Western Alaska Salmon Stock Identification Program **Technical Document**:[1] 13

Title: Selection of a Prior for Mixed Stock Analysis

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Introduction

One of the goals of the Western Alaska Salmon Stock Identification Program (WASSIP) is to identify key Western Alaska stocks as they migrate and are intercepted as bycatch, or harvested in targeted salmon fisheries. In order to do this a Bayesian approach to genetic mixed stock analysis (MSA), the Pella-Masuda model (Pella and Masuda, 2001), has been selected. The Bayesian method used in MSA to estimate the proportion of stocks caught within each fishery requires four pieces of information: 1) a baseline of allele frequencies for each population; 2) a grouping of populations into reporting groups desired for MSA; 3) prior information about the stock proportions of the fishery, and 4) data from the fishery. From these four components the posterior distribution of the stock proportions is generated that summarizes our knowledge of these parameters. The prior information about stock proportions is incorporated in the form of a Dirichlet probability distribution in which the sum of the prior Dirichlet parameters sum to K and can be interpreted as adding K individuals to the fishery sample known as the "prior count". While K can be assigned any positive value, it is typically held at 1 (Pella and Masuda, 2001). The reporting group identity of the prior count is fixed, while the reporting group identities of all other individuals in the fishery mixture are stochastic.

Unfortunately there is not a standard method for selecting a prior distribution for these types of analyses. While the influence of the prior may be limited to that of a single fish, the magnitude of this effect on the analysis depends on the strength of the structure among the stocks being resolved. We expect the prior effect to be small with strongly structured baseline stocks, and the

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prior effect to be greater with weakly structured baseline stocks, making prior selection a very important decision.

We propose a sequential prior (see below) that is initiated using a prior derived from one of several alternative methods that we outline below. We are seeking Technical Committee (TC) input on the most appropriate method to derive an initial prior.

For the purpose of this document we will refer to the following terms: population, identifiable unit, sub-regional reporting group, and regional reporting group (Technical Document 11).

Population - a group of individuals spawning in close enough proximity such that members of the group can potentially mate with any other member.

Identifiable unit – the smallest group of populations in a genetic baseline to which portions of a mixture are allocated with acceptable accuracy during MSA; constructed based on genetic distinction and statistical resolution only. Identifiable units can include one or more populations and may or may not coincide with a reporting group [See Technical Document 11].

Sub-regional Reporting Group - a group of one or more identifiable units in a genetic baseline to which portions of a mixture are allocated during MSA; constructed based on a combination of stakeholder needs, genetic distinction, and statistical resolution.

Regional Reporting Group– a group of one or more sub-regional reporting groups that are generally concordant with Management Areas; constructed based on a combination of stakeholder needs, genetic distinction, and statistical resolution.

The Sequential Prior

For the purpose of choosing priors for WASSIP, the Gene Conservation Laboratory (GCL) proposes to use a sequential process similar to that used by Michielsen et al. (2008). These authors combined information from multiple Bayesian stock assessments in a sequential process that allowed the analysis to be implemented in a relatively simple fashion. In the context of MSA, within a fishery stratum the sequential process uses the posterior estimate of sub-regional reporting group proportions from one temporal stratum as the prior for the next stratum's analysis. The source of the prior for a given temporal stratum can be either from within the same year, or from a complementary stratum from a previous year, depending on where the temporal variation in sub-regional reporting group proportions is most stable.

Temporal variation in reporting group proportions within a fishery stratum may occur both intra- and inter-annually. Patterns of intra-annual variation occur as the relative proportion of reporting groups rise and fall with time as they pass through a fishery due to differences in migration timing among reporting groups. Patterns of inter-annual variation occur as different reporting groups rise and fall in productivity from year to year. Whichever source of variation is lower should provide the guidance for determining where to seek prior information. If intra-annual variation is lower, then each intra-annual stratum is linked to the next (e.g. *A1*→*B1*→*C1*→*D1*, Figure 1). Alternatively, if the inter-annual variation is lower, then each inter-annual sampling effort is linked to the next (e.g. *B1*→ *B2*→ *B3*→ *B4*, Figure 1).

