).

SFP created the FishSource online database (www.fishsource.com) in 2007 as its main tool for the generation of impartial, accurate, up-to-date information about fish stocks and impacts of fishing activities. The website is intended to inform both fish suppliers and retailers through the presentation of sustainability scores and summaries, as well as the fishery science community and general public through the inclusion of more descriptive information and in-depth research results for some fisheries.

FishSource is not intended to serve as an independent eco-label. There are several fisheries eco-labeling programs currently in existence, each with its own specificities in terms of assessment methodology and protocols. While eco-labels and associated assessments can provide valuable information to seafood retailers, they do not cover all of the world's fisheries due to their cost and political inertia among fisheries with improvement needs that are unlikely to pass when assessed against particular certification schemes. Assessment reports are also often quite technical in their nature and not likely to achieve a wide audience in the seafood industry.

FishSource addresses considerations of cost and audience fatigue with overly technical information by using a simplified scoring format that currently covers only five criteria of sustainability, while eco-label certification assessments typically cover upwards of 30 criteria. SFP has chosen to prioritize those performance indicators that can be scored affordably and reliably based on standard fisheries statistics commonly available for assessed fisheries around the world.

As it is not an independent eco-label, FishSource does not have its "own" sustainability ratings. Instead, FishSource scoring is based upon Marine Stewardship Council (MSC) standards. SFP considers the MSC a good, global "average" standard to measure the relative sustainability of a fishery at a given time. In 2007, SFP conducted a statistical analysis of MSC whitefish fishery assessment ratings, developing the underlying ratios and scoring benchmarks for FishSource's five sustainability criteria on its basis (Table 1) (Cannon 2007). FishSource scores fisheries on a scale of 0–10, while MSC uses a scale of 60–100. FishSource scores of 6–10 align with MSC ratings of 60–100, with critical benchmarks occurring at the 6/60 (scores below this threshold are considered to have failed an MSC assessment), 8/80 (scores below this threshold on an MSC assessment indicate that improvements are needed), and 10/100 (unconditional MSC assessment pass) levels.

Table 1: Five criteria for target stock status and management quality employed by FishSource for scoring and the respective goal posts (Sousa et al. *in draft*).

Issue	Measure	Underlying Ratio
Is the management strategy precautionary?	Determine whether harvest rates are reduced at low stock levels.	$F_{advised}/F_{target\ reference\ point}$ or $F_{actual}/F_{target\ reference\ point}$
Do managers follow scientific advice on output controls?	Determine whether the catch limits set by managers are in line with the advice in stock assessments.	Set TAC / Advised TAC
Do the fishers comply?	Determine whether the actual catches are in line with the catch limits set by managers.	Actual catch / Set TAC
Is the fish stock healthy?	Determine if current biomass is at long-term target levels.	SSB/B_{40} or equivalent
Will the fish stock be healthy in the future?	Determine if current fishing mortality is at the long-term target level.	$F/F_{target\ reference\ point}$

In 2012, MSC released a draft salmon-specific default assessment tree for public stakeholder review after spending 2 years working to develop separate guidelines for the assessment of salmon fisheries (MSC 2012). The biology and management specificities of the salmon species group, including the different parameterization of management statistics vis-à-vis whitefish, were motivating factors in MSC's decision to undertake this effort. Correspondingly, SFP decided to develop a separate FishSource method for salmon. As with derivation of the original FishSource scoring model, a statistical analysis of MSC rating of salmon fisheries was conducted as described in this paper. Where statistically significant trends were identified, the MSC method was condensed into a desktop-assessment format suitable for FishSource's purposes.

While the main purpose of this work was to develop an assessment method for use in the FishSource database, this work is also applicable to MSC and other eco-labeling organizations in their quality control efforts to tighten scoring around means and reduce

variability among the efforts of independent certification bodies. Such statistical analyses could also be used to compare one certification scheme with another and determine whether scoring thresholds are comparable.

2. Methodology and analysis

A FishSource salmon working group was convened to advise on the development of this project. The group included members familiar with salmon management systems in Alaska, Russia, and British Columbia. On the basis of personal expertise and initial empirical, non-statistical analysis of MSC assessments of salmon fisheries and the main themes that are contained within, the working group identified **escapement-based management** and **hatcheries** as two defining features of salmon fishery management, a conclusion supported by management policies and scientific literature (ADF&G 1992; Augerot and Smith 2010; Makeev 2010). Consequently, these issues were prioritized when conducting the statistical analysis of MSC ratings in an effort to develop scoring criteria and benchmarks that align as much as possible with MSC's approach. Other salmon-specific elements of fisheries management that were deemed relevant to the FishSource approach to fisheries assessment were also identified.

The overall strategy with respect to detailed analyses of the two focal issues involved examination of all relevant, MSC textual performance indicator rationales and identification of the variables that were influential in the determination of MSC ratings. Both quantitative and qualitative variables were identified. For quantitative variables, relevant, supporting data sets were compiled both from assessment reports and from stock assessment documentation and other publicly available information. For each of the qualitative variables, a categorization was developed to reflect the content of the textual MSC rationales.

Exploration of the two prioritized issues resulted in the successful adaptation of two of the five FishSource scores for use in assessment of salmon fisheries. Score 4 is devoted to stock status (including assessment of escapement trends), and Score 5 focuses upon hatchery impacts on wild stocks. The other three scores were also adapted to the specificities of salmon fishery management, but without rigorous analysis of MSC assessments.

2.1 Data

<u>Stock Status (Score 4)</u>

Data regarding stock status was compiled both at the certification unit scale and at the stock[1] scale. MSC ratings for 30 certification units were taken from the stock status

[1] The FishSource definition of salmon "stock" - A group of salmon of the same species that is geographically and temporally related and is managed as a unit. This is the group of fish for which there is (or could be) a single escapement goal, i.e., the part of a fish population that is under consideration from the point of view of actual or potential utilization.

performance indicators 1.2.2 (in older assessments) and 1.1.1 (in new assessments). Both of these indicators focus upon the current status of the target species or stocks, with benchmarks that describe specific levels of performance against reference points (SCS 2007; MSC 2010). As most salmon fisheries are mixed-stock fisheries that target multiple salmon stocks, most MSC certification units include more than one stock. For the purposes of our analysis, MSC stock status ratings of certification units were attributed to all stocks nested within a certification unit – it was assumed that all stocks inherited the same rating. In cases where the certification body applied a rating of "na" to a particular certification unit (unique to the Alaskan and British Columbia sockeye salmon certifications), data for stocks in those certification units was not included in the analysis.[2]

Examination of MSC rating rationales yielded a list of seven variables that were possibly influential in determination of ratings (Table 2), most of which are quantitative in nature.

Table 2: The seven variables found to be potentially influential in explaining variation in MSC rating of stock status performance indicators.

1	Number of missed escapement goals
2	Number of missed Limit Reference points
3	Trends in escapement
4	Trends in harvest
5	Role of ocean conditions in determining stock status trends
6	Role of inherent productivity dynamics in determining stock status trends
7	Management responsiveness to stock status declines

Fifteen-year per-stock escapement and certification unit harvest data series were obtained from publicly available management reports, as were escapement goals. For each of the seven certified fisheries (Alaska, Annette Island, British Columbia pink salmon, British Columbia sockeye salmon, Iturup Island pink and chum salmon, Northeast Sakhalin pink salmon, and Ozernaya sockeye salmon), the 15-year series ends with the last date referred to in scoring rationales of the assessment (2006, 2008, 2006, 2008, 2007, 2011, and 2011, respectively).

Escapement data was obtained in units of both percent of spawning ground filled (Annette Island, Iturup Island, Northeast Sakhalin, and Ozernaya) and number of fish (all other fisheries). In the 30 salmon certification units[3] for which ratings in a finalized certification

[2] The Alaskan and British Columbia sockeye salmon MSC assessment certification bodies awarded ratings of "na" for performance indicator 1.2.2 when no stocks of regulatory concern were included in a certification unit. In some of these cases, stocks within these certification units had failed to meet management objectives multiple times in the recent past. However, this was not taken into account, and the ratings of "na" were summarily assigned to the units. In the other MSC salmon fishery assessments, certification bodies considered stock performance against management objectives in scoring. As the ratings of "na" were assigned using a different process than that of other ratings, we did not consider them to be equal to "100," and instead decided to leave them out of the data set. We consider these ratings of "na" as examples of undesirable varying interpretation of the MSC standard by certification bodies.

[3] The Southeast Alaska gillnet and purse seine certification units were treated as a single unit for the purposes of this analysis, as the units were scored identically on relevant performance indicators.

report existed at the time of the analysis, our research found a total of 388 stocks with management objectives (escapement goals or exploitation rate limits) currently in place. However, many of these stocks are not explicitly cited in stock status performance indicator rating rationales and do not seem to have motivated determination of ratings. Therefore, only data sets for the remaining 89 stocks that are cited in relevant rating rationales were included in the analysis (Box 1, Annex B).

Box 1: Textual rationale for the MSC rating of stock status performance indicator 1.2.2 for the Bristol Bay certification unit in the 2007 Alaska salmon assessment (SCS 2007). While the Bristol Bay salmon fishery is managed to achieve 15 escapement goals, the MSC rating rationale indicates that the Kvichak sockeye salmon stock was focal in determination of the rating of "90." Therefore, only data for this stock was included in our analysis.

1.2.2: Depleted Stocks. - ADFG and the Board of Fisheries has identified the Kvichak sockeye salmon stock as the only depleted stock in Bristol Bay. ADFG has not allowed directed fishing on Kvichak salmon for most recent years. ADFG has taken actions to reduce incidental harvests of Kvichak salmon in adjacent areas by moving these fisheries into river mouths where Kvichak salmon are likely to be less abundant. Genetic analyses will be conducted to evaluate Kvichak salmon taken in adjacent areas. Some research indicates that Kvichak sockeye salmon has innate low productivity relative to other stocks and that its decline is largely related to environmental factors beyond ADFG's control. There is general agreement that methods to estimate escapement and harvest rates of targeted stocks in Bristol Bay are adequate. Several other stocks have experienced escapement levels below the goal in some years but harvest rates are typically low: Nushagak River coho, and Naknek Chinook salmon (incidental harvest). ADFG has recommended revisions of escapement goals for some Bristol Bay stocks.

Escapements were compared against escapement goal lower bounds (if the goal is expressed as a range, or just against the goal if not), as well as against limit reference points. Because limit reference points are often not explicitly defined by salmon management systems, they were derived from the escapement goal lower bound, and were assumed to be equal to 50% of the lower bound. This aligns with Alaska Department of Fish and Game's principle of a Sustainable Escapement Threshold that is equal to 50% of MSY escapement (Swanton 2005). For those stocks with escapement expressed as percent of spawning grounds filled, the escapement goal lower bound was assumed to be 50% of spawning grounds filled, (and the limit reference point, 25% of spawning grounds filled). This aligns with the MSC's approach to the assessment of three Russian salmon fisheries that use this type of goal (SCS 2009; MRAG Americas 2012a and 2012b).

Fishery harvest data was gathered for the same 15 years in the units in which it is reported. Data was organized at the scale of the certification unit rather than the stock. Fifteen-year harvest data series were also gathered for two neighboring fisheries (generally those located to the north and south of the certification unit) in order to explore whether trends were motivated by ocean conditions. Such comparative harvest trend analyses have been used in other studies to explore causes for harvest declines; notably, Hilborn and Eggers (2000) compared wild harvest trends of pink salmon between Prince William Sound and nearby Kodiak to explore the possible link between abundance declines and density-dependent interactions with hatchery fish.

Two categorized variables were included in the stock status data set – for each stock, one, two, or three points were attributed for management responsiveness to stock status declines, as rating rationales indicated that responsiveness was a motivating factor in determination of ratings despite the fact that other performance indicators in the MSC assessment tree focus particularly upon it. A single point indicates no management response to stock declines; two points, inadequate response; and three points, adequate response or absence of stock declines. These rankings were derived from rating rationales for stock status or management responsiveness-related performance indicators.

The second categorization addressed the question of whether a particular stock's "inherent productivity dynamics" were responsible for declines in escapement (for example, productivity declines in a sockeye salmon stock due to declines in lake nutrient quantities that cannot be attributed to human activity). Two points were attributed to fisheries if such issues were implicated in stock declines in MSC rating rationales, while one point was granted if not.

Hatchery Impacts (Score 5)

As pertains to hatcheries,[4] the following quantitative data was gathered from publicly-available sources: percent of hatchery contribution to harvest or total returns (generally either one or the other estimate was available for a fishery), number of annual hatchery releases, and percent of hatchery fish marked. An examination of MSC rating of the most relevant performance indicators (1.1.1.5 in old assessments, which addresses enhancement outcomes, management, and information; and indicators 1.3.1, 1.3.2, and 1.3.3 in new assessments, which are targeted toward those three sub-issues[5]) yielded 27 additional qualitative variables that were potentially influential in determination of ratings. We categorized these variables (as with management responsiveness above) in order to reflect the nature of the certification body's assessment (Table 3). Details on the categorization process can be found in Annex A.

Because most of the hatchery data could be aggregated only at the certification unit/fishery scale rather than the stock scale, the MSC rating analysis was limited by the number of data points (i.e., the number of data points was equal to the number of certification units that received ratings in MSC reports). Recognizing that the sample size could limit further inference, the following steps were taken to increase the number of data points:

1. Four British Columbia chum salmon certification units were included although the assessment report was in draft at the time of our analysis (Annex B);
2. Data points were added when certification units were re-rated during surveillance audits; and

[4] Fish from spawning channels were also considered "hatchery fish" in this study.
[5] For the purposes of this study, the lowest rating of each of the three enhancement-related performance indicators was taken as the single observation for fisheries that underwent assessments under the more recent assessment tree. As a result, all fisheries were represented by one multivariate observation in hatchery impacts statistical analyses, except for those fisheries that were re-rated in subsequent MSC surveillance audits, resulting in two observations.

3. Ratings of "na" given to units without hatchery programs, and thus referring to situations where absence of hatchery impacts is reasonable to expect, were replaced with ratings of "100" and included in our analysis.

Table 3: The 30 variables found to be potentially influential in explaining variation in MSC ratings of hatchery performance indicators.

1	Percent of hatchery fish in catch or in total returns
2	Number of hatchery releases
3	Percent of hatchery fish marked
4	Species of salmon assessed
5	Are hatchery fish harvested in a terminal fishery?
6	Is the quantity of hatchery releases small?
7	Are there ongoing mark & recapture studies that support a wild stock-focused management effort?
8	Is there stock-specific escapement and straying monitoring?
9	Are there adequate harvest estimates and exploitation rate information for individual stocks?
10	Does management attempt to manage for the wild stock?
11	Is the percent of hatchery fish in catch or total returns small?
12	Are precautionary (differential) harvest measures in place?
13	Is existing research published and sufficient to prove that hatchery impacts are insignificant?
14	Are wild stock-specific escapement goals in place?
15	Have wild stock-specific productivity estimates been generated?
16	Is it likely that hatcheries have directly, negatively impacted wild stocks?
17	If straying has not been sufficiently measured, is the likelihood of significant straying high?
18	Is there a conservation hatchery program in place? / Is there a hatchery program in the fishery that is substituting for a stock rebuilding strategy?
19	Is current hatchery management sufficiently precautionary?
20	Are adequate numbers of fish marked?
21	Has the quantity of hatchery releases been increased during the certificate period?
22	Are up-to-date wild salmon policies, enhancement plans, monitoring plans, and/or long-term objectives in place?
23	Do existing studies indicate that straying exceeds thresholds suggested by research/management?
24	Have sufficient management actions been taken to reduce straying?
25	Are hatcheries evaluated as part of the fishery management evaluation?
26	How often are management evaluations conducted?
27	Are the evaluations peer reviewed?
28	Is impact on wild stocks assessed as part of the hatchery evaluation process?
29	Are hatchery evaluators independent?
30	Are hatchery evaluation results made public?

2.2. Methods

The overall approach employed in this analysis involved assemblage of data sets that address certification unit performance with respect to the variables identified in Tables 2 and 3. Where possible, supporting quantitative data was assembled. For those variables that were more qualitative in nature (e.g., variables 5, 7, 8, etc., in Table 3 – see more in Annex

A), categorization was accomplished to reflect the MSC performance indicator rationales. Exploratory statistical methods were used to identify those variables with potentially meaningful impacts upon rating variability. Inferential statistical methods (statistical modeling) were then employed to test for the presence of statistically significant correlations and then to make rating predictions upon the explanatory variable set. Finally, results were incorporated into FishSource sub-criteria scoring benchmarks.

Stock Status (Score 4)

Assessment trees applied in the MSC salmon assessments differ in their benchmarks for escapement performance against management objectives. The various benchmarks look at performance against target reference points or limit reference points over 5 years, 10 years, or an unspecified period of "recent years." Due to this variation in assessment tree language, we calculated the number of missed escapement goals in the 15, 10, 7, and 5 years prior to assessment. The percent change in escapement over 15 years, which we consider to be the most optimal period of time for the assessment of trends (as it includes multiple generations of any salmon species or brood line), was calculated using the method of Geiger and Zhang (2002). This robust regression approach yields annual change expressed as a percent of year-zero – this rate of annual change was then multiplied by 15 to yield an estimate of the rate of change in stock escapement over the 15-year period.

Escapement data was not available for some years of the 15-year series of particular stocks. In those instances, missing data points were filled in with the mean of data points on either side of the missing point. In other cases, it was not clear whether an escapement goal was in effect in earlier years of the series. In those instances, it was assumed that the earliest-appearing goal in the series was also in place in the earlier years of the series. See the Appendix to the FishSource salmon scoring method for more details on the use of the Geiger and Zhang method (Portley et al. 2013).

Only 3 years of escapement data prior to issuance of the MSC assessment report were available for Iturup Island pink and chum salmon. Due to the paucity of escapement data for Iturup Island stocks, data for 2008–2011 was also included in the analysis. While this data was not available at the time of rating determination, it was available to the certification body during subsequent certification audits, and changes to ratings could have been made upon their basis.