For sockeye salmon, the GCL has historically relied on previous intra-annual strata as the prior information, under the premise that this method tracks progression of stock proportions through the course of a fishery. Where we have looked at it, the intra-annual variation is lower than the inter-annual variation. For example, we examined the variation in proportions of sockeye salmon harvested from strata within years and across years in one fishery; the Egegik District of Bristol Bay. Intra-annual and inter-annual fluctuations are shown in Figure 2. The intra-annual absolute differences in sub-regional reporting group proportions of this fishery vary gradually, with the absolute difference across all reporting groups for all four years averaging 3.1%. On the other hand, while reporting groups do appear to have similar run-timing across years, they also appear to have somewhat different run-strengths each year, and the inter-annual absolute differences in sub-regional reporting group proportions averaged 3.9% across the four years for all reporting groups; approximately 25% greater than the average intra-annual difference. This result suggests that intra-annual variation tends to be more stable, an intuitive outcome considering that this source of variation accounts for inter-annual changes in reporting group strength, which can be large for sockeye salmon in Bristol Bay (Hilborn et al. 2003).

Because of the relatively small intra-annual variation in reporting group proportions, a sequential prior based on the previous sample within the same year seems most reasonable to use. Thus, for the depiction of samples in Figure 1, the posterior estimates from temporal sample *A1* will be used as a prior for *B1*, and *B1* will be used as the prior for *C1*, and so on. To initiate the first stratum within a year, the results from the first stratum of the previous year will be used. Under this method of determining the prior for the first stratum in the first year, *A1*, still remains a problem.

Each fishery is a unique set of strata determined from the location and type of harvest, thus for chum there are 31 initial fishery strata, each of which requires a prior consisting of the estimate for the 18 sub-regional reporting groups (Appendix A) and for sockeye, there are 24 fishery strata with 25 sub-regional reporting groups (Appendix B). Selecting the best method to initiate the analysis, i.e. what prior to use for *A1* for each fishery, is the topic of the remainder of this paper.

Selection of Priors for Initial Strata

Initiating sample *A1* with a prior can be done in one of two ways: 1) a non-informative prior, or 2) an informative prior. A non-informative prior distribution is often implemented under the "principle of insufficient reason" that requires the distribution to be uniform unless there is a definite reason to consider an alternative (Jeffery's method as described in Kass and Wasserman 1996). If a prior other than uniform distribution is suggested, then the researcher is expressing confidence in an alternative before the data are available.

An informative prior takes into account information about the fishery and the reporting groups to which it is assigning individual fish. Information such as abundance of different regional reporting groups, sub-regional reporting groups and populations, the migration patterns of the fish, and the proximity of the fishery to the reporting group can be included in determining the prior. Ideally such information would be incorporated into a prior, however, this becomes difficult if accurate information is not known, and may be problematic if incorrect assumptions are made. Alternatively, an informative prior can be based on information from various, often non-standardized sources that are organically synthesized (intuition).

Here we present two non-informative and two informative prior methods that might be used alone or in combination to develop a prior for the initial fishery sample (*A1*). We describe these methods and describe the advantages and disadvantages for each. We are looking for TC direction regarding which method or combination of methods to implement for WASSIP.

Non-informative Priors

Population Flat Prior – A population flat prior attempts to apply the "principle of insufficient reason" at the population level. A population flat prior assumes that the proportions of each population in the mixture are equal:

$$\propto_i = \frac{1}{C}$$

Where α_i is the prior Dirichlet parameter assigned to the i^{th} population's proportion, and C is the number of populations. Pella and Masuda (2001) propose that a population flat prior be used in MSA, and it has been utilized in a variety of fisheries analyses (Beacham et al. 2009; Tucker et al. 2009). However, while this prior is uniform with respect to individual populations, it is not uniform with respect to reporting groups, and it gives disproportionate prior mass to the reporting groups represented by many populations. Because the GCL reports estimates at the sub-regional reporting group level, we typically deem this prior to be less desirable than other priors which attempt to spread the prior mass uniformly across populations rather than the sub-regional reporting groups.

Advantages: Simple to implement; objective.
Disadvantages: Assumes the best information available is that the expected proportions of fish from each population are equal and constant for every fishery; is actually informative with respect to reporting groups based on the number of populations within a group.

Sub-Regional Reporting Group Flat Prior – A sub-regional reporting group flat prior attempts to apply the "principle of insufficient reason" to the sub-regional reporting group level (see Technical Document 11 for sub-regional reporting groups for WASSIP). This prior presumes that the proportion of individuals found in the fishery is equal for each sub-regional reporting group, and for each population within a reporting group and can be represented mathematically as:

$$\propto_{g,k} = \frac{1}{GC_g}$$

Where $\propto_{g,k}$ is the proportion of the sample assigned to population *k*, in sub-regional reporting group *g*. Here, *G* is the number of sub-regional reporting groups, and C_g is the number of populations in group *g*. This is chosen because it attempts to give equal weight to all sub-regional reporting groups, and should not be biased towards those that have more populations.

However, this type of prior, as with the population flat prior is uninformative with respect to abundance, migration pathways, and proximity of fishery to population, all of which are likely to influence the fishery composition.

Advantages: Simple to implement; objective.
Disadvantages: Assumes the best information available is that the expected proportions of fish from each sub-regional reporting group are equal and constant for every fishery.

Informative Priors

Biology-Based Prior – A biology-based prior incorporates variables that are thought to be correlated with proportions of reporting groups expected within fisheries. These priors require base information about the variables and a relationship between the variables and expected proportions (a model).

Abundance

Regional run-size estimates – In order to include estimates of abundance in our informative prior, a method must be determined to estimate the relative proportions of each sub-regional reporting group in the fishery. The Alaska Department of Fish and Game does have estimates on the orders of magnitude of abundance for these groups, however, using this information may be circular because a goal of WASSIP to estimate the relative abundance of each of these sub-regional reporting groups using genetic data. In addition, different stakeholders may have competing ideas on orders of magnitudes of certain reporting groups, which makes establishing abundances somewhat subjective.

Local F_{ST} – An alternative is to use genetics to estimate the abundance of each population; the inverse of local F_{ST} (Falush et al. 2003) can be used as a proxy for abundance according to the approximation:

$$F_{ST}^{(i)} \approx \frac{1}{4N_e^{(i)}m^{(i)} + 1}$$

Where $N_e^{(i)}$ is the effective population size and $m^{(i)}$ is the proportion of immigrants for population *i*. Local $F_{ST}^{(i)}$ can be interpreted as a measure of differentiation between the population in question and the meta-population, defined by all populations in the baseline. Estimates of these parameters are easily calculated via the F-model (Gaggiotti and Foll 2010).

Implementation of the F-model for estimating relative abundance requires two key assumptions: 1) migration rate *m* remains constant for all populations, and 2) the ratio of effective population size to actual size (N_e/N) remains constant for all populations. If these two assumptions hold, then the inverse of the local $F_{ST}^{(i)}$ is proportional to abundance, and the constant of proportionality is the same for all populations. The inverse of $F_{ST}^{(i)}$ for each population would be summed within the sub-region to estimate a surrogate for sub-region abundance. These surrogates would then be standardized to sum to one. This calculation assumes that all populations within each sub-region are represented in the baseline.

Adherence to these assumptions is questionable, because it is unlikely that immigration rates are equal across all populations as differences in straying rates have been documented in a variety of salmon species (Labelle 1992; Hard and Heard 1999, Hendry et al. 2004). It is also unknown if the relationship between effective population size and actual population size is constant among populations (Kalinowski and Waples 2002). This is especially true for populations derived from a small number of colonizing individuals or for populations that go through periodic bottlenecks due to barriers to migration (Habicht et al. 2004). Finally, it is likely that not all populations within all the sub-regional reporting groups are represented in the baseline; this is especially true of baseline populations east and west of WASSIP.

Migration

In order to include migration in our informative prior a model of migration must be selected. The two competing migratory models in the literature would predict different stock composition estimates (and therefore priors) within the WASSIP fisheries north of the Alaska Peninsula. In both models the fish swim from the North Pacific into the Bering Sea through the eastern Aleutian Islands. However, in one model, the fish then move east and follow the shoreline to their home drainage (i.e. Straty 1975; Figure 3a). In this model, each fishery would be expected to capture local fish as well as fish from drainages further along the migration pathway. In the second model, fish move north from the Aleutian Islands and feed in the Bering Sea before migrating eastwardly to their home streams (i.e. Urawa 2005; Figure 3b). In this model, each fishery would be expected to capture fish from drainages near the fishery.

In both models local fish would be expected to be present at disproportionally higher proportions than would be expected based on abundance alone because local fish are migrating closer to shore, where the fisheries occur. Both models predict that fish migrating into the Bering Sea, but still in the North Pacific Ocean, would be migrating westward along the south side of the Alaska Peninsula. Finally, both models predict that fish in the eastern North Pacific Ocean migrating toward drainages east of WASSIP would also be present in fisheries of the south Peninsula. Determining the abundance of these stocks would depend on how far east in the North Pacific Ocean the fish migrate before starting their homeward migration and how close to shore they migrate during their easterly migration. Much of this information is not available.

Proximity

Distance is easy to measure and objective, however, to use proximity alone, a relationship between distance and expected contribution would need to be established.

Multiple variables in combination

More comprehensive models could include multiple variables in combination. These models can get complex and require information on the relationships outlined above for each independent variable along with information about interactions among the variables.