The Geiger and Zhang robust regression analysis was also applied to certification unit harvest data, yielding an estimate of the annual rate of change in harvest expressed as a percent of the year-zero harvest. Where it was possible to do so, hatchery fish were excluded from this calculation in order to obtain estimates particular to wild stocks. The same analysis was applied to the harvest data of two neighboring fisheries. Categorization was used to summarize the results of the harvest analysis and represent the likely role of ocean conditions in determination of declining stock trends: if there were not annual declines of at least 3% in the fishery and both of its neighbors, one point was assigned to the fishery (ocean conditions are likely not responsible for declines); if declines of 3% or more were present in all three fisheries, two points were granted (it is possible that ocean

conditions are resulting in declining harvest trends). The categorization was applied equally to all nested stocks within a particular certification unit.

Hatchery Impacts (Score 5)

Most (27 of 30) of the variables that were possibly influential in MSC ratings were best addressed through categorization rather than quantitative data sets. Many of the variables were categorized to reflect binary rater responses (i.e., one point for a response of "no," two points for a response of "yes"). The categorizations for some other covariates were more complex, with different amounts of points awarded for 3–5 possible gradations of performance.

For both the stock status and hatchery rating data sets, exploratory statistical methods were employed to identify best candidate variables for additional analysis of variation. Normal distribution was assumed. Boxplots were the chief method employed, both with categorized and quantitative data sets. Following identification of a sub-set of variables that might exhibit statistically significant co-variation with ratings, Generalized Linear Models were developed in an effort to explain variation in ratings as a function of covariate interaction. All exploratory and inferential statistical analyses were accomplished using R statistical software, version 2.15.1. Modeling results were incorporated into FishSource assessment benchmarks.

Other Salmon-Specific Adaptations (Scores 1, 2, 3)

Other issues relevant to FishSource scoring (illegal fishing, management responsiveness, management guidelines, data accuracy) were addressed using a rapid assessment format that looked at MSC assessment rating rationales of relevant performance indicators which were rated at or around the benchmark thresholds of 60, 80, and 100. Supporting evidence from assessment tree language was also used in some cases.

3. Results

On the basis of the salmon working group's efforts to identify those salmon-specific fisheries management elements that are relevant to the FishSource assessment model and addressed in MSC assessments, the five FishSource scores were adapted for use with salmon fisheries (Table 4). The overall structure was maintained, with the addition of nested sub-scores within the five-score framework. The first four scores in the adapted salmon version align with the original whitefish scores in their overall focus, although Score 3 is expanded to explore overall accuracy of data, including deviance in harvest data that results from illegal fishing. As with the original version, Score 4 of the salmon version addresses current stock health; although escapement and harvest trends, rather than spawning biomass (a parameter that is not used on a standardized basis in management of salmon fisheries), are used as the indicators of stock status in alignment with results of MSC rating analysis. Due to the importance of hatcheries in salmon fishery management, the focus of Score 5 was adapted to particularly address hatchery impacts upon wild stocks.

The process of developing scoring benchmarks to accompany each sub-criterion ensued upon finalization of the scoring structure, with prioritization of Scores 4 and 5 in terms of efforts at alignment with MSC ratings. The following two sub-sections describe the results of exploratory and inferential analyses focused upon development of benchmarks for those two scores.

Table 4: Salmon-specific adaptation of the five FishSource scores developed for use in assessment of whitefish fisheries.

Issue /Score (Whitefish)	Issue/Score (Salmon)	Nested Sub-Scores
1. Is the management strategy precautionary?	1. Is management responsive?	1.1 In-season responsiveness 1.2 Multi-season responsiveness 1.3 Responsiveness to habitat issues
2. Do managers follow scientific advice on output controls?	2. Are the management guidelines appropriate?	2.1 Escapement goal development and implementation
3. Does the fishery comply?	3. Are the management guidelines and responses based on adequate data?	3.1 Illegal harvest and deviation between reported and actual catch 3.2 Harvest monitoring 3.3 Escapement monitoring
4. Is the fish stock healthy?	4. Has stock productivity been maintained?	4.1 Escapement trends 4.2 Harvest trends
5. Will the fish stock be healthy in the future?	5. Are hatcheries or other enhancement activities negatively affecting wild stocks?	5.1 Hatchery contribution to fishery 5.2 Wild stock management 5.3 Straying magnitude and measurement 5.4 Hatchery: wild stock mixing 5.5 Hatchery policies

3.1 Stock Status (Score 4)

Exploratory analysis: stock status

Exploratory analysis of escapement data indicated that there was wide variation with respect to impact on MSC ratings (Figures 1 and 2). Similarly high variability was observed for stock performance against both escapement goal lower bounds and limit reference points, as well as for the 15-, 10-, 7-, and 5-year time series.

Sample size was small for desegregation at the 15-year scale (89 data points, 16 groups); therefore, the number of missed escapement goal lower bounds was categorized. We categorized the variable into three groups chosen in order to maximize difference in MSC rating – 0–3 missed escapement goals (group 1), 4–7 (group 2), and 8–15 (group 3). Three groupings were used in an effort to devise FishSource benchmarks for the "6," "8," and "10" scoring levels. Categorization of this variable indicated meaningful differences between ratings of those stocks that missed 0–3 goals compared to the other two groups (no overlap of "notches" in boxplots strongly suggests significant differences between groups – Figure 3). No differences are suggested between groups 2 and 3, although the few observations within the latter group may weaken this conclusion.

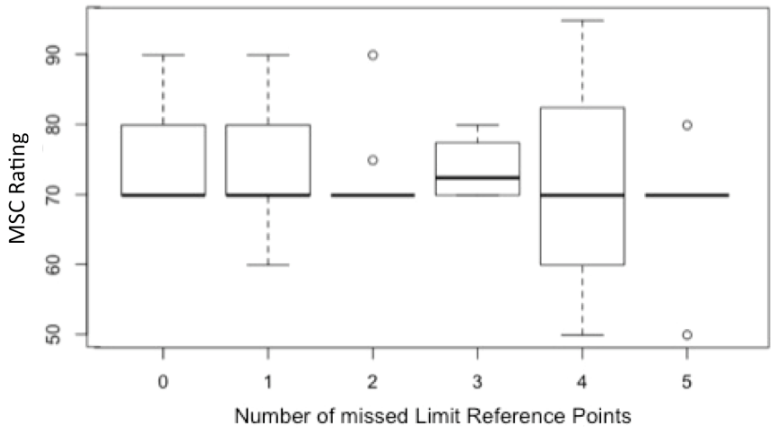

Figure 1: Comparison between the number of missed limit reference points in the 5 years prior to MSC assessment and the MSC ratings that were received. The 89 stocks referred to in supporting textual rationales are included in the data set. No difference in rating across the number of missed reference points was detected. One would expect higher ratings for stocks with fewer misses.

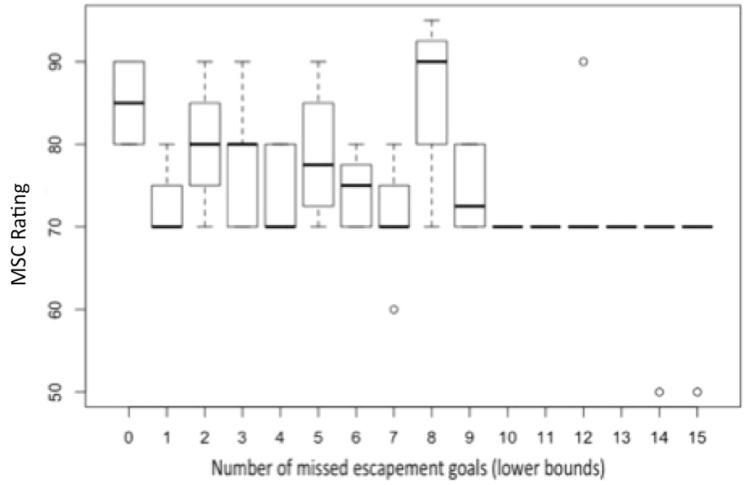

Figure 2: Comparison between the number of missed escapement goal lower bounds in the 15 years prior to MSC assessment and the MSC ratings that were received. The 89 stocks referred to in supporting textual rationales are included in the data set. No difference in rating across stocks with 0-8 missed goals was detected. Higher ratings are expected for fewer missed goals.

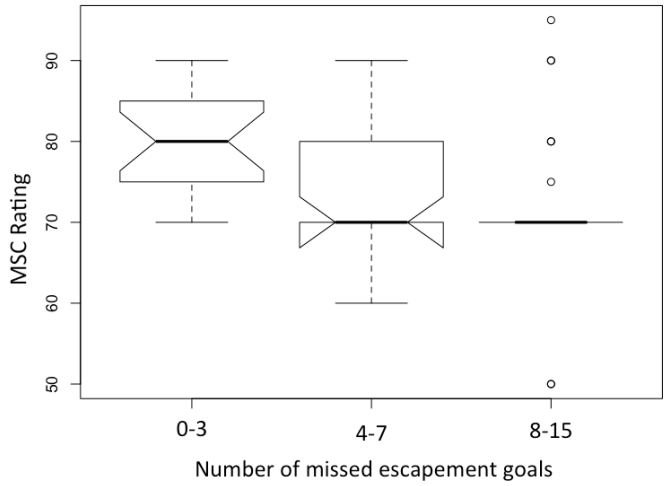

Figure 3: The results of Figure 2 (number of missed escapement goal lower bounds in the last 15 years versus MSC scores) are presented in categorized format. Groupings were chosen in order to maximize difference in MSC rating, and three groupings are used in an effort to devise FishSource benchmarks for the "6," "8," and "10" scoring levels.

Boxplots (and linear plots for desegregated data, not shown) of MSC ratings versus percent change in escapement indicated wide variability in ratings with respect to this variable. While it was expected that stocks with declines in escapement would rate lower than stocks with stable or increasing escapements, no meaningful conclusions could be drawn from the data (Figure 4).

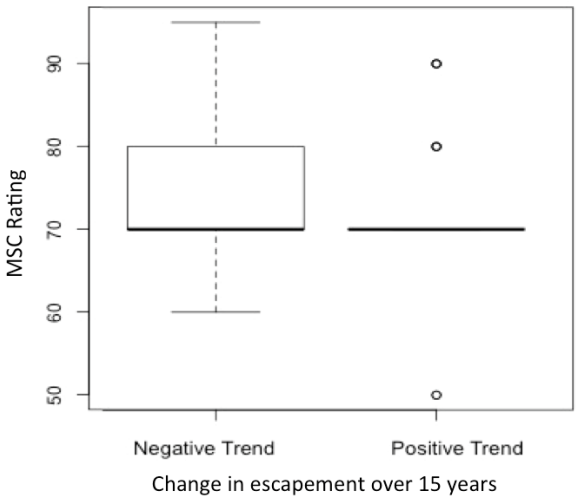

Figure 4: Escapement trend: no meaningful difference in MSC ratings was detected between those stocks that had negative trends in escapement prior to scoring and those stocks with positive trends.

As with escapement trends, ratings of certification units with negative and positive wild harvest trends were compared using a boxplot (Figure 5). Categorization was also employed to compare different harvest scenario trends among the assessed certification unit and its two neighboring fisheries (Figure 6). Scenarios where meaningful declines in harvest trends were shared by neighboring fisheries were scored higher than other fisheries, indicating that certification bodies may have scored lighter for situations where ocean conditions were perceived as the main driver of stock status.

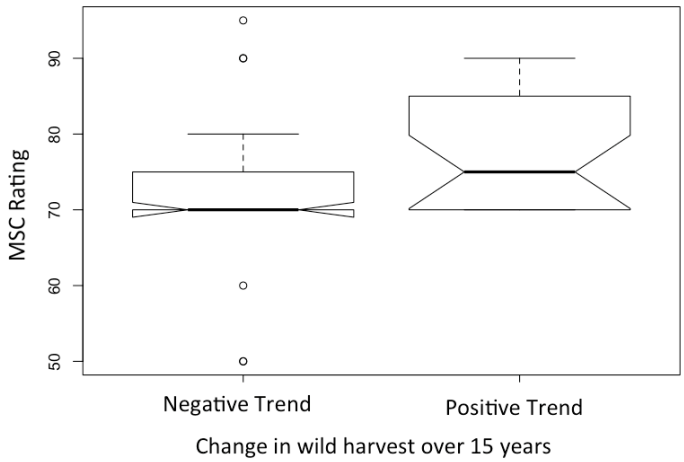

Figure 5: Ratings of fisheries with negative and positive trends in harvest over the 15 years prior to scoring are compared. As expected, those fisheries with positive harvest trends appear to have received higher ratings, although there is overlap between notches.

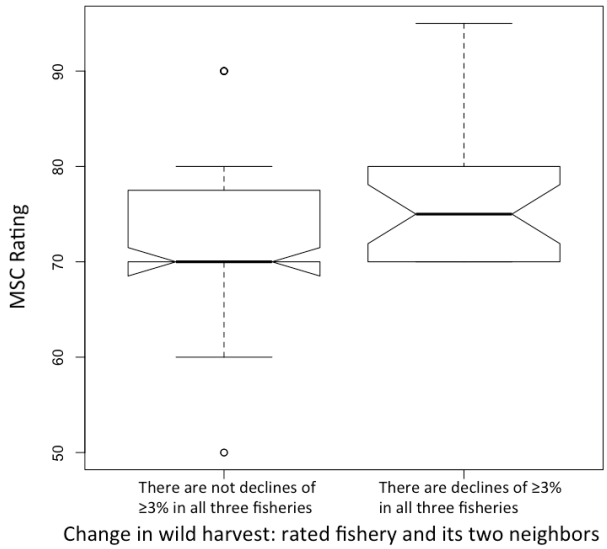

Figure 6: Fisheries with larger rates of annual decline in wild harvest that are shared among neighboring fisheries received higher ratings than those with less meaningful trends, suggesting that scorers made allowances for ocean productivity.

The impact of management responsiveness upon MSC ratings was also explored in a boxplot comparing ratings of fisheries where management was responsive to declines (or fisheries where there were no declines) with those where management was not responsive (Figure 7). Results were not clear (notches overlap), but fisheries that exhibited responsiveness did receive a higher range of scores than those that did not.

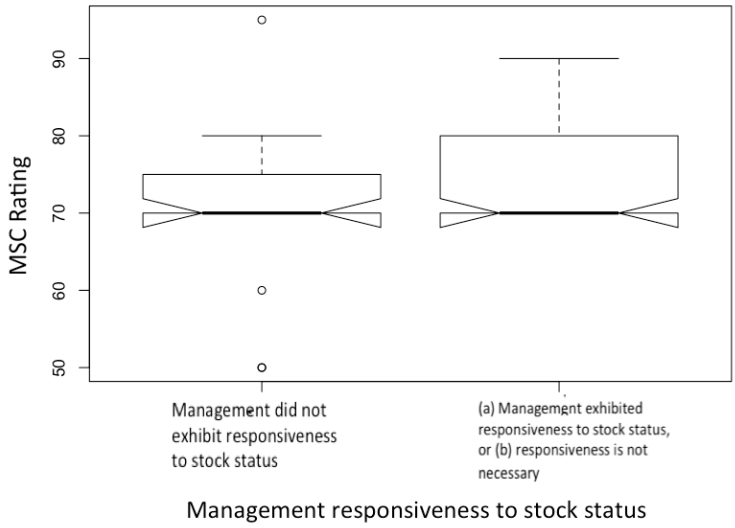

Figure 7: Comparison of ratings between fisheries in which either (a) management exhibited responsiveness to stock status declines, or (b) no declines occurred; and fisheries in which management did not exhibit responsiveness to stock status. No meaningful difference in MSC ratings was detected between stocks that had declined without management responsiveness and stocks where either management had been responsive or no declines occurred. The range of scoring does extend higher for the second grouping, however.

Exploratory analyses suggested that three of the variables (escapement performance against goals, wild harvest trends among the certification unit and two neighboring fisheries, and management responsiveness) may influence variability of MSC ratings. Generalized linear modeling (GLM) was used to explore this subset of variables further.

Modeling: stock status

GLM modeling was conducted using MSC ratings of stock status indicators as the response variable (treated as continuous) and the following co-variables: categorized escapement performance over the 15 years prior to scoring (groupings align with Figure 3), categorized harvest trends (Figure 5), categorized role of ocean productivity in determining stock status trends (Figure 6), and categorized responsiveness of management to declines in stock status (Figure 7). The Gaussian distribution model was assumed for the response with the identity link function.

It was not possible to generate a GLM with desired statistical significance of co-variables and accountability for variance in ratings. The best model, achieved through a "stepwise, backward approach," is indicated in Figure 8, and can be used as a basis upon which to incorporate the four included co-variables into FishSource benchmarks for stock status. All variables included in the model are statistically significant ($p < 0.1$), but the model explains a small proportion of the total variance in the data (about 37%). According to this model, on average, and constrained by the high amount of unexplained variance, a stock with 0–3 missed escapement goals in the past 15 years, stable or increasing harvest, and responsiveness to stock status declines (or no problems with stock status) would rate approximately "82." If harvest trends are declining, 6.7 points are subtracted from the score, but if ocean productivity trends are motivating the declines, the points subtracted for harvest declines are basically reinstated (6.6 points are added).

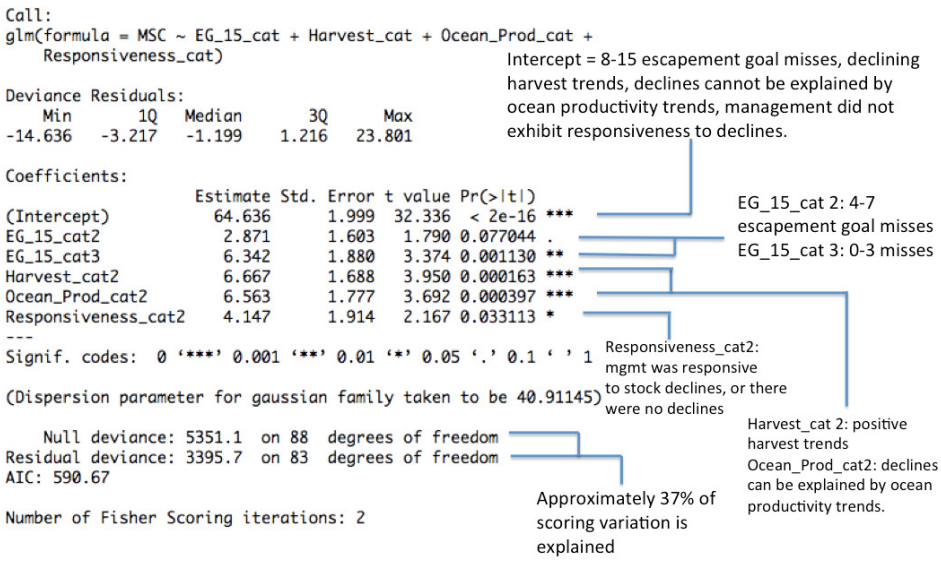

Figure 8: Generalized Linear Model result analyzing variance in MSC ratings for stock status performance indicators.

Figures 9–11 include alternative models to the final one, noting lower variability explained and/or statistical insignificance of co-variables.

```
Call:
glm(formula = MSC ~ EG_15_cat + Harvest_cat + Ocean_Prod_cat)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-18.087   -3.159   -1.252    1.913   21.841

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)      68.087      1.235  55.142  < 2e-16 ***
EG_15_cat2        3.165      1.632   1.939 0.055863 .
EG_15_cat3        7.695      1.812   4.247 5.58e-05 ***
Harvest_cat2      6.378      1.719   3.710 0.000372 ***
Ocean_Prod_cat2   5.073      1.675   3.029 0.003257 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 42.71118)

    Null deviance: 5351.1  on 88  degrees of freedom
Residual deviance: 3587.7  on 84  degrees of freedom
AIC: 593.57

Number of Fisher Scoring iterations: 2
```

Figure 9: Alternative Generalized Linear Model result analyzing variance in MSC ratings for stock status performance indicators.

```
Call:
glm(formula = MSC ~ EG_15_cat + Ocean_Prod_cat + Responsiveness_cat)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-17.510   -2.546   -1.058   -1.058   23.759

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)         67.510      2.017  33.467  < 2e-16 ***
EG_15_cat2           2.756      1.737   1.587 0.116356
EG_15_cat3           7.567      2.009   3.767 0.000306 ***
Ocean_Prod_cat2      3.731      1.762   2.118 0.037171 *
Responsiveness_cat2  3.548      2.067   1.717 0.089718 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 48.02371)

    Null deviance: 5351.1  on 88  degrees of freedom
Residual deviance: 4034.0  on 84  degrees of freedom
AIC: 604.01

Number of Fisher Scoring iterations: 2
```

Figure 10: Alternative Generalized Linear Model result analyzing variance in MSC ratings for stock status performance indicators.

```
Call:
glm(formula = MSC ~ Harvest_cat + Ocean_Prod_cat + Responsiveness_cat)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-14.5132   -2.3519   -0.7699    1.3914   22.6481

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)         64.513      2.025  31.857  < 2e-16 ***
Harvest_cat2         7.512      1.754   4.282 4.84e-05 ***
Ocean_Prod_cat2      7.839      1.817   4.313 4.31e-05 ***
Responsiveness_cat2  6.257      1.907   3.281   0.0015 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 45.68951)

    Null deviance: 5351.1  on 88  degrees of freedom
Residual deviance: 3883.6  on 85  degrees of freedom
AIC: 598.62

Number of Fisher Scoring iterations: 2
```

Figure 11: Alternative Generalized Linear Model result analyzing variance in MSC ratings for stock status performance indicators.

3.2 Hatchery Impacts (Score 5)

Exploratory analysis: hatchery impacts

Boxplots indicated several variables that might prove influential in explaining the variability observed in MSC ratings when tested in modeling. Among the three quantitative variables included in the study, percent hatchery contribution to production or harvest and number of releases appear to influence scoring as expected (Figures 12 and 13), although a small sample size within groups was observed. Groupings were selected to maximize difference in MSC ratings among groups. Percent of marked fish, the third quantitative variable, was not found to influence scoring (Figure 14). This result is expected, as the scale of the marking program does not indicate the scale of the associated recapture program.

For all further exploratory analyses, fisheries with no enhancement were removed from the data set, leaving 23 multivariate observations (rows in the model matrix). In order to determine which factors influenced rating of hatchery impacts, it was deemed best to remove fisheries without enhancement from consideration, as their ratings may be influenced by considerations other than present hatchery impacts (Figures 12 and 13 indicate a wide amount of variation in scoring of fisheries without enhancement).

Analyses were hindered by the fact that textual rationales for MSC ratings do not refer to all qualitative variables – the average rationale includes reference to only six qualitative variables. To minimize the negative effect of too many non-responses (missed observations) in the data, only those variables with five or more rater responses that fall into two or more categories are discussed below, as the other data is not considered likely

to be reflective of actual trends in rating across multiple assessments. In total, eight variables met these characteristics.

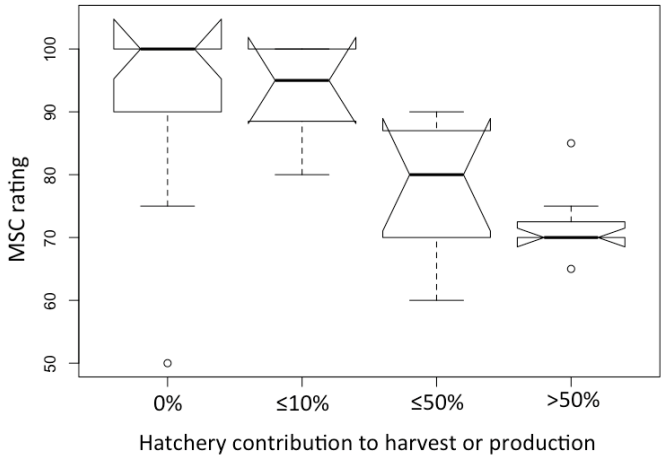

Figure 12: Increased hatchery contribution to harvest or production was associated with lower MSC ratings, as expected; the likelihood for impacts upon wild stocks is greater when hatchery fish make greater contributions to the fishery. No meaningful difference in rating was found between fisheries with ≤10% hatchery contribution to production/harvest and fisheries without hatchery production.

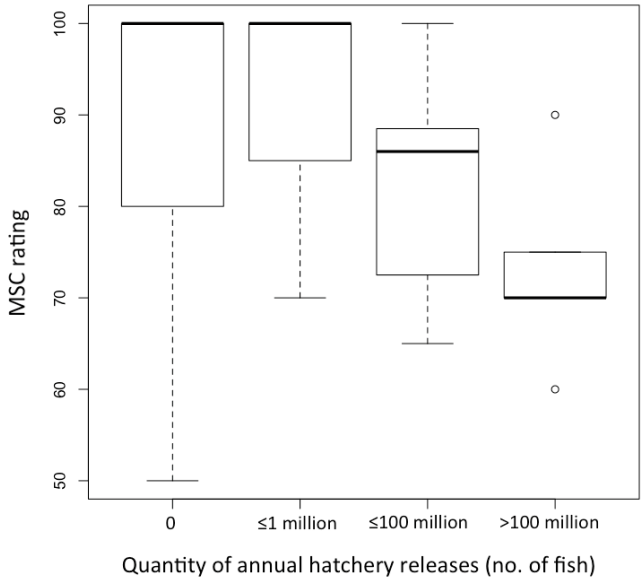

Figure 13: Increased quantities of annual hatchery releases were associated with lower MSC ratings as expected. As with contribution to production, the likelihood for impacts upon wild stocks is greater when higher numbers of enhanced fish are released.

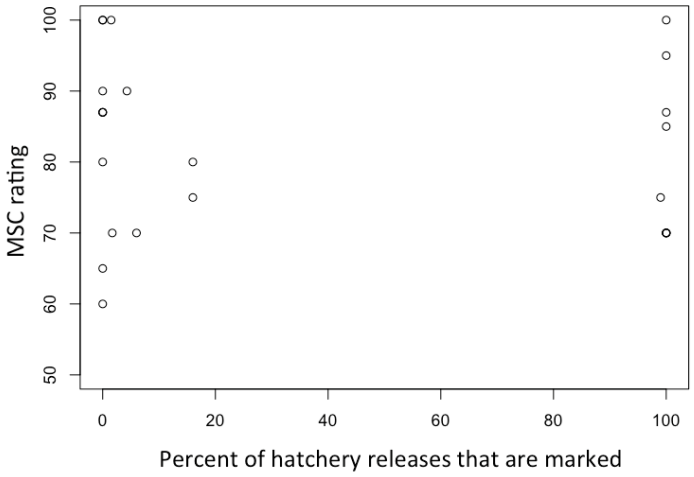

Figure 14: No correlation between MSC rating and the percent of hatchery releases that are marked was found. Most fisheries either mark all hatchery fish (generally otolith marking programs) or a small (<10%) proportion (generally coded wire tagging), but ratings varied widely within both groups. This is expected, as the quality of the recapture program is a more important indicator of monitoring effectiveness.

These eight variables were organized into three groups after exploratory analyses: those with clear likelihood of influence on rating (Figure 15), those with possible influence (Figure 16), and those where no clear trends were found (Figure 17).

Variables with possible influence were examined further by going back to the original information (MSC assessment reports). An interesting interrelationship between the terminal fishery and mark-and-recapture variables was found: some fisheries with terminal harvest areas but no active mark-and-recapture programs rated highly, as did other fisheries with mark-and-recapture programs but no terminal harvest areas. The result is sensible in that a fishery where there is certainty (possibly on the basis of older mark-and-recapture data) that almost all hatchery fish are being harvested and are not straying into wild spawning habitat may not need to have an active mark-and-recapture program (e.g., Kodiak was rated "90" on the 2007 MSC assessment of the Alaska fishery) (SCS 2007). Conversely, a fishery with an ongoing mark-and-recapture program that indicates managers' success in separate management of wild stocks might not be harvesting hatchery fish in a terminal harvest area. Other wild stock management strategies may be used – for example, spatial and temporal differentiation of harvest rates. The decision tree in Figure 18 indicates how data points were filtered from each analysis to achieve the plots in Figure 19 that depict the expected results.

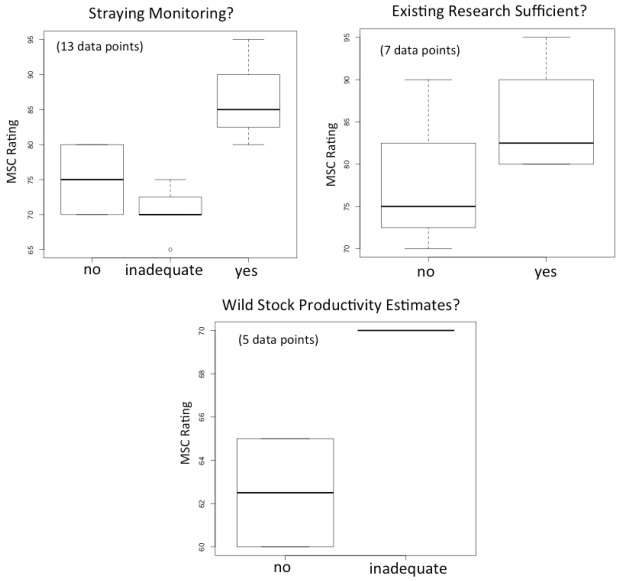

Figure 15: Boxplots of the three variables that appear influential upon determination of MSC ratings as expected: adequate monitoring of straying; sufficient existing, published research showing that hatchery impacts are minimum; and availability of some stock productivity information specific to wild stocks.

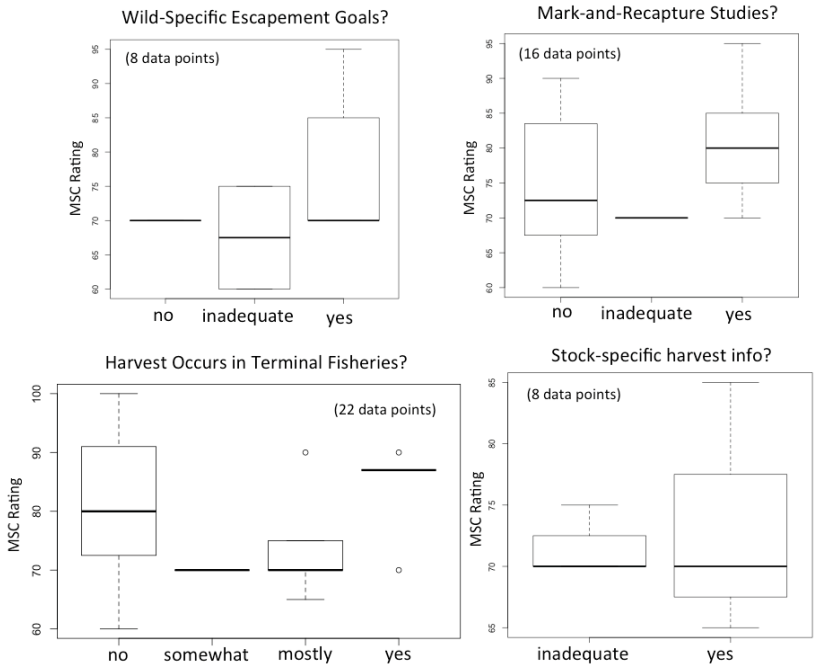

Figure 16: Boxplots of the four variables that may influence MSC ratings as expected: presence of escapement goals specific to wild stocks, use of mark-and-recapture studies, harvest of hatchery fish in terminal fisheries, and ability to differentiate between hatchery and wild harvest. In the plots focused upon goals, mark-and-recapture studies, and harvest information, good performance is associated with a higher range of ratings, but boxes overlap. In the other plot, complete terminal fisheries rate higher than fisheries that use terminal fisheries to an incomplete degree, but a wide variety of ratings is awarded for fisheries that do not harvest hatchery fish in terminal fisheries.

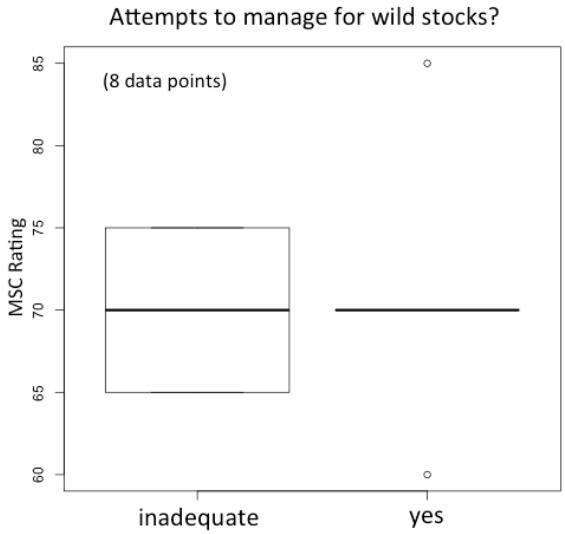

Figure 17: For one of the variables examined (attempts to manage for wild stocks), influence upon MSC ratings was not clear. Management may attempt to manage for a wild stock but not achieve success in doing so.

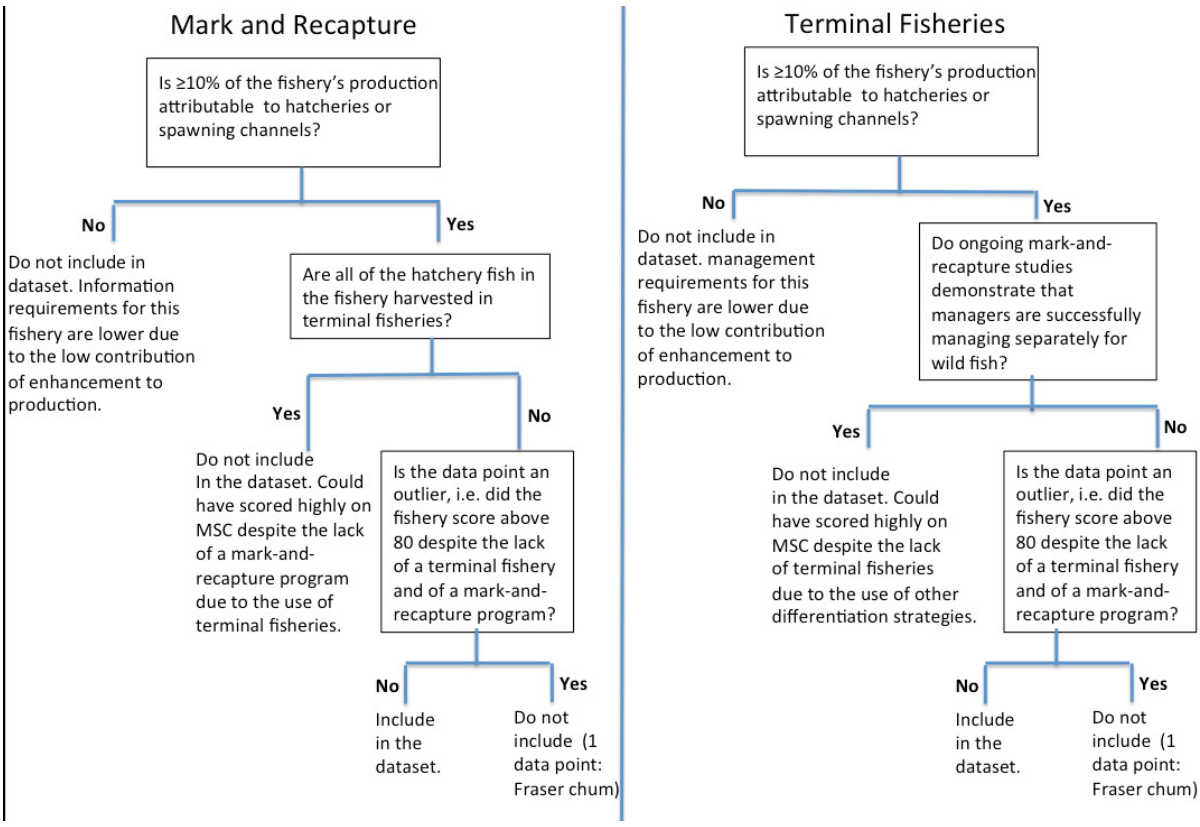

Figure 18: Upon further analysis of the interrelationship between the mark-and-recapture and terminal fishery variables, certain data points were filtered from each analysis in accordance with this decision tree.