Advantages: Objective, once base assumptions are made; uses biological information.
Disadvantages: Difficult to establish base assumptions due to lack of information.

Subjective Prior – A subjective prior incorporates information from various sources and allows the use of different information sources for each fishery stratum. One subjective prior could use the Advisory Panel (AP) as "expert witnesses" to assign expected proportional harvest of each fishery to sub-regional reporting groups. For example, the AP could provide fishery estimates for those sub-regional reporting groups that are expected to comprise more than 10% of the fishery. For the remaining sub-regional reporting groups a flat prior would be assigned (i.e. the remaining proportion of the fishery would be split equally among all remaining sub-regions). A minimum of least 1% should be assigned to each sub-region to ensure that each population acquires some non-zero prior value: failure to do so may result in rounding zeros, leading to problems with convergence.

The subjective prior has the advantage of using the experience and knowledge of the AP to inform the prior, while still maintaining the possibility of small stocks through the use of the flat prior spread amongst stocks with less than 10%. A drawback to this method is that it requires the AP to agree on proportions of the fishery assigned to several stocks (Appendix A, B).

Advantages: Allows for incorporation of information from multiple sources. Simple to administer once consensus is achieved.

Disadvantages: Subjective and may be difficult to reach consensus.

ADF&G Recommendation

Based on the "principle of insufficient reason," the Department recommends using flat priors based on the sub-regional reporting groups for all initial (A1) priors used in WASSIP. Priors for all subsequent strata will follow the sequential prior approach. Among informative priors, subjective expert opinion from the AP has merit for all initial (A1) priors, and should be discussed to determine if this approach provides sufficient basis for departing from flat priors.

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Specific questions for the Technical Committee:

1. Is the sequential prior approach appropriate for all strata except A1?
    a. If not, what approach do you recommend?
2. Are any of the methods proposed for initiation of the A1 prior acceptable?
    a. If not, what method do you recommend?
    b. If any are, please rank acceptable methods in order of preference.

Technical Committee review and comments

Document 13: Selection of a Prior for Mixed Stock Analysis

The comments below are based on TC review of Technical Document 13 and the addendum prepared by ADFG staff (sent by email 26 September), as well as discussions at the September 21-22, 2011 meeting.

General comments:

Technical Document 13 is a thoughtful approach to a complex problem, which arises because stock composition estimates are constrained to fall in the biologically feasible range 0-1. As a consequence of this constraint, stocks that are large contributors tend to have their contributions underestimated, and stocks that are absent or minor contributors tend to have their contributions overestimated. In the latter case, the proportional error in estimating contributions by small stocks can be substantial. In Bayesian analyses such as those used here, the choice of priors for stock composition estimates can help alleviate these types of biases. If genetic differences among stocks are large, the data will overwhelm the priors and they will have little influence and the resulting estimates will have little bias. When genetic differences are weak, however, as occurs for many stock groups of chum salmon, the priors can be much more influential in determining the magnitude of bias in the posterior distribution of the estimated stock compositions. The ideal priors are the true stock compositions; unfortunately, these are not known. Two general options are available:

1) use ‘uninformed’ or ‘flat’ priors. Two flavors of flat priors were considered:

a) Population-based. Each of the n populations in the baseline gets a prior proportional to 1/n

b) Reporting-group based. Each of the q reporting groups gets an overall prior proportional to 1/q, which is equally divided among the number of populations in that reporting group.

Option 1a equalizes priors across populations but this means that some reporting groups might have higher priors than others.

Option 1b equalizes priors across reporting groups but this means that some populations might have higher priors than others.

Which 'flat' option is preferable will depend on which better reflects underlying realities, as well as the goals of the project. In the present case, since fishery composition estimates will be assessed at the level of reporting groups, option 1b is perhaps preferable to 1a.

2) Use 'informed' priors, which draw on prior information that suggests some populations are more likely to contribute to the mixture than others. Several types of information that might be used are discussed in Technical Document 13.

a) Run-size estimates. Larger populations would get higher priors.

b) Local Fst. Populations with large Fst would be presumed to be small and get lower priors.

c) Migration. Presumed migration pathways would be used to adjust priors up or down.

d) Proximity. Populations that are farther from a particular fishery would be considered less likely contributors.

e) Subjective expert opinion.

f) Stock compositions estimates for the same fishery in different years or seasons

Absent empirical data illustrating its usefulness in this context, we do not recommend 2b since it is well-known that inferences regarding Fst can be very sensitive to violation of underlying assumptions. In particular, we don't see any reason to believe that the assumptions that migration rates or the ratio Ne/N are equal among all populations are reasonable for these populations.