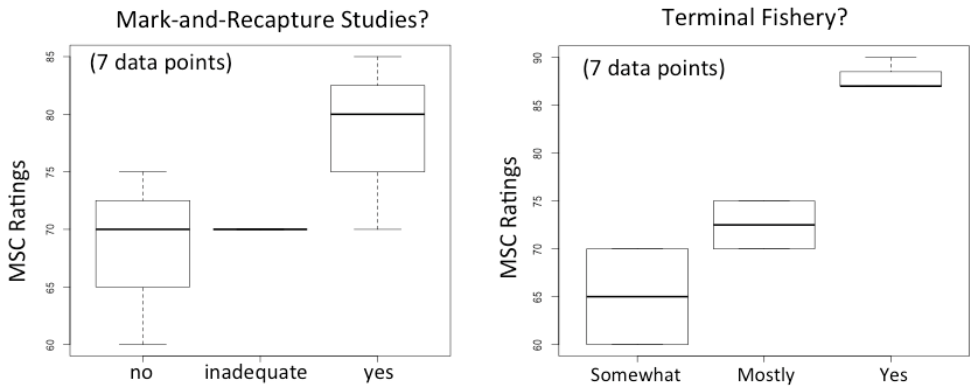

Figure 19: After data filtering, boxplots indicated influence upon rating in better alignment with expectations for the two variables – compare with unfiltered results depicted in Figure 16.

To summarize results displayed in Figures 18–19, hatchery-related monitoring (mark-and-recapture, straying studies, differentiated harvest and productivity information) and use of wild stock-management techniques (harvest of hatchery fish in terminal fisheries) were attributed higher ratings in MSC.

Modeling: hatchery impacts

GLM modeling was conducted using MSC ratings of hatchery indicators as the response variable (treated as continuous) and the following co-variables: percent hatchery contribution, categorized percent hatchery contribution (groupings align with Figure 12), categorized quantity of hatchery releases (groupings align with Figure 13), monitoring of straying (Figure 15), harvest of hatchery fish in terminal fisheries (Figure 19), and verification of stock-specific management success through the use of an active mark-and-recapture monitoring program (Figure 19). The Gaussian distribution model was assumed for the response with the identity link function.

As with stock status modeling, it was not possible to generate a GLM for hatchery ratings with desired statistical significance of co-variables and accountability for variance in ratings. Models of the two quantitative variables (percent hatchery contribution and quantity of hatchery releases) had adequate sample size (all fisheries that include a hatchery component) and account adequately for the variance in the data, but desired statistical significance ($p < 0.1$) is not achieved for all co-variables (an example is shown in Figure 20). Meanwhile, sample size for the qualitative co-variables was prohibitively small for the generation of meaningful models (an example is included in Figure 21). Inclusion of unenhanced fisheries in models could increase sample size in some cases, but did not result in a model that achieves all desired outcomes (Figures 22–23). Not all results of modeling are shown, but Figures 20–23 generally reflect the overall quality of results.

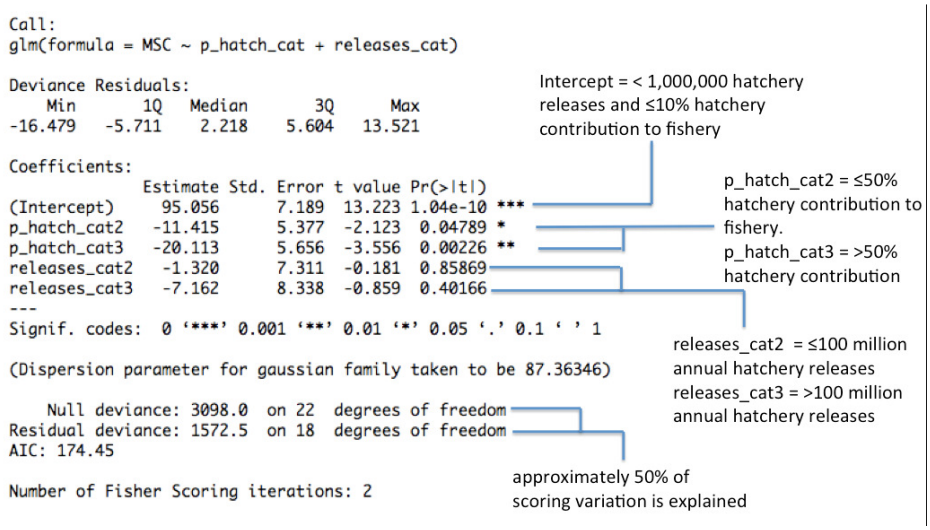

Figure 20: Best GLM model results: quantitative variables' set / enhanced fisheries. The co-variables included in this model are categorized percent hatchery contribution and categorized quantity of annual hatchery releases. The sample size of 23 consists of all MSC ratings of salmon fisheries that have enhancement programs. The model explains a meaningful quantity of variation in rating (50%), but not all co-variables exhibit desired statistical significance ($p < 0.1$). According to this model, a fishery with >50% hatchery contribution to the fishery and >100 million annual hatchery releases would rate approximately "68."

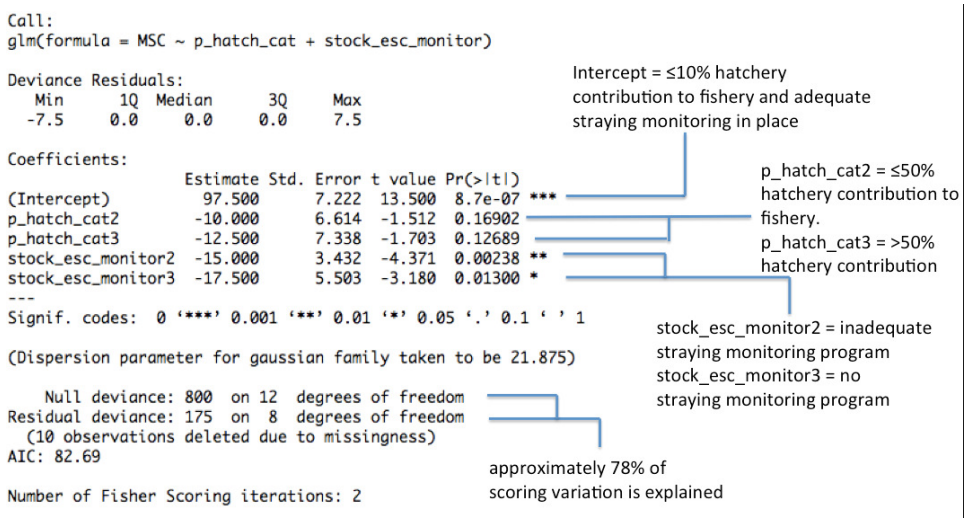

Figure 21: Alternative GLM model results: quantitative and qualitative variables' set / enhanced fisheries. The co-variables included in this model are categorized percent hatchery contribution and categorized presence/absence of a straying monitoring program. The sample size of 23 consists of all MSC ratings of salmon fisheries that have enhancement programs. Only 13 of those observations cite straying monitoring programs in textual rating rationales; the other 10 observations were deleted due to missingness in analysis of the role of the straying variable in determination of variance. The model explains a meaningful quantity of variation in rating (78%), but not all co-variables desired statistical significance ($p < 0.1$) and sample size is very small. That being said, according to this model, a fishery with >50% hatchery contribution to the fishery and no monitoring of straying would rate approximately "68."

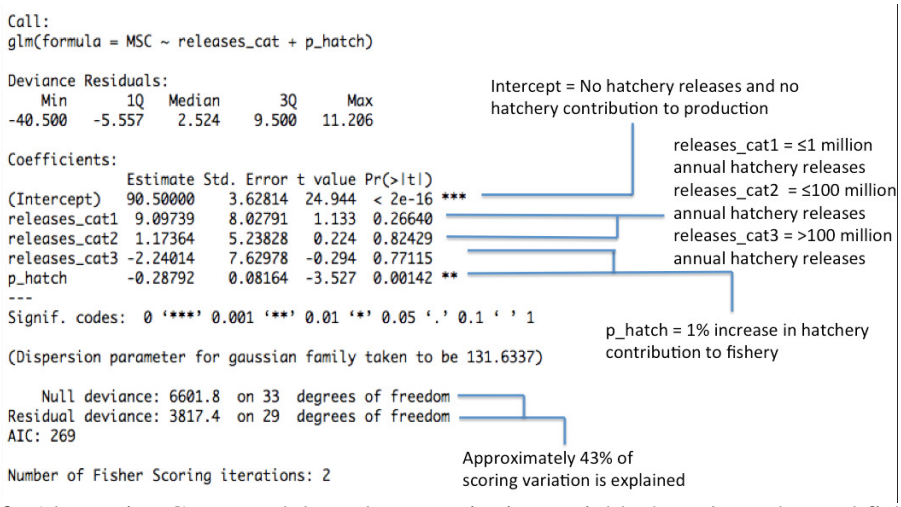

Figure 22: Alternative GLM model results: quantitative variables' set / unenhanced fisheries added. The co-variables included in this model are categorized quantity of annual hatchery releases and percent of hatchery contribution to the fishery (desegregated). The sample size of 33 consists of all MSC ratings of salmon fisheries on hatchery performance indicators. The model explains less than half of variation in ratings (43%), and most co-variables do not exhibit desired statistical significance ($p < 0.1$). Having these limitations in mind, according to this model, a fishery with 99% hatchery contribution to the fishery and >100 million annual hatchery releases would rate just under "60."

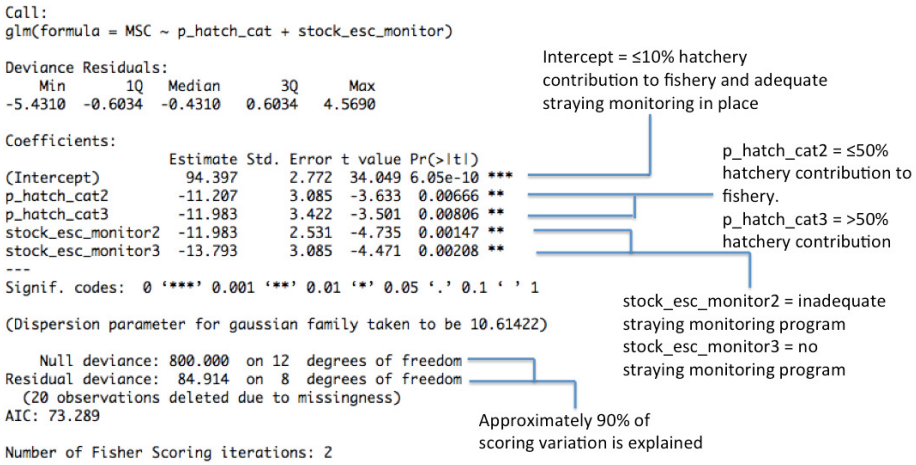

Figure 23: Alternative GLM model results: quantitative and qualitative variables' set / unenhanced fisheries added. The co-variables included in this model are categorized percent hatchery contribution and categorized presence/absence of a straying monitoring program. The sample size of 32 consists of all MSC ratings of salmon fisheries, with the deletion of one outlier (Annette Island sockeye salmon scored a "50" despite no current hatchery production and some stray study results). Only 13 of those points cite straying monitoring programs in textual rating rationales; the other 10 observations were deleted due to *missingness* in analysis of the role of the straying variable in determination of variance. The model explains a meaningful quantity of variation in rating (78%) and all co-variables exhibit desired statistical significance ($p < 0.1$), but sample size is prohibitively small for generation of meaningful predictions. However, having this limitation in mind and for the sake of the example, according to this model, a fishery with >50% hatchery contribution to the fishery and no monitoring of straying would rate approximately "69."

4. The FishSource Scores Adapted to Salmon Fisheries

Statistical exploration of MSC certification body ratings of salmon fisheries on stock status and hatchery performance indicators revealed high variability across the various assessments and certification units. The unexplained variance in data rendered difficult the effort to align FishSource benchmarks with MSC ratings and further develop a FishSource method. However, we were able to use some of the information generated through this project and believe that we have made the best possible effort amidst information gaps to incorporate MSC results into the FishSource salmon fishery assessment method.

4.1 Stock status (Score 4)

Exploratory and inferential analyses indicated that four variables explained a portion of the variability observed in ratings: (1) escapement performance against goals, (2) harvest trends, (3) management responsiveness, and (4) ocean productivity's role in determining stock status trends. The FishSource method incorporates the first variable into sub-criterion 4.1 (Escapement trends), and addresses the other three in sub-criterion 4.2 (Harvest trends).

Escapement trends (sub-criterion 4.1)

On the basis of Figure 3, fisheries with 0–3 escapement goal misses in a 15-year series were grouped together at the "10" benchmark, 4–7 misses at the "7" benchmark, and 8–15 misses at the "6" benchmark. While it was not possible to align benchmarks with precision due to variance in data, Figure 3 indicates that the median fishery with 0–3 escapement goal misses received a rating of "80," i.e., an unconditional pass, while the other two groupings' medians represent conditional passes.

Some elements of the FishSource method were not derived directly from MSC results. MSC provides no indication of how stocks without escapement goals should be rated. We decided to include benchmarks for the magnitude of decline over 15 years in these stocks, although there is no clear correlation between escapement trends and MSC ratings. There is also no indication in MSC results that more recent goal misses are of greater concern than earlier misses. However, inclusion of some shorter timeframes in assessment tree language for stock status performance indicators (for example, 5 years in the Alaska salmon assessment, performance indicator 1.2.2 "60" and "80" benchmarks) indicated that MSC does consider recent misses to be of particular concern. Therefore, additional language regarding the quantity of misses in the most recent 7 years was added to the FishSource "6" benchmark (Annex C).

Harvest trends (sub-criterion 4.2)

In alignment with Figures 5 and 6, absence of meaningful harvest declines is scored at "10," and declines due to ocean productivity or management responsiveness (fishery closures, curtailment) are scored at "8." Declines that cannot be attributed to ocean

productivity trends are scored at "7," and a score of "5" results if harvest is continuing at the same rate despite the chronically diminished status of a stock. The sub-criterion wording thereby addresses harvest trends, ocean productivity, and management responsiveness.

4.2 Hatchery Impacts (Score 5)

Hatchery contribution to the fishery (sub-criterion 5.1)

Fisheries without hatcheries or other forms of enhancement are scored at "10" in the FishSource method, in alignment with later MSC salmon assessments (MRAG Americas 2012a and 2012b). As indicated in Figure 9, there is not much difference between MSC ratings of fisheries without hatcheries and those with hatcheries that contribute ≤10% of fishery harvest or production. Correspondingly, these fisheries, as well as those that keep hatchery and wild fish completely separate, receive a score of "9" in FishSource and do not undergo further analysis.

Wild stock management (sub-criterion 5.2)

For those fisheries that do not achieve a "10" or "9," four sub-criteria are assessed. The first addresses the question of wild stock management and mark-and-recapture program implementation – adequately wild stock-targeted management is scored at "8," and various levels of inadequate performance are scored at "7" and "6" in accordance with Figure 16. The absence of a mark-and-recapture program, past or present, or existence of a program indicating failure to manage wild stocks separately is scored at "5." This is not supported by MSC results due to the existence of only one "<6" (failing) rating (Annette River sockeye salmon), but the worst plausible performance was logically attributed a failing score.

Straying magnitude and monitoring (sub-criterion 5.3)

Sub-criterion 5.3 focuses upon straying and monitoring of straying. As the GLM results in Figure 18 suggest, fisheries with higher hatchery contributions (higher likelihood of straying) have higher expectations for straying monitoring programs than those with smaller likelihood of straying. This question of straying potential is addressed in the formulation of benchmarks corresponding with scores of "8," "7," "6," "5," and "4" (Annex C). Each benchmark describes levels of performance with respect to the volume of straying studies that have been accomplished and the likelihood of straying. A score of "0" is awarded when potential for straying is high and no studies have been accomplished. As with the wild management sub-criterion, this is not supported by MSC results due to the absence of multiple failing scores.

Intentional mixing of hatchery and wild stocks (sub-criterion 5.4)

A sub-criterion regarding hatchery/wild stock mixing was added despite the fact that the associated variable ("Is there a conservation hatchery program in place? / Is there a hatchery program in the fishery that is substituting for a stock rebuilding strategy?") appeared in only four scoring rationales. The issue appears prominently in the assessment trees used in the various MSC salmon assessments, and also in the draft salmon-specific default assessment tree. The benchmarks in FishSource represent an adaptation of the benchmarks used in the later salmon assessments and the new draft default tree. Both in MSC and FishSource, mixing of hatchery and wild stocks as a wild stock rebuilding strategy is not regarded favorably and only allowable in limited quantities to achieve the FishSource "6" benchmark.

Management policies and hatchery evaluations (sub-criterion 5.5)

In the MSC salmon assessments, hatchery-relevant conditions were assigned to fisheries not only in scoring of the hatchery-focused performance indicators, but also in scoring of other performance indicators that are indirectly related to hatcheries. These performance indicators were too complex to include in our analysis due to limitations of sample size and mixing of fisheries for which scoring was motivated by hatchery issues with fisheries for which scoring was not motivated by hatchery issues. However, in review of MSC assessments, the following four policy-relevant issues were noted among the other indirectly-related performance indicators:

- long-term objectives: Annette Island was assigned a condition against performance indicator 3.1.3 (long-term objectives) describing the need to develop an objective, regulation, or policy regarding hatchery enhancement relative to conservation of wild populations.
- fishery-specific objectives: Iturup Island was assigned a condition against indicator 2.2.2 (ecosystem impacts of hatcheries) regarding the establishment of objectives for the proportion of natural-origin fish used in hatchery broodstock.
- compliance and authority: the results of Alaska Department of Fish and Game's 2006 review of Prince William Sound Aquaculture Corporation hatchery management, which raised some issues regarding compliance, were discussed in audit reports regarding progress on performance indicators 1.1.1.5 and 2.2.2 following the 2007 recertification of the Alaska salmon fishery (Intertek Moody Marine Ltd. 2010).
- hatchery evaluations: Alaska was scored at "barely 60" against indicator 3.1.10 (hatchery evaluations) and the relevant condition describes the need to conduct hatchery program evaluations in Prince William Sound.

These four issues, which mirror four Principle III performance indicators in the MSC default assessment tree (3.1.3, 3.2.1, 3.2.3, and 3.2.5), were incorporated into the language of sub-criterion 5.5. FishSource benchmarks generally align with MSC assessment tree benchmark language, with the exceptions that:

- A fishery can receive a "6" in FishSource with only two of the four policy issue areas integrated into the management regime, as long as those policies are stringently followed. At the "60" rating threshold, MSC requires evidence of some activity in all four policy issue areas (MSC rates more stringently than FishSource).
- FishSource seeks explicit statement of policies at the "6" level, while MSC is satisfied with implicit long-term and fishery objectives at the "60" level (FishSource scores more stringently than MSC).

4.3 Other sub-criteria

The other three criteria and associated sub-criteria in the FishSource salmon method were developed through analyzing the assessment tree language and fisheries scoring at or near benchmark thresholds.

<u>In-season management responsiveness (sub-criterion 1.1)</u>

Older MSC salmon assessments (e.g., the Alaska 2007 recertification assessment) do not include a separate performance indicator devoted to harvest control strategy and effectiveness. These issues are indirectly covered as part of the stock status performance indicator 1.2.2. However, assessments from 2010 onward that were informed by the default assessment tree included in the MSC's Fisheries Assessment Methodology do include four performance indicators devoted to harvest strategy. Two of these indicators, 1.2.1 (harvest strategy) and 1.2.2 (harvest control rules and tools), include benchmark language directed at gauging the level of in-season management responsiveness Rationales for MSC ratings at or near main benchmark thresholds yielded information used in drafting of FishSource benchmarks (Table 5).

Table 5: Exemplary MSC ratings on harvest strategy performance indicators relevant to in-season management responsiveness.

MSC Assessment, Year	Performance Indicator	Score	Rationale
Ozernaya sockeye salmon, 2012	1.2.1	95	"The harvest strategy for this fishery involves daily assessments of run strength, timing and escapement during the fishing season and closure periods (pass days) for inriver fisheries to ensure that escapement goals are met." (MRAG Americas 2012b)
Northeast Sakhalin pink salmon, 2012	1.2.2	75	Temporal and spatial closures based on in-season escapement data are implemented, but they may not be adequate in even (weak) run years, when escapement is observed to be below target reference points. (MRAG Americas 2012a)

Table 5 (continued)

Annette Island Reserve sockeye salmon, 2011	1.2.1	60	Some harvest controls have been implemented, but high exploitation rates are implicated in stock declines. (SCS 2011)

On the basis of the ratings in Table 5, FishSource sub-criterion 1.1 awards 10 points for consistent in-season responsiveness (e.g., Ozernaya), 8 points for inconsistent in-season responsiveness (e.g., Northeast Sakhalin), and 5 points for completely ineffective in-season management (e.g., a situation worse than that of Annette Island sockeye salmon).

Multi-season management responsiveness (sub-criterion 1.2)

Both older and newer assessments contain a performance indicator devoted to multi-season management responsiveness and stock rebuilding (1.2.1 and 1.1.3, respectively). Rationales for MSC ratings at or near main benchmark thresholds yielded information used in drafting of FishSource benchmarks (Table 6).

Table 6: Exemplary MSC ratings on stock recovery performance indicators.

MSC Assessment, Year	Performance Indicator	Score	Rationale
Ozernaya sockeye salmon, 2012	1.1.3	"na"	No stocks are depleted. (MRAG Americas 2012b)
Southeast Alaska gillnet-caught salmon, 2007	1.2.1	95	Hugh Smith Lake sockeye salmon were listed as a stock of concern after falling below escapement goals in 1993–2002. An action plan was drafted and corresponding harvest restrictions were implemented. Effectiveness of the action plan measures was evaluated. Recent escapements suggest that the recovery plan has been successful. (SCS 2007)
Fraser River sockeye salmon, 2010	1.2.1	70	There is a recovery plan in place for Cultus Lake sockeye salmon, but there are concerns regarding the effectiveness of measures in place. (Moody Marine International 2010)
Annette Island Reserve sockeye salmon, 2011	1.1.3	<60	Some recovery measures have been undertaken, but they have been ineffective. No increases in escapement (other than those attributable to hatchery production) are evident. (SCS 2011)

On the basis of the ratings in Table 6, a fishery scores "10" in FishSource if there are no stock status declines or if stocks in decline are officially designated a stock of concern and effective recovery action planning is carried out. A "6" is awarded if recovery actions have been undertaken, but have been only partially effective (e.g., Fraser River sockeye salmon). A "4" is given if no recovery actions have been undertaken (no such cases have been rated by MSC). A benchmark of "8" was established for those fisheries that carried out stock recovery effectively, albeit without a formal stock-of-concern listing (no such cases have been rated by MSC).

Responsiveness to habitat issues (sub-criterion 1.3)

Only one MSC assessment to date (Alaskan reassessment, 2007) has addressed management responsiveness to habitat issues substantially limiting access to trends in data (Table 7). Declines in particular Pacific salmon populations across the North Pacific have been linked with freshwater habitat quality (Augerot and Foley 2005). Therefore, in order to reflect the importance of management stewardship with respect to habitat, FishSource followed the Alaska MSC reassessment by including a relevant sub-criterion in its salmon fishery assessment method. Responsiveness to all planned or active development projects occurring in salmon habitat earns a "10," effective responsiveness to some development projects earns a "7," ineffective responsiveness earns a "4," and no responsiveness scores "0."

Table 7: MSC rating of responsiveness to habitat issues.

MSC Assessment, Year	Performance Indicator	Score	Rationale
Alaska salmon, 2007	3.1.9	95	"The management agencies have a proven track record of significant protection of fish habitat." There is some concern that "current practices are trending toward more leniency in habitat protection." (SCS 2007)

Escapement goal development and implementation (sub-criterion 2.1)

Both older and newer MSC assessments contain performance indicators particularly focused upon reference points (1.1.3.1 and 1.1.3.2 in older assessments, and 1.1.2 in newer assessments). Rationales for MSC ratings at or near main benchmark thresholds yielded information used in drafting of FishSource benchmarks (Table 8).

In accordance with the MSC ratings in Table 8, a fishery scores a "10" in FishSource if science-based escapement goals or operational equivalents are in place and have not been

lowered without a sound basis for doing so (e.g., Yakutat). A score of "7" is awarded if escapement goals have been lowered in association with missed management objectives or do not adequately account for life history diversity at the sub-stock scale (e.g., Chignik and Ozernaya). A score of "5" results if goals have been lowered twice in the recent past in association with missed management objectives, or no goals are in place (e.g., Annette Island sockeye salmon). An additional benchmark of "4," not based on efforts to align with MSC, addresses cases where details of the escapement goal-setting process or the goals themselves are not made public.

Table 8: Exemplary MSC ratings on reference point-focused performance indicators.

MSC Assessment, Year	Performance Indicator	Score	Rationale
Yakutat (Alaska) salmon, 2007	1.1.3.2	97	Escapement goals are in place for the fishery's 11 stocks, and they have been reviewed in recent years using updated and improved data. (SCS 2007)
Chignik (Alaska) salmon, 2007	1.1.3.2	75	Escapement goals for two stocks were lowered with little explanation for the change. (SCS 2007)
Ozernaya sockeye salmon, 2012	1.1.2	70	"The target and limit reference points are not demonstrated to be highly likely to maintain the inherent diversity and reproductive capacity of early and late stock subcomponents." The escapement goal was lowered by 60% in the 1990s and may not be equivalent with MSY. (MRAG Americas 2012b)
Annette Island Reserve sockeye salmon, 2011	1.1.2	<60	No escapement goals have been established. (SCS 2011)

Illegal harvest and deviation between reported and actual catch (sub-criterion 3.1)

The benchmarks for proportions of illegal harvest are taken directly from the FishSource standard, non-species-specific assessment method (Cannon 2007). It was not considered necessary to adjust this sub-criterion for specificities of salmon fisheries.

Harvest monitoring (sub-criterion 3.2)

Older MSC assessments contain a performance indicator particularly focused upon accuracy of harvest data (1.1.2.1), while newer assessments address harvest data together

with other types of data in a single rating focused upon information and monitoring (1.2.3). Rationales for MSC ratings at or near main benchmark thresholds yielded information used in drafting of FishSource benchmarks (Table 9).

In accordance with the MSC ratings in Table 9, a fishery receives a "10" in FishSource for timely, accurate, stock-specific catch reporting for a large proportion (>90%) of the fish harvested by the fishery (e.g., the Southeast Alaska troll fishery). Timely, accurate data that is not stock-specific earns a "9" (e.g., Chignik). A "6" is awarded if an unknown and likely substantial portion of harvest is undocumented (e.g., Ozernaya, Annette Island). A "5" results if the majority of harvest is undocumented (no such cases were rated by MSC).

Table 9: Exemplary MSC ratings on performance indicators relevant to harvest monitoring.

MSC Assessment, Year	Performance Indicator	Score	Rationale
Southeast Alaska troll-caught salmon, 2007	1.1.2.1	100	Accurate, timely, stock-specific harvest estimates are available for the fishery's target stocks. (SCS 2007)
Chignik (Alaska) salmon, 2007	1.1.2.1	90	Accurate and timely harvest estimates are available for the fishery's target stocks, but there is a lack of quantitative data on stock composition. (SCS 2007)
Ozernaya sockeye salmon, 2012	1.2.3	70	Harvest information at terminal fishing areas is accurate and timely, but there are uncertainties surrounding harvest data in the offshore driftnet fishery and set net fisheries located to the north of the Ozernaya river mouth (these fisheries intercept migrating Ozernaya stocks). (MRAG Americas 2012b)
Annette Island Reserve sockeye salmon, 2011	1.2.3	60	Fishery-specific exploitation rates cannot be calculated for local stocks. (SCS 2011)

Escapement monitoring (sub-criterion 3.3)

Older MSC assessments contain a performance indicator particularly focused upon accuracy of escapement monitoring (1.1.2.2), while newer assessments address escapement data together with other types of data in a single rating focused upon information and monitoring (1.2.3). Rationales for MSC ratings at or near main benchmark thresholds yielded information used in drafting of FishSource benchmarks (Table 10).

Table 10: Exemplary MSC ratings on performance indicators relevant to escapement monitoring.

MSC Assessment, Year	Performance Indicator	Score	Rationale
Bristol Bay (Alaska) salmon, 2007	1.1.2.2	90	A mix of appropriate techniques (direct counts with weirs, aerial index surveys) is used to generate daily and annual escapement estimates for the fishery's stocks. (SCS 2007)
Fraser River sockeye salmon, 2007	1.1.2.2	90	Direct counts of escapement are available for many of the fishery's target stocks. (Moody Marine International 2010)
Fraser River chum salmon, 2013	1.1.2.2	85	Index methods appropriate for the species and circumstance are used to measure escapement in the fishery. (Intertek Moody Marine 2013)
Southeast Alaska gillnet-caught salmon, 2007	1.1.2.2	70	There is a lack of stock-specific escapement information for chum salmon in Southeast Alaska. Index streams represent only a small proportion of spawning streams in the region. (SCS 2007)

On the basis of the MSC ratings in Table 10, scores of "10" are awarded when stocks' escapement is directly measured on an annual basis. If stocks' escapement is measured using an index method (escapement is measured for a portion of the stock to generate a series showing trends, but in units not comparable to the catch statistics) appropriate for the species and circumstance, an "8" is awarded. A "7" results for index methods that do not represent all components of the stock (e.g., Southeast Alaska). A score of "5" is awarded if escapement is not measured (no such cases were rated by MSC). An additional benchmark of "6," not based on efforts to align with MSC, addresses data transparency issues and surrogate measures of run strength.

5. Conclusions

Beginning in May 2010, SFP's Science, Research and Data division adopted an approach of making available actionable information tailored to specific seafood commodities, starting with the creation of a salmon working group. The findings presented here have resulted from this project, which has generated a new species-specific approach for FishSource, contributed to availability of actionable information on salmon fisheries, and expanded the evaluation methodology for salmon on a global scale.

The work described is iterative in nature, and the following opportunities to improve results and conduct further analyses were identified:

1. A statistical approach similar to that applied to the two focal topic areas could also be tentatively used in analysis of the other themes addressed in criteria 1–3 of FishSource. However, the textual nature of rating rationales in MSC assessments and the limited availability of quantitative observations for relevant performance indicators would represent important challenges on drawing meaningful conclusions.
2. Quantitative data predominated in the analysis of stock status MSC ratings, while mainly categorized, qualitative co-variables were included in the hatchery rating analysis. The discrepancy in method between the two thematic areas could have introduced some variation into our results. With additional time and effort, more quantitative data (straying surveys, mark-and-recapture data) could be introduced into the hatchery data set and used in further analysis.
3. Statistical analyses could be repeated upon issuance of new MSC assessments of salmon fisheries. The inclusion of additional observations is especially necessary for some of the hatchery-focused analyses, which were limited by small sample size. After the MSC finalizes its salmon-specific assessment tree and several new assessment reports that used the tree are released, it will be particularly timely to repeat some of the analyses described in this paper. MSC's species-specific approach can be deemed successful if variation in rating is shown to have been limited.
4. The small sample size for some of the hatchery co-variables could also be addressed through the replacement of rater non-responses with estimated ratings on the basis of best available data. The application of statistical re-sampling methods (for example, *bootstrap* or *jackknife*) could also be explored.
5. Similar analyses could be conducted for MSC ratings of species groups other than salmon.

When possible, we incorporated our results of the analyses of MSC scoring and assessment tree language into the FishSource salmon assessment method, the full text of which is included in Appendix B of this document. In a couple of notable cases, we diverge from MSC:

1. There is a small group of salmon fisheries that occur in the open ocean, are managed on a basis of pre-season forecasts, and focus upon achievement of objectives for a mixed-stock aggregate rather than for individual stocks. These

mixture-pool management fisheries have particular concerns with respect to stock identification and catch limit determination that are not shared by *stock-directed management fisheries*, which occur in coastal or river locations and are managed to achieve objectives for individual stocks. FishSource is applying a modified set of criteria in the analysis of mixture-pool management fisheries (Annex C). MSC has certified one of these fisheries (the Southeast Alaska troll certification unit), but until other mixture-pool management fisheries undergo MSC assessment, it is not possible to align the benchmarks of our modified criteria set with MSC ratings.

2. FishSource includes low-scoring benchmarks for certain sub-criteria regarding lack of data transparency. While MSC has scored leniently with respect to this issue, FishSource depends upon publicly available data for its scores, and therefore this issue is of particular importance to our organization.

SFP looks forward to continuing to work with its partners in the sustainable seafood movement to improve the quality of fishery assessments, to promote transparent and prompt access to fisheries information, and to foster active dialogue among stakeholders in the aim of fisheries improvement.

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Annex A: Categorical Co-Variable Key

No.	Variable	Abbreviation	Categories
Stock Status Co-Variables			
1	Number of missed escapement goals in 15, 10, 7, and 5 years, categorized	EG_15_cat (for 15 years)	1: 8-15 missed goals in 15 years 2: 4-7 missed goals in 15 years 3: 0-3 missed goals in 15 years
2	Number of missed Limit Reference Points in 15, 10, 7, and 5 years, categorized	LEB_10_cat (for 10 years)	1: 5-10 missed goals in 10 years 2: 3-4 missed goals in 10 years 3. 1-2 missed goals in 10 years 4: 0 missed goals in 10 years
3	Trends in escapement	esc_change	1: negative trend in escapement in 15 years 2: positive trend in escapement in 15 years
4	Trends in harvest	harvest_cat	1: negative trend in wild harvest in 15 years 2: positive trend in wild harvest in 15 years
5	Role of ocean conditions in determining stock status trends	ocean_prod_cat	1: There are not annual harvest declines of ≥3% over the last 15 years in the fishery and its two closest neighbors. 2: There are annual harvest declines of ≥3% over the last 15 years in all three fisheries.
6	Role of inherent productivity dynamics in determining stock status trends	inherent_prod	1: Issues other than ocean conditions that cannot be attributed to human activity are not implicated in stock declines according to MSC rating rationales. 2: Such issues are implicated in stock declines according to MSC rating rationales.
7	Management responsiveness to stock status declines	responsiveness_cat	1: management has not exhibited responsiveness to stock status declines according to MSC rating rationales. 2: management did exhibit responsiveness to stock status declines, or no declines occurred, according to MSC rating rationales.
Hatchery Impacts Co-Variables			
8	Does the fishery target Chinook salmon?	chinook	1: no 2: yes
9	Does the fishery target chum salmon?	chum	1: no 2: yes
10	Does the fishery target coho salmon?	coho	1: no 2: yes
11	Does the fishery target pink salmon?	pink	1: no 2: yes
12	Does the fishery target sockeye salmon?	sockeye	1: no 2: yes

13	Are hatchery fish harvested in a terminal fishery?	all_terminal	1: no 2: somewhat 3: mostly 4: yes
14	Is the quantity of hatchery releases small?	releas_small	1: no 2: yes
15	Are there ongoing mark-and-recapture studies that support a wild stock-focused management effort?	mark_recap	1: no 2: inadequate 3: yes
16	Is there stock-specific escapement and straying monitoring?	stock_esc_monitor	1: no 2: inadequate 3: yes
17	Are there adequate harvest estimates and exploitation rate information for individual stocks?	harvest_info	1: inadequate 2: yes
18	Does management attempt to manage for the wild stock?	manage_wild	1: inadequate 2: yes
19	Is the percent of hatchery fish in catch or total returns small?	p_hatch_small	1: no 2: yes
20	Are precautionary (differential) harvest measures in place?	precau_man	1: inadequate 2: yes
21	Is existing research published and sufficient to prove that hatchery impacts are insignificant?	e_research	1: no 2: yes
22	Are wild stock-specific escapement goals in place?	esc_goals	1: no 2: inadequate 3: yes
23	Have wild stock-specific productivity estimates been generated?	stock_prod_est	1: no 2: inadequate 3: yes
24	Is it likely that hatcheries have directly, negatively impacted wild stocks?	hatch_impact_wild	1: yes 2: no
25	If straying has not been sufficiently measured, is the likelihood of significant straying high?	likely_straying	1: yes 2: no
26	Is there a conservation hatchery program in place? / Is there a hatchery program in the fishery that is substituting for a stock rebuilding strategy?	c_hatchery	1: yes 2: no
27	Is current hatchery management sufficiently precautionary?	hatch_man_precau	1: no 2: inadequate
28	Are adequate numbers of fish marked?	a_mark	1: no 2: yes
29	Has the quantity of hatchery releases been increased during the certificate period?	i_releases	1: yes 2: no
30	Are up-to-date wild salmon policies, enhancement plans, monitoring plans, and/or long-term objectives in place?	policies	1: no 2: inadequate 3: yes

31	Do existing studies indicate that straying exceeds thresholds suggested by research/management?	stray_thresholds	1: yes 2: somewhat
32	Have sufficient management actions been taken to reduce straying?	management_straying	1: no 2: yes
33	Are hatcheries evaluated as part of the fishery management evaluation?	hatchery_eval	1: no 2: yes
34	How often are management evaluations conducted?	periodicity_eval	1: (a) less than once every 5 years; (b) regularly, but not for all parts of the management structure 2: once every 5 years 3: annually
35	Are the evaluations peer-reviewed?	peer_review	1: no 2: unclear 3: inadequately 4: yes
36	Is impact on wild stocks assessed as part of the hatchery evaluation process?	impact_wild	1: no 2: planned
37	Are hatchery evaluators independent?	eval_independent	1: no 2: yes
38	Are hatchery evaluation results made public?	eval_public	1: no 2: planned 3: yes

Annex B: Marine Stewardship Council Assessments, Certification Units, and Stocks Included in Data Analysis

	Assessments
1	Alaska salmon (2007 final assessment report)
2	Annette Islands Reserve salmon (2011 final assessment report)
3	British Columbia chum salmon (2012 draft assessment) – used in the hatchery analysis only
4	British Columbia pink salmon (2011 final assessment report)
5	British Columbia sockeye salmon (2010 final assessment report)
6	Iturup Island pink and chum salmon (2010 final assessment report)
7	Northeast Sakhalin pink salmon (2012 final assessment report)
8	Ozernaya sockeye salmon (2012 final assessment report)
	Certification Units
1	Alaska Peninsula and Aleutian Islands salmon (Alaska)
2	Annette Island Reserve Chinook salmon
3	Annette Island Reserve chum salmon
4	Annette Island Reserve coho salmon
5	Annette Island Reserve pink salmon
6	Annette Island Reserve sockeye salmon
7	Barkley Sound sockeye salmon (British Columbia)
8	Bristol Bay salmon (Alaska)
9	Chignik salmon (Alaska)
10	Copper-Bering salmon (Alaska)
11	Fraser chum salmon (British Columbia) - used in the hatchery analysis only
12	Fraser pink salmon (British Columbia)
13	Fraser sockeye salmon (British Columbia)
14	Inner South Coast chum salmon (British Columbia) - used in the hatchery analysis only
15	Inner South Coast pink salmon (British Columbia)
16	Iturup Island pink and chum salmon
17	Kodiak salmon (Alaska)
18	Kotzebue salmon (Alaska)
19	Kuskokwim salmon (Alaska)
20	Lower Cook Inlet salmon (Alaska)
21	Nass sockeye salmon (British Columbia)
22	North-Central Coast and Queen Charlotte Islands chum salmon (British Columbia) - used in the hatchery analysis only
23	North-Central Coast and Queen Charlotte Islands pink salmon (British Columbia)
24	Northeast Sakhalin pink salmon
25	Norton Sound salmon (Alaska)
26	Ozernaya sockeye salmon
27	Prince William Sound salmon (Alaska)
28	Skeena sockeye salmon (British Columbia)
29	Southeast Alaska gillnet and purse seine-caught salmon (two units treated as one in our analysis)

30	Southeast Alaska troll-caught salmon
31	Upper Cook Inlet salmon (Alaska)
32	West Coast Vancouver Island chum salmon (British Columbia) - used in the hatchery analysis only
33	Yakutat salmon (Alaska)
34	Yukon salmon (Alaska
Stocks (listed with certification unit, organized alphabetically by certification unit)	
1	Annette Island Reserve Chinook salmon: Chickamin River Chinook salmon
2	Annette Island Reserve Chinook salmon: Unuk River Chinook salmon
3	Annette Island Reserve chum salmon
4	Annette Island Reserve pink salmon
5	Annette Island Reserve sockeye salmon: Tamgass Lake sockeye salmon
6	Annette Island Reserve sockeye salmon: Trout Lake sockeye salmon
7	Barkley Sound sockeye salmon: Somass sockeye salmon
8	Bristol Bay salmon: Kvichak sockeye salmon
9	Fraser pink salmon: Odd-year pink salmon
10	Fraser sockeye salmon: Early Stuart sockeye salmon
11	Fraser sockeye salmon: Early Summer sockeye salmon
12	Fraser sockeye salmon: Summer sockeye salmon
13	Fraser sockeye salmon: Late Summer sockeye salmon
14	Inner South Coast pink salmon: Bond to Knight even-year pink salmon
15	Inner South Coast pink salmon: Bond to Knight odd-year pink salmon
16	Inner South Coast pink salmon: Burrard Inlet odd-year pink salmon
17	Inner South Coast pink salmon: Howe Sound odd-year pink salmon
18	Inner South Coast pink salmon: Jervis Inlet odd-year
19	Inner South Coast pink salmon: Johnstone Strait even-year
20	Inner South Coast pink salmon: Johnstone Strait odd-year
21	Inner South Coast pink salmon: Kingcome Inlet even-year
22	Inner South Coast pink salmon: Kingcome Inlet odd-year
23	Inner South Coast pink salmon: Longborough to Bute even-year pink salmon
24	Inner South Coast pink salmon: Longborough to Bute odd-year pink salmon
25	Inner South Coast pink salmon: Mid-Vancouver Island even-year
26	Inner South Coast pink salmon: Mid-Vancouver Island odd-year
27	Inner South Coast pink salmon: Toba Inlet odd-year
28	Inner South Coast pink salmon: Upper Vancouver Island even-year
29	Inner South Coast pink salmon: Upper Vancouver Island odd-year
30	Iturup Island pink and chum salmon: Kurilsky chum salmon
31	Iturup Island pink and chum salmon: Prostor chum salmon
32	Iturup Island pink and chum salmon: Kurilsky pink salmon
33	Iturup Island pink and chum salmon: Prostor pink salmon
34	Kodiak salmon: Mainland chum salmon
35	Kodiak salmon: Eastside chum salmon
36	Kodiak salmon: Northeast chum salmon

37	North-Central Coast and Queen Charlotte Islands pink salmon: Area 1, even-year pink salmon
38	North-Central Coast and Queen Charlotte Islands pink salmon: Area 2E, even-year pink salmon
39	North-Central Coast and Queen Charlotte Islands pink salmon: Area 2W, even-year pink salmon
40	North-Central Coast and Queen Charlotte Islands pink salmon: Area 3, even-year pink salmon
41	North-Central Coast and Queen Charlotte Islands pink salmon: Area 3, odd-year pink salmon
42	North-Central Coast and Queen Charlotte Islands pink salmon: Area 4, even-year pink salmon
43	North-Central Coast and Queen Charlotte Islands pink salmon: Area 4, odd-year pink salmon
44	North-Central Coast and Queen Charlotte Islands pink salmon: Area 5, even-year pink salmon
45	North-Central Coast and Queen Charlotte Islands pink salmon: Area 5, odd-year pink salmon
46	North-Central Coast and Queen Charlotte Islands pink salmon: Area 6, even-year pink salmon
47	North-Central Coast and Queen Charlotte Islands pink salmon: Area 6, odd-year pink salmon
48	North-Central Coast and Queen Charlotte Islands pink salmon: Area 7, even-year pink salmon
49	North-Central Coast and Queen Charlotte Islands pink salmon: Area 7, odd-year pink salmon
50	North-Central Coast and Queen Charlotte Islands pink salmon: Area 8, even-year pink salmon
51	North-Central Coast and Queen Charlotte Islands pink salmon: Area 8, odd-year pink salmon
52	North-Central Coast and Queen Charlotte Islands pink salmon: Area 9, even-year pink salmon
53	North-Central Coast and Queen Charlotte Islands pink salmon: Area 9, odd-year pink salmon
54	North-Central Coast and Queen Charlotte Islands pink salmon: Area 10, even-year pink salmon
55	North-Central Coast and Queen Charlotte Islands pink salmon: Area 10, odd-year pink salmon
56	Northeast Sakhalin pink salmon: Okhotsk pink salmon
57	Norton Sound salmon: North River – Unalakleet River Chinook salmon
58	Norton Sound salmon: Shaktoolik Chinook salmon
59	Norton Sound salmon: Bonanza River chum salmon
60	Norton Sound salmon: El Dorado River chum salmon
61	Norton Sound salmon: Flambeau River chum salmon
62	Norton Sound salmon: Kwiniuk River fall-run chum salmon
63	Norton Sound salmon: Nuikluk River fall-run chum salmon
64	Norton Sound salmon: Nome River chum salmon
65	Norton Sound salmon: Sinuk Ruver chum salmon
66	Norton Sound salmon: Snake River chum salmon
67	Norton Sound salmon: Solomon River chum salmon
68	Ozernaya sockeye salmon
69	Southeast Alaska gillnet and purse seine-caught salmon: McDonald Lake sockeye salmon
70	Southeast Alaska troll-caught salmon: Blossom River Chinook
71	Upper Cook Inlet salmon: Yentna sockeye salmon
72	Yukon salmon: Anvik River Chinook salmon
73	Yukon salmon: Canada - main stem Chinook salmon
74	Yukon salmon: Chena Chinook salmon
75	Yukon salmon: East Fork Andreafsky River Chinook salmon
76	Yukon salmon: Gisasa Chinook salmon
77	Yukon salmon: Nulato Chinook salmon
78	Yukon salmon: Salcha Chinook salmon
79	Yukon salmon: West Fork Andreafsky River Chinook salmon

80	Yukon salmon: Chandalar fall-run chum salmon
81	Yukon salmon: Delta River fall-run chum salmon
82	Yukon salmon: Fishing Branch River fall-run chum salmon
83	Yukon salmon: Sheenjek fall-run chum salmon
84	Yukon salmon: Tanana River fall-run chum salmon
85	Yukon salmon: Toklat River fall-run chum salmon
86	Yukon salmon: Yukon mainstem fall-run chum salmon
87	Yukon salmon: Anvik River summer-run chum salmon
88	Yukon salmon: East Fork Andreafsky River summer-run chum salmon
89	Yukon salmon: Delta Clearwater River coho salmon

Annex C: The FishSource Salmon Fishery Assessment Method (version 1.3, December 20, 2012)

FishSource, an online fisheries database managed by the Sustainable Fisheries Partnership (SFP), is envisioned as "one-stop shopping" for an audience of fish buyers and the general public interested in both fishery sustainability assessments that are accessible to the non-scientist and in descriptive research information. The database feeds two websites with targeted audiences: www.fishsource.com (for fish suppliers and retailers) and www.fisherieswiki.org (for fisheries scientists and the general public).

While both sites feature text-based profiles and graphed data sets, www.fishsource.com also provides sustainability scores of 0–10 for five assessment criteria derived from Marine Stewardship Council's (MSC) Fisheries Assessment Methodology (FAM). Information on ecological impacts of fisheries is also provided in text format in the body of the profiles. This text should include responses to a set of true-false questions ("ecological parameters") that have been specifically adapted to salmon fisheries and are listed at the end of this report.

The five assessment criteria are scored quantitatively for most whitefish fisheries using standard fisheries statistics. When scores cannot be calculated quantitatively, qualitative scoring is conducted using the same benchmark cutoffs (<6, ≥6, ≥8) applied in MSC fishery assessments.

Due to the specificities of salmon fishery management, reflected in MSC's current development of a separate, salmon-specific default assessment tree, FishSource is applying a separate qualitative assessment framework to the assessment of salmon fisheries. Through a peer review process, SFP hopes to maximize correspondence between this draft assessment framework and MSC's forthcoming salmon assessment tree over the coming months.

Due to the specific concerns of open-ocean, predominantly preseason-managed salmon fisheries (e.g., the Southeast Alaskan Chinook troll fishery, the Pacific Northwest Chinook troll fishery, the Russian Far East gill driftnet fisheries, etc.), a slightly modified set of criteria, also included in this document, will be applied to these fisheries, which we are referring to as "mixture-pool management fisheries" (management of these fisheries is

focused primarily upon a mixed-stock aggregate rather than achieving objectives for individual stocks).[6]

The Five Assessment Criteria

Criteria #1–3 concern governance quality:
Criterion #1: Is management responsive?
Criterion #2: Are the management guidelines appropriate?
Criterion #3: Are the management guidelines and responses based on adequate data?

Criteria #4–5 examine stock status:
Criterion #4: Has the productivity of the stock been maintained?
Criterion #5: Are hatcheries negatively affecting wild stocks?

Important Definitions

District: A mid-level aggregation of stocks into a larger administrative collection, for which statistics are collected and reported, such as Prince William Sound in Alaska. Each district fishery receives a separate fishery profile in FishSource.

Region: A large-scale collection of stocks for which statistics are produced under a unified management authority, such as those from Japan, Alaska, the Pacific Northwest (of the United States, etc.). Region-scale salmon profiles in FishSource summarize the scores received by nested district fisheries.

Wild Stock: A group of salmon of the same species (excluding aggregations composed of first-generation hatchery fish) that is geographically and temporally related and is managed as a unit. This is the group of fish for which there is (or could be) a single escapement goal (i.e., the part of a fish population that is under consideration from the point of view of actual or potential utilization).[7]

Stock Component: Sub-aggregates of salmon within a *stock* that may not be managed for individually, but are reproductively isolated or have unique life history attributes.

Additional Information

As most salmon fisheries are mixed-stock in nature, the criteria and underlying sub-criteria will be scored separately for each wild stock harvested in the fishery, and then aggregated to the district fishery scale. All wild stocks of the targeted species that originate within the geographic boundaries of the fishery's freshwater habitat will be assessed. The fishery's impact on stocks of other salmon species will be considered in the ecological parameters.

[6] The Pacific Salmon Treaty makes a similar distinction between types of salmon fisheries, using the terms "Aggregate Abundance-Based Management" (analogous to our term "mixture-pool management") and "Individual Stock-Based Management" (which we refer to as "stock directed management").
[7] The FishSource definition for "wild stock" is derived from: Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada, Bulletin 191, Ottawa.

Some distant, potentially transiting stocks that originate outside the geographic boundaries of the fishery's freshwater habitat and are inconsequential contributors to a fishery will not be rated against the five criteria. Ideally, assessors would look at estimated contribution rates to the fishery and harvest rates in the fishery to make a determination as to whether the contribution is large enough to be considered consequential. Unfortunately, in most cases these statistics are not available. In the absence of a clear indication that a stock is present in substantial numbers in a fishery over time, the assessors will assume the distant or transiting stock is present (and will include the stock in the criteria assessment) if any regulatory agency has called for regulation or action to limit the harvest of the distant or transiting stock within the fishery.

FishSource Salmon Fishery Assessment Framework: Stock-Directed Management Fisheries

Criterion #1: Is management responsive?

This criterion will be scored through the use of a qualitative assessment framework that considers three sub-criteria individually for each stock in the fishery. Each sub-criteria will receive a score on a 0–10 scale in alignment with the scoring benchmarks described below,[8] with "8" corresponding to the threshold above which a fishery passes an MSC assessment without conditions, "7" and "6" representing various states of performance that conditionally pass an MSC assessment but require varying degrees of additional work to maintain certification, and scores below "6" representing various states of performance that would not meet MSC certification standards. The overall criterion score will represent the lowest sub-criterion score received by any stock in the district fishery.

Sub-criterion 1. *In-season management responsiveness*

- Over the last decade, has fisheries management exhibited in-season responsiveness to stock status?

1. Yes, in-season management is used to respond to real-time run size, and harvest has been reduced when management objectives are not being met in 100% of these instances: award 10 points.
2. Yes, in-season management is used to respond to real-time run size, and harvest has been reduced in some cases when management objectives are not being met: award 8 points.
3. No, the management approach relies on pre-season regulations only (not in-season management): award 7 points.
4. Yes, but in-season management has been ineffective, and harvest has never been reduced when management objectives are not being met: award 5 points.

Sub-criterion 2. *Multi-year management responsiveness*

- Has fisheries management responded appropriately over the last 15 years if the stock has failed to meet management objectives or maintain yields?

[8] Scoring benchmarks in the salmon fishery assessment system are intended to serve as representative guidelines for scoring analysts. In some cases, analysts may find situations not explicitly described in the benchmarks, in which case the benchmarks are to be used as guides in the determination of the score.

1. (a) Yes, if the stock exhibited a recurring failure either to maintain yield or to meet management objectives over a 6-year period, fisheries management responded with a formal *stock of regulatory concern*[9] designation; a recovery plan was developed and implemented; the effectiveness of the plan was evaluated on a regular basis; and, if the stock did not respond, management took increasingly strong measures over time to bring about stock restoration; or (b) no stocks in the fishery have failed to meet management objectives or maintain yields: award 10 points.
2. Yes, if the stock exhibited recurring failure to meet management objectives or maintain yields over a 6-year period, fisheries management responded with increasingly strong measures over time to bring about stock restoration: award 8 points.
3. Partially, if the stock exhibited recurring failure to meet management objectives or maintain yields over a 6-year period, fisheries management responded with identifiable steps to address the failure, but response was slow or the steps were only partially effective: award 6 points.
4. No, there was no response to a failure to meet the stock's management objectives over a 6-year period: award 4 points.

Sub-criterion 3. *Management responsiveness to habitat issues*

- Has management (a government agency or group of government agencies) exhibited responsiveness to concerns regarding the conservation and restoration of the stock's essential freshwater, estuarine, and coastal habitats during the last 10 years?

1. Yes, management has a record of halting or modifying new development projects so as to have substantially slowed the loss of essential salmon habitat and stock productivity, and it has actively restored habitats that were historically impaired: award 10 points.
2. Partially, management has halted or modified some new development projects so as to have partially slowed the loss of essential salmon habitat and stock productivity, and has restored some degraded habitats: award 7 points.
3. Partially, management has made some efforts to regulate development of lands and water necessary for the stock's production, but its responses are slow or ineffective, or its recommendations are often ignored or overruled: award 4 points.
4. No, management has formally encouraged and prioritized development and extractive industry projects over the protection of salmon habitat: award 0 points.

Criterion #2: Are the management guidelines appropriate?

This criterion will be scored through the qualitative assessment of a single question for each stock within the district under assessment. A score of "8" corresponds to the threshold above which a fishery passes an MSC assessment without conditions, "7" and "6" represent various states of performance that conditionally pass an MSC assessment but require varying degrees of additional work to maintain certification, and scores below "6" represent

[9] Species/stocks of regulatory concern are species or stocks for which special conservation measures have been enacted through regulatory and management systems due to their depletion or failure to meet management objectives. Federal and regional designations (e.g., ESA, COSEWIC, SARA, Russian Red Book, Alaskan fish stocks of concern) will always be applied. International designations (e.g., IUCN) may be applied at the discretion of the reviewers if federal and regional designations are deemed inadequate.

various states of performance that would not meet MSC certification standards. For a fishery that harvests less than four stocks assessed under the FishSource qualitative assessment framework, the overall criterion score will represent the lowest score received for any stock in the district fishery. For a fishery that harvests four or more stocks assessed under this framework, the overall criterion score will represent the 25th percentile of the scores for each stock, thereby capturing poor performance but not failing fisheries due to "outlier" scenarios.

Sub-criterion 1. *There are appropriate management objectives in place for the fishery's wild stock(s)*

- Have appropriate escapement goals been developed and implemented?

1. Yes, science-based escapement goals or operational equivalents that cover all wild components of the stock have been implemented, and they have never been lowered in association with missed management objectives: award 10 points.
2. (a) Yes, escapement goals or operational equivalents that cover all wild components of the stock have been implemented, but they have been lowered once over the last 10 years in association with a missed management objective; or (b) yes, escapement goals or operational equivalents have been implemented and they have never been lowered in association with missed management objectives, but they do not adequately cover all wild components of the stock: award 7 points.
3. No, there are no escapement goals or similar targets and no knowledge of habitat production capacity, and there is no direct fishery on the stock: award 6 points.
4. (a) Yes, escapement goals or operational equivalents have been implemented, but were lowered two or more times over the last 10 years in association with missed management objectives; or (b) no, there are no escapement goals or similar targets and no knowledge of habitat production capacity, and there is a direct fishery on the stock: award 5 points.
5. Yes, there are escapement goals or operational equivalents in place, but the details of the goal-setting process or the goals themselves are not made public: award 4 points.

Criterion #3: Are the management guidelines and responses based on adequate data?

This criterion will be scored through the use of a qualitative assessment framework that considers three sub-criteria individually for each stock in the fishery. Each sub-criteria will have a score on a 0–10 scale, with "8" corresponding to the threshold above which a fishery passes an MSC assessment without conditions, "7" and "6" representing various states of performance that conditionally pass an MSC assessment but require varying degrees of additional work to maintain certification, and scores below "6" representing various states of performance that would not meet MSC certification standards. The overall criteria score will represent the lowest sub-criterion score received by any stock in the district fishery.

Sub-criterion 1. *Illegal, unreported, and unregulated (IUU) fishing*

- Is a portion of the stock's harvest over the last decade attributable to illegal, unreported, or unregulated fishing, resulting in official harvest data that is lower than the actual catch?

1. No, in the past decade there have been no reported occurrences of illegal,

unreported, or unregulated harvest; there are enforced legal penalties for misreporting; and there is no obvious incentive for misreporting: award 10 points.
2. Yes, there is some illegal, unreported, or unregulated harvest of the stock (≤12.5% of the legal harvest volume): award 8 points.
3. Yes, illegal, unreported, or unregulated harvest accounts for a more substantial portion of total harvest of the stock (≤25% of the legal harvest volume): award 6 points.
4. Yes, there is substantial illegal, unreported, or unregulated harvest of the stock (>25% of the legal harvest volume): award 5 points.

Sub-criterion 2. *Measurement and reporting of harvest*

- Is the stock's harvest, possibly in aggregation with the harvest of other stocks, adequately and accurately measured and reported?

1. Yes, the vast majority (greater than 90%) of the harvest in fisheries directed at this stock (commercial, sport, and other fisheries) is measured with a catch-tracking system that captures stock-specific information: award 10 points.
2. Yes, the majority (greater than 70%) of the harvest in fisheries directed at this stock (commercial, sport, and other fisheries) is measured with a catch-tracking system or an on-site probability-based survey or census, and very little of the harvest is unmeasured and undocumented on an annual basis: award 9 points.
3. Barely, the majority of the harvest in fisheries directed at this stock (commercial, sport, and other fisheries) is measured with a catch-tracking system or an on-site probability-based survey or census, but an unknown fraction of the harvest is unmeasured; documentation of sale does not always exist or is not verified; or a substantial fraction of the catch is measured with a post-season survey requiring the person filling out the survey to recall catch amounts: award 6 points.
4. No, the majority of the harvest in fisheries directed at this stock (commercial, sport, and other fisheries) is not directly measured: award 5 points.

Sub-criterion 3. *Measurement and reporting of escapement*

- Has the stock's escapement been adequately and accurately measured and publicly reported?

1. Yes, the escapement is directly measured annually (using weirs, sonars, counting towers, or similar methods) in the same units as the catch for the majority of the stock; escapement measures are reported publicly: award 10 points.
2. Yes, the escapement is measured annually either directly or indirectly (using methods appropriate for the species and circumstance) for a portion of the stock, allowing the construction of an escapement index (i.e., a series showing trends but in units not comparable to the catch statistics); escapement measures are reported publicly: award 8 points.
3. Yes, the escapement is measured annually either directly or indirectly (using methods appropriate for the species and circumstance) for a portion of the stock, allowing the construction of an escapement index (i.e., a series showing trends but in units not comparable to the catch statistics); however, there is reason to believe not all components of the stock are adequately represented by the index: award 7 points.
4. (a) Partially, the escapement is measured either directly or indirectly (using methods

appropriate for the species and circumstance) for a portion of the stock, allowing the construction of an escapement index (i.e., a series showing trends but in units not comparable to the catch statistics); escapement measures are not reported publicly for some or all of the stocks; or (b) no, the escapement is not measured annually, but the fishery has a low harvest rate and surrogate measures of run strength are publicly reported (e.g., Catch Per Unit Effort): award 6 points.

5. No, the escapement is not measured on an annual basis and there is no surrogate measure for run strength: award 5 points.

Criterion #4: Has the productivity of the stock been sustained?

This criterion will be scored through the qualitative assessment of two questions for each stock in the district under assessment. A score of "8" corresponds to the threshold above which a fishery passes an MSC assessment without conditions, "7" and "6" represent various states of performance that conditionally pass an MSC assessment but require varying degrees of additional work to maintain certification, and scores below "6" represent various states of performance that would not meet MSC certification standards. For a fishery that harvests four or more stocks assessed under this framework, the score for each sub-criterion will represent the 25th percentile of the scores for each stock, thereby capturing poor performance but not failing fisheries due to "outlier" scenarios.

Sub-criterion 1. *Escapement levels*

- Has the escapement measure been maintained above an escapement goal or threshold, or has the harvest rate has been below the target harvest rate?

1. Yes, the escapement measure has been maintained above the goal or threshold, or the harvest rate has been below the goal, for at least 12 of the last 15 years: award 10 points.
2. Yes, the escapement measure has been above the goal or threshold (or the harvest rate below the target) at least eight times over the previous 15-year period, and less than five of the missed goals were in the last 7 years of the series: award 7 points.
3. No, the escapement level has been below the fixed escapement goal or threshold (or the harvest rate above the target) eight or more times over the previous 15-year period or there have been five or more missed goals in the last 7 years of the series: award 6 points.
4. No, there is no escapement goal, but the trend in the escapement measure has been level or increasing over a 15-year period: award 9 points.
5. No, there is no escapement goal, but the escapement has declined less than 30% over a 15-year period: award 8 points.
6. No, there is no escapement goal, but the escapement has declined less than 50% over a 15-year period: award 6 points.
7. No, there is no escapement goal, but the escapement has declined more than 50% over a 15-year period: award 5 points.
8. No, the fishery is responsible for the stock's complete extirpation: award 0 points.

Sub-criterion 2. *Catch levels*[10]

- *Has the catch trend been level or increasing over a 15-year period?*

1. Yes: award 10 points
2. (a.) No, catch trends for the stock have declined, catch declines are consistent with declines in other stocks in the region, and the declines appear to be related to normal inter-decadal fluctuations in marine productivity; or (b.) No, catch trends for the stock have declined, but the trends result from active management responsiveness to stock declines (e.g., commercial fishery closures): award 8 points
3. No, the catch trends have declined over the previous 15-year period and the decline has not been explained or observed in other stocks in the region: award 7 points.
4. The stock is chronically diminished or a stock of regulatory concern, but harvest is occurring at the expense of escapement: award 5 points.

Criterion #5: Are hatcheries or other enhancement activities[11] negatively affecting wild stocks?

This criterion will be scored through the use of a qualitative assessment framework that considers three sub-criteria individually for each stock in the district fishery, and a fourth sub-criterion for the district as a whole. Prior to assessing the four sub-criteria, the assessors will consider questions 0(a) and 0(b) at the district scale. If results indicate that the assessment should proceed with consideration of the four sub-criteria, then each sub-criterion will receive a score on a 0–10 scale, with "8" corresponding to the threshold above which a fishery passes an MSC assessment without conditions, "7" and "6" representing various states of performance that conditionally pass an MSC assessment but require varying degrees of additional work to maintain certification, and scores below "6" representing various states of performance that would not meet MSC certification standards. The overall criterion score for the district will represent the lowest score awarded to a stock in any of the first three sub-criteria included in the evaluation, or awarded to the district in the fourth sub-criterion.

0(a) There is no hatchery production affecting the fishery

- There is no hatchery production of the species targeted by the fishery occurring anywhere within the freshwater habitat that produces the fishery's target stock(s): award 10 points as the overall criteria score, otherwise proceed to the following questions.

0(b) Hatchery-produced fish are not a potential threat to wild stocks

- Hatcheries account for 10% or less of the fishery's total production, or hatchery-produced fish are not in substantial contact with wild salmon: award 9 points as the overall criteria score, otherwise proceed to the following questions.

[10] If there has been no harvest of a particular stock in the last 15 years, the stock should receive a score only for sub-criterion 1 and not for sub-criterion 2. If there is not sufficient escapement data to score sub-criterion 1, only sub-criterion 2 will be scored. If there is no stock-specific harvest data, total fishery harvest trends will generate the score for sub-criterion 2.

[11] While the language for this criterion refers to "hatchery" stocks for the sake of simplicity, it is also intended to address production of salmon in spawning channels. Stocks produced in spawning channels should be considered hatchery stocks in scoring this criterion.

Sub-criterion 1. *Managers can and do actively manage for the wild stock*

- Are managers able to manage for the (wild) stock in a fishery that also contains hatchery stocks of salmon?

1. Yes, hatchery fisheries are spatially and temporally separate from the fishery that targets the wild stock, as demonstrated by a technically sound monitoring program: award 8 points.
2. No, there is some spatial and temporal overlap between hatchery stocks and the wild stock, but an ongoing, technically sound monitoring program identifies hatchery-produced fish in the fishery and managers prioritize wild stock management: award 7 points.
3. No, previous studies show mostly temporal and spatial separation, and managers attempt to manage for the wild stock: award 6 points.
4. (a) Managers or hatchery operators believe there is spatial or temporal separation, and managers believe they can manage for the wild stock, but there have been no studies to demonstrate this; or (b) managers or hatchery operators believe that there is spatial or temporal separation and are attempting to manage for the wild stock, but evidence suggests that they are not succeeding: award 5 points.
5. No, there is no attempt to distinguish wild and hatchery-produced fish in the fishery, but managers attempt to manage for the wild stock: award 4 points.
6. No, managers manage for combined wild and hatchery run strength: award 0 points.

Sub-criterion 2. *Hatchery straying is low and adequately measured in the escapement*

- Is there a low quantity of hatchery strays in the escapement throughout the freshwater habitat of the wild stock, and is hatchery straying quantified by means of a technically sound data collection and analysis?

1. Yes, ongoing studies document almost no straying: award 8 points.
2. Yes, limited studies have documented a minor amount of straying into geographically isolated areas: award 7 points.
3. (a) Very limited studies have been conducted, but there is low potential for straying; or (b) more substantial studies indicate more significant straying: award 6 points.
4. (a) Studies have been conducted and there have been high stray rates (e.g., >10% in some cases); or (b) no studies have been conducted, but it is reasonable to expect limited hatchery straying based upon location and magnitude of hatchery releases: award 5 points.
5. Inadequate studies have been conducted, and it is reasonable to expect substantial straying based upon location and magnitude of hatchery releases: award 4 points.
6. No studies have been conducted, and there is potential for substantial straying into major wild-stock producing systems: award 0 points.

Sub-criterion 3. *Intentional stock mixing is prohibited in spawning populations*

- Over the past 10 years, have hatchery strays, hatchery out-plants, or any returning hatchery-produced fish been intentionally allowed to mix with the wild stock during spawning?

1. No, hatchery-wild mixing is never intentionally allowed and there are never any occurrences: award 8 points.

2. Yes, but only 1–2 occurrences (intentional stock mixing in a particular year by a particular hatchery) have been documented, accounting for <3% of wild stock production, and with limited stock rebuilding objectives and controls on stock movement in place: award 7 points.
3. (a) Yes, more than two occurrences (recurring at the same location or in multiple years) have been documented, accounting for <10% of wild stock production; or (b) yes, hatchery-wild mixing commonly occurs as a stock-rebuilding strategy, but there is no direct fishery on the stock: award 6 points.
4. Yes, hatchery-wild mixing commonly occurs, but the management system takes actions to limit its magnitude: award 5 points.
5. Yes, hatchery-wild mixing commonly occurs as a rebuilding strategy for a stock targeted by the fishery, and is reflected in the siting of hatcheries or release sites at wild stock run locations: award 2 points.
6. Yes, hatchery-wild mixing commonly occurs with no restrictions: award 0 points.

Sub-criterion 4. *Policies*[12]

- Are there active and effective policies that (1) establish objectives for the conservation of wild salmon, (2) put into place operational systems that limit hatchery impacts on wild stocks, (3) grant sufficient oversight and authority over individual hatchery programs to management agencies, and (4) establish a hatchery evaluation system that monitors the performance of individual hatcheries against wild salmon conservation objectives?

1. Yes, policies with all four of the above-listed components are in place and are strictly followed throughout the district with almost no exceptions: award 8 points.
2. Yes, policies with all four components are in place and are generally followed with only an occasional exception; or policies with three of the four components are in place and are strictly followed throughout the district with almost no exceptions: award 7 points.
3. Yes, policies with three of the four components are in place and are generally followed with only an occasional exception, or policies with two of the four components are in place and are strictly followed throughout the district with almost no exceptions: award 6 points.
4. Yes, there are polices with 1–4 of the above-listed components in place, but they are frequently ignored or waved; or (b) no, there are no such policies: award 4 points.
5. Yes, there are polices with 1–4 of the above-listed components in place, but they are always ignored or waived: award 0 points.

FishSource Salmon Fishery Assessment Framework: Mixture-Pool Management Fisheries

All sub-criteria will be scored at the district fishery scale rather than stock-by-stock. Each sub-criteria will receive a score on a 0–10 scale, with "8" corresponding to the threshold above which a fishery passes an MSC assessment without conditions, "7" and "6"

[12] Sub-criterion 4 will generate a single score awarded to all stocks within a district fishery (in contrast with the first three sub-criteria, which can generate differing scores for different stocks).

representing various states of performance that conditionally pass an MSC assessment but require varying degrees of additional work to maintain certification, and scores below "6" representing various states of performance that would not meet MSC certification standards. Overall criteria scores will represent the lowest nested sub-criterion scores received by the fishery.

Criterion #1: Is management responsive?

Sub-criterion 1. *In-season management responsiveness: Part 1*

- Over the last decade, has fisheries management exhibited in-season responsiveness to stock status?

1. Yes, in-season management is used to respond to real-time run size, and harvest has been reduced when run strength is below the forecast in 100% of these instances: award 10 points.
2. Yes, in-season management is used to respond to real-time run size, and harvest has been reduced in some cases when run strength is below the forecast: award 8 points.
3. No, the management approach relies on pre-season regulations only (not in-season management): award 7 points.
4. Yes, but in-season management has been ineffective, and harvest has never been reduced when run strength is below the forecast: award 5 points.

Sub-criterion 2. *In-season management responsiveness: Part 2*

- Has the management system maintained catch consistently below the catch limit, if there is one, during the last 15 years?

1. Yes, catch was below the catch limit for at least 12 of the last 15 years: award 10 points.
2. Yes, catch was below the catch limit for at least 10 of the last 15 years, and the cumulative overage and underage is less than 10% of the average annual catch limit: award 7 points.
3. Partially, catch was below the catch limit for at least 8 of the last 15 years, or the cumulative overage and underage is 10–20% of the average annual catch: award 6 points.
4. No, catch was above the catch limit eight or more times in the last 15 years, or the cumulative overage and underage is more than 20% of the average annual catch limit: award 5 points.

Sub-criterion 3. *Multi-year management responsiveness*

- Has fisheries management responded appropriately over the last 15 years if a stock has failed to meet management objectives or maintain yields?

1. (a) Yes, if the stock exhibited a recurring failure either to maintain yield or to meet management objectives over a 6-year period, fisheries management responded with a formal *stock of regulatory concern* designation; a recovery plan was developed and implemented; the effectiveness of the plan was evaluated on a regular basis; and if the stock did not respond, management took increasingly strong measures over time to bring about stock restoration; or (b) there are no stocks in the fishery that have failed to meet management objectives or maintain yields: award 10 points.

2. Yes, if a stock exhibited recurring failure to meet management objectives or maintain yields over a 6-year period, fisheries management responded with increasingly strong measures over time to bring about stock restoration: award 8 points.
3. Partially, if a stock exhibited recurring failure to meet management objectives or maintain yields over a 6-year period, fisheries management responded with identifiable steps to address the failure, but response was slow or the steps were only partially effective: award 6 points.
4. No, there was no response to a failure to meet a stock's management objectives over a 6-year period: award 4 points.

Sub-criterion 4. *Management responsiveness to habitat issues*

- Has management (a government agency or group of government agencies) exhibited responsiveness to concerns regarding the conservation and restoration of the fishery's essential freshwater, estuarine, and coastal habitats during the last 10 years?

1. Yes, management has a record of halting or modifying new development projects so as to have substantially slowed the loss of essential salmon habitat and stock productivity, and it has actively restored habitats that were historically impaired: award 10 points.
2. Partially, management has halted or modified some new development projects so as to have partially slowed the loss of essential salmon habitat and stock productivity, and has restored some degraded habitats: award 7 points.
3. Partially, management has made some efforts to regulate development of lands and water necessary for the stock's production, but its responses are slow or ineffective, or its recommendations are often ignored or overruled: award 4 points.
4. No, management has formally encouraged and prioritized development and extractive industry projects over the protection of salmon habitat: award 0 points.

Criterion #2: Are the management guidelines appropriate?

- Are the management guidelines appropriate and subject to scientific oversight?

1. Yes, a transparent, science-based model is used in establishing management guidelines, and is subject to scientific oversight: award 10 points.
2. Partially, a science-based model is used in establishing management guidelines, but it is either not entirely transparent or subject to scientific oversight only occasionally: award 7 points.
3. No, there is no scientific oversight of the process that establishes management guidelines, or there is political interference in scientific oversight: award 5 points.

Criterion #3: Are the management guidelines and responses based on adequate data?

Sub-criterion 1. *Illegal, unreported, and unregulated (IUU) fishing*

- Is a portion of the fishery's harvest over the last decade attributable to illegal, unreported, or unregulated fishing resulting in official harvest data that is lower than the actual catch?

1. No, in the past decade there have been no reported occurrences of illegal, unreported, or unregulated harvest; there are enforced legal penalties for misreporting; and there is no obvious incentive for misreporting: award 10 points.
2. Yes, there is some illegal, unreported, or unregulated harvest resulting in total harvest that exceeds the catch limit by 12.5% or less: award 8 points.
3. Yes, more substantial illegal, unreported, or unregulated harvest results in total harvest that exceeds the catch limit by 25% or less: award 6 points.
4. Yes, substantial illegal, unreported, or unregulated harvest results in total harvest that exceeds the catch limit by more than 25%: award 5 points.

Sub-criterion 2. *Measurement and reporting of harvest*

- Is harvest of the fishery mixture adequately and accurately measured and reported?

1. Yes, the vast majority (greater than 90%) of the harvest in this fishery is measured with a catch-tracking system: award 10 points.
2. Yes, the majority (greater than 70%) of the harvest in this fishery is measured with a catch-tracking system or an on-site probability-based survey or census, and very little of the harvest is unmeasured and undocumented on an annual basis: award 9 points.
3. Barely, the majority of the harvest this fishery is measured with a catch-tracking system or an on-site probability-based survey or census, but an unknown fraction of the harvest is unmeasured; documentation of sale does not always exist or is not verified; or a substantial fraction of the catch is measured with a post-season survey requiring the person filling out the survey to recall catch amounts: award 6 points.
4. No, the majority of this fishery's harvest is not directly measured: award 5 points.

Sub-criterion 3. *Stock identification*

- Have stock identification efforts been undertaken to determine the fishery's stock composition?

1. An ongoing, high-quality, genetic study is determining the stock composition of this fishery's harvest: award 10 points.
2. An ongoing, tag-based study is determining the stock composition of this fishery's harvest: award 8 points.
3. Stock composition estimates are based upon assumptions and modeling that are in line with a prior genetic, tag-based, or other type of study: award 6 points.
4. Stock composition estimates are derived through a non-transparent, technically unsound process: award 5 points.

Sub-criterion 4. *Measurement and reporting of escapement*

- Is escapement measured in a substantial and well-distributed quantity of stocks harvested by the fishery?

1. The escapement is measured for a large number of component stocks of the fishery that are well distributed given the correlation among stock run strengths: award 10 points.
2. The escapement is measured for a moderate number of component stocks of the fishery that are adequately distributed given the correlation among stock run strengths: award 8 points.

3. The escapement is measured for a moderate number of component stocks of the fishery, but their distribution could be improved given the correlation among stock run strengths: award 6 points.
4. The escapement is measured for a small number of component stocks of the fishery that are poorly distributed given the correlation among stock run strengths: award 5 points.
5. There is no escapement monitoring of component stocks of the fishery: award 0 points.

Criterion #4: Has productivity of the fishery been maintained?

Sub-criterion 1. *Escapement levels*

- Have escapement trends of the fishery's stock aggregate been level or increasing over the last 15 years?

1. Yes, escapement among indicator stocks of the fishery has been level or increasing for the last 15 years, and there is no geographic clustering of declines: award 10 points.
2. (a) Yes, escapement of indicator stocks of the fishery has been level or increasing for the last 15 years, but there is geographic clustering of declines; or (b) no, escapement among indicator stocks of the fishery is declining, but no more than 5% of component stocks have declined by 75%: award 7 points.
3. No, escapement among indicator stocks of the fishery is declining, and more than 5% of component stocks have declined by 75%: award 5 points.

Sub-criterion 2. *Catch levels*

- Has the fishery's catch trend been level or increasing over a 15-year period?

1. Yes: award 10 points.
2. (a) No, catch trends for the fishery have declined, and the declines appear to be related to normal inter-decadal fluctuations in marine productivity; or (b) no, catch trends for the stock have declined, but the trends result from active management responsiveness to stock declines (e.g., commercial fishery closures): award 8 points.
3. No, catch trends have declined over the previous 15-year period and the declines do not appear to be related to normal inter-decadal fluctuations in marine productivity: award 7 points.
4. No, the stock mixture is chronically diminished, but harvest is occurring at the expense of escapement: award 5 points.

Criterion #5: Are hatcheries negatively affecting wild stocks?

0(a) There is no hatchery production affecting the fishery

- There is no hatchery production of the species targeted by the fishery occurring anywhere within the freshwater habitat that produces the fishery's target stocks: award 10 points as the overall criteria score, otherwise proceed to the following questions.

0(b) Hatchery-produced fish are not a potential threat to wild stocks

- Hatcheries account for 10% or less of the fishery's total production, or hatchery-

produced fish are not in substantial contact with wild salmon: award 9 points as the overall criteria score, otherwise proceed to the following questions.

Sub-criterion 1. *Identification and quantification of hatchery stocks*

- Are managers able to identify and quantify hatchery fish in the mixed-stock aggregate?

1. Yes, an ongoing, technically sound monitoring program identifies and quantifies hatchery-produced fish: award 8 points.
2. Partially, an ongoing monitoring program identifies and quantifies hatchery-produced fish, but not all hatchery components are adequately marked: award 7 points.
3. Partially, an ongoing monitoring program identifies and quantifies hatchery-produced fish, but significant non-sampling error results in inaccurate estimates of hatchery contribution to the fishery: award 6 points.
4. No, managers cannot identify and quantify hatchery fish: award 0 points.

Sub-criterion 2. *Hatchery contribution and catch limit determination*

- Does hatchery abundance overly influence the determination of the fishery's catch limit?

1. No, wild stock run strength predominantly determines the fishery's catch limit: award 8 points.
2. Wild run strength is a major determinant of the fishery's catch limit; however, hatchery run strength is also influential: award 6 points.
3. Yes, hatchery stock run strength predominantly determines the fishery's catch limit: award 5 points.
4. Yes, hatchery stock run strength entirely determines the fishery's catch limit: award 0 points.

Ecological Parameters: Bycatch[13] of species/stocks of regulatory concern

1. There is substantial bycatch of a species or stock (salmon of a different species) of regulatory concern.
2. Bycatch mortality is implicated in the failure of populations of the species or stock (salmon of a different species) of regulatory concern to rebuild.
3. Bycatch of the species or stock (salmon of a different species) of regulatory concern is monitored.
4. There is a ceiling or other regulatory constraint on bycatch of the species or stock (salmon of a different species) of regulatory concern.
5. The ceiling or other regulatory constraint, if in place, is being met.

Other Bycatch

6. There is substantial bycatch of another species or salmon stock (of a different species) that is not an object of regulatory concern.

[13] Bycatch species or salmon stocks of a different species: Species or stocks that have been taken incidentally and are not retained (usually because they have no commercial value or because they cannot be retained or sold according to management rules).

7. There is no general bycatch monitoring system in place, i.e., there is no bycatch monitoring, or bycatch monitoring focuses only upon species or stocks (salmon of another species) of regulatory concern.

Retained Harvest[14] of Salmon Stocks of a Different Species

8. There is substantial retained harvest of one or more salmon stock(s) of a different species.
9. Retained harvest of a salmon stock of a different species is implicated in that stock's failure to recover from stock declines.
10. If there is substantial retained harvest of one or more salmon stock(s) of a different species, the harvest is monitored, and studies have been undertaken to determine the origins and fishery contribution rate for the stock(s) in question.
11. There is a ceiling or other regulatory constraint in place to reduce or regulate the harvest of the stock(s) in question.
12. Management has undertaken sufficient measures to limit the harvest rates of the stock(s) in question, and all regulatory constraints, if in place, are being met.

Annex D: Salmon Fishery Profiles in FishSource

Sustainable Fisheries Partnership plans to adapt its online FishSource database in 2013 to better reflect the specificities of salmon fishery management and the FishSource salmon assessment method. The scores page of salmon fishery profiles will indicate the scores for all sub-criteria, and will also include harvest and escapement graphs both for individual stocks and the aggregate fishery (Figures 24–25).

[14] Retained species or salmon stocks of a different species: Species or stocks that are retained by the fishery under assessment (usually because they are commercially valuable or because they are required to be retained by management rules).

1

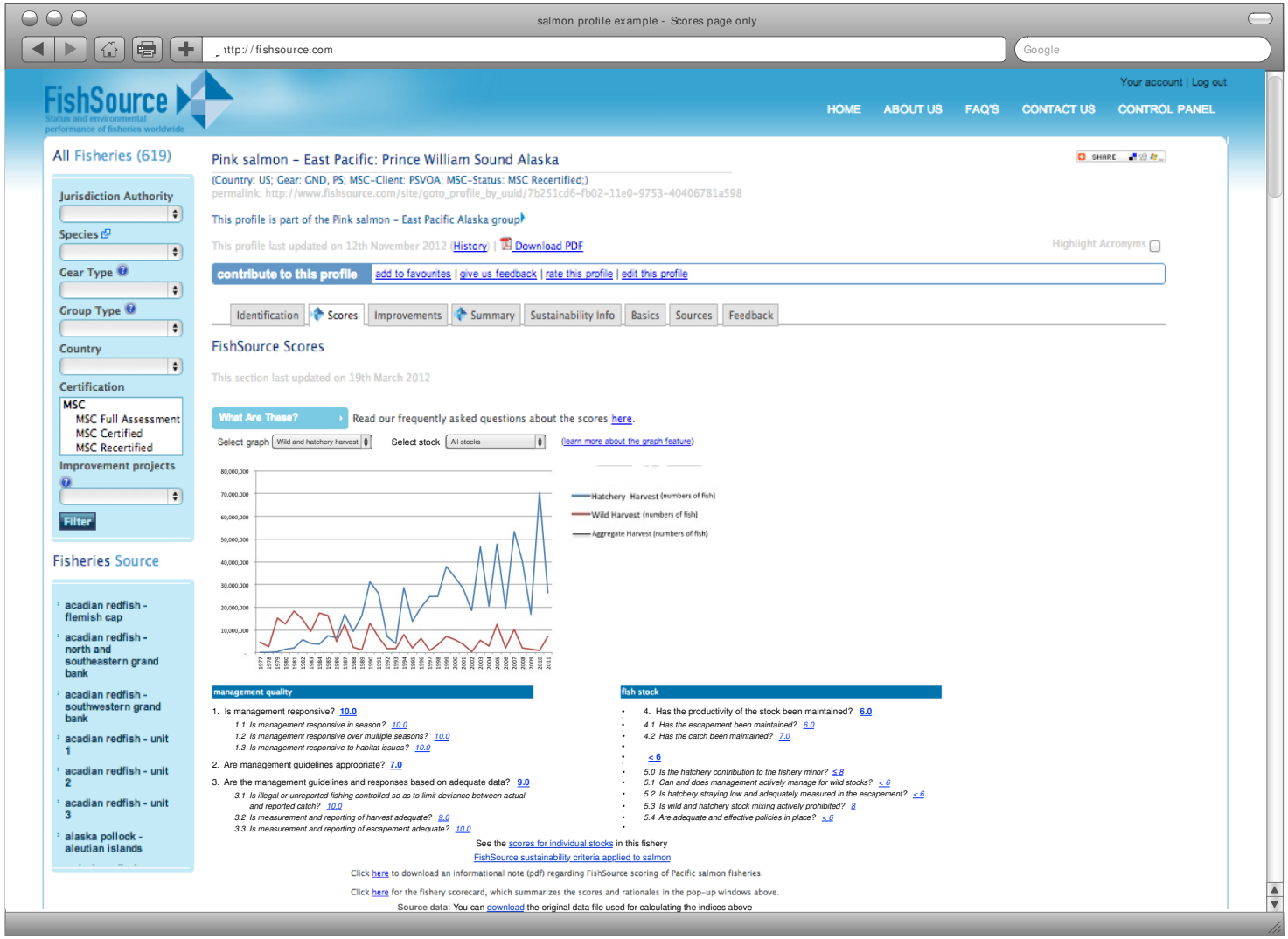

Figure A1: Future design of a scores page of a salmon profile on www.fishsource.com. Scores for all sub-criteria are listed at the bottom of the page, and a graph of aggregate fishery wild and hatchery harvest components is displayed.

6

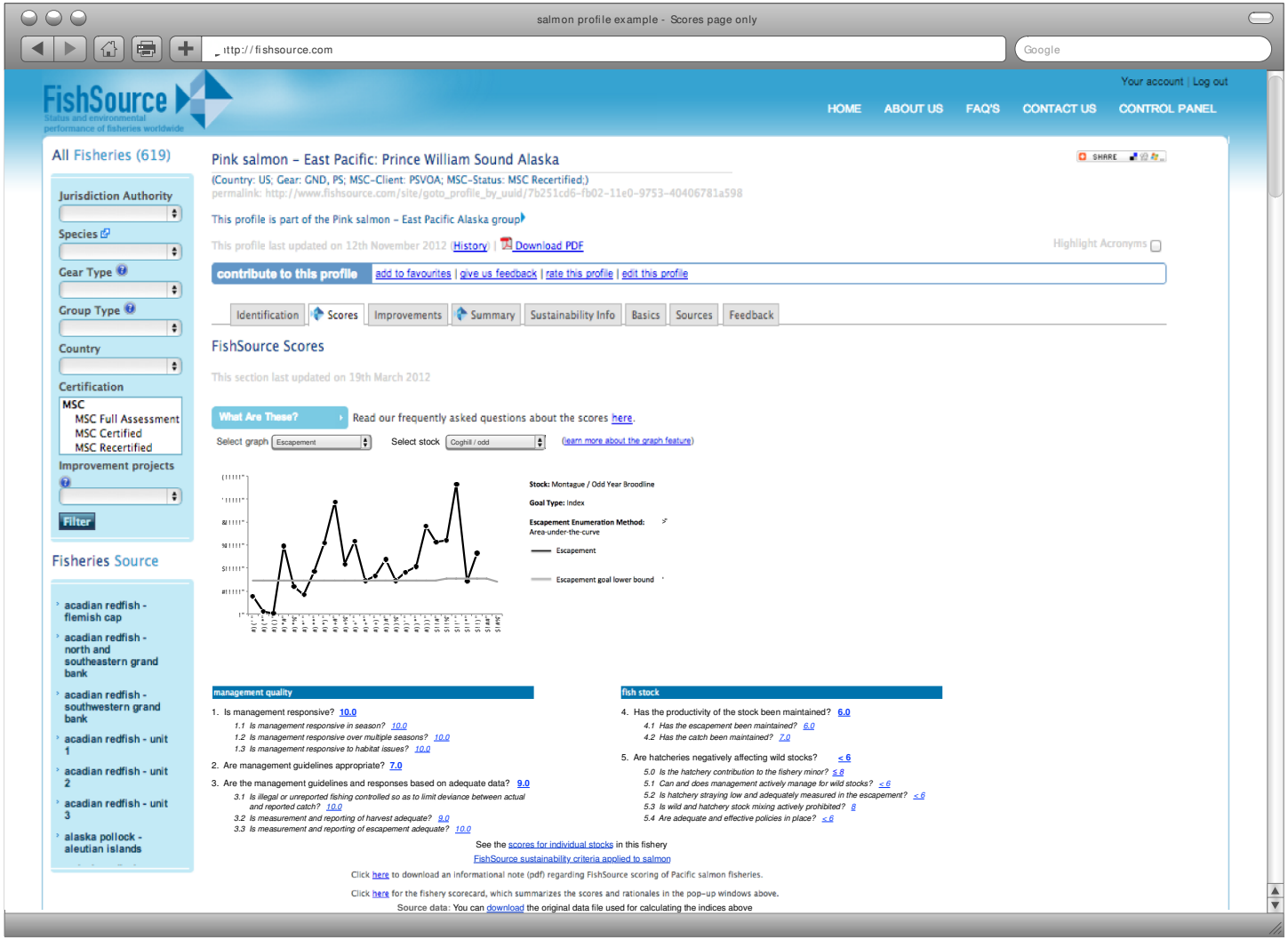

Figure A2: Future design of a scores page of a salmon profile on www.fishsource.com. Graphs of escapement vs. goals for individual stocks will also be accessible from the scores page.