We believe that 2a,c,d,e all have some potential usefulness for developing priors, but each would require considerable effort to implement. We suspect that none of these would be feasible within the time frame available for the current project, but would be worth considering in the future. One that was discussed at the meeting involved a 'binary uniform' prior, in which professional judgment by AP members is used to eliminate some populations as unlikely contributors. This method seems to have some potential merit, esp. if combined with other approaches to weight the priors for the 'likely' contributors. But it seems unlikely that consensus could be reached on how to implement this option in time.

The final option (2f) has considerable potential, in our opinion. It draws on (at least largely) independent information that is directly relevant to the underlying problem. Some variation of the sequential approach proposed in Technical Document 13 seems a reasonable way to go. We have a few comments:

- We expect that whether inter-annual or intra-annual variation is larger will vary depending on the fishery and perhaps the species. So, this evaluation might have to be made independently for every fishery.
- Technical Document 13 proposes to determine which source of variation is smaller (inter- or intra-annual) and use only that information that to direct the sequential process. However, this discards potentially useful information, particularly if the magnitudes of variation are not too different. A better approach would be to use information from both prior years and seasons within the year, each weighted by an inverse function of the respective variances. This would give less weight to comparisons with higher variance but would not discount this information entirely.
- This hierarchical approach potentially might be extended to include some of the other biological factors listed under 2). As noted above, however, this is probably a project for the future.

Priors for the first seasonal fishery in the first year (stratum A1 in Technical Document 13) cannot be developed in the manner described above. The authors propose using flat priors based on reporting groups for A1. We believe a better approach is to use something like the method proposed in the Addendum, which uses stock composition estimates from other strata to inform priors for A1. The logic for this approach is that there is nothing inherently directional about the 3 years of data for each species; one might as easily start with 2009 and end with 2007 as start with 2007 and end with 2009. This approach entails a bit of circularity, as results from A1 are then used to help set priors for some of these same strata. However, we expect that the potential benefits in providing better priors for A1 outweigh any drawbacks.

With respect to specific questions posed in Technical Document 13:

1. Is the sequential prior approach appropriate for all strata except A1?

a. If not, what approach do you recommend?

We suggest a variation of the sequential prior approach (see below for details)

2. Are any of the methods proposed for initiation of the A1 prior acceptable?

a. If not, what method do you recommend?

b. If any are, please rank acceptable methods in order of preference.

As noted above, all but 2b are reasonable to consider. However, it seems unlikely that any of 2a,c,d, or e could be implemented within the short time frame available. We would rank the other approaches as follows, in order of decreasing priority: 2f, [1b = 1a]. See below for details about option 2f.

Minor points:

Line 124: actually, this method is sensitive to the number of SAMPLED populations, which might be different from the number of actual populations

Note that the major shifts in stock composition in Bristol Bay sockeye described by Hilborn et al. 2003 occurred over at least a half century and hence are not necessarily a good indication of the degree of inter-annual variation to be expected.

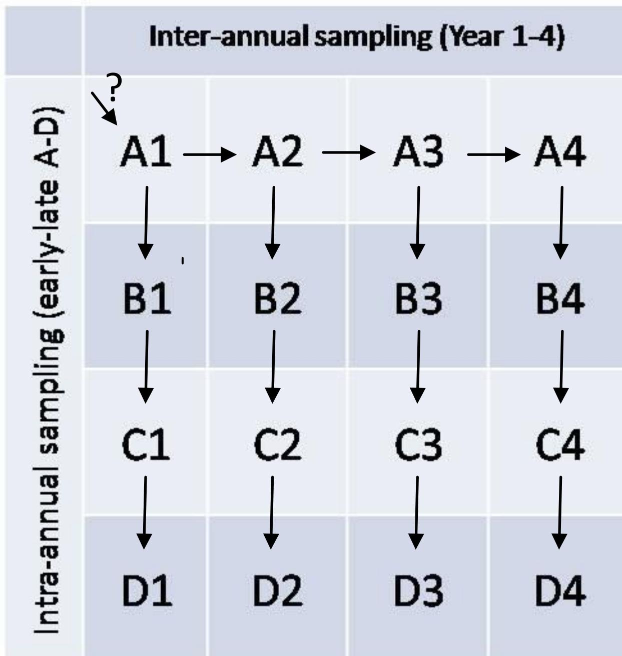

Figure 1. Depiction of the temporal sampling within a year and between years. The arrows show the sequential prior method assuming that intra-annual variation is lower than inter-annual variation. The only stratum that needs a prior initiated is A1.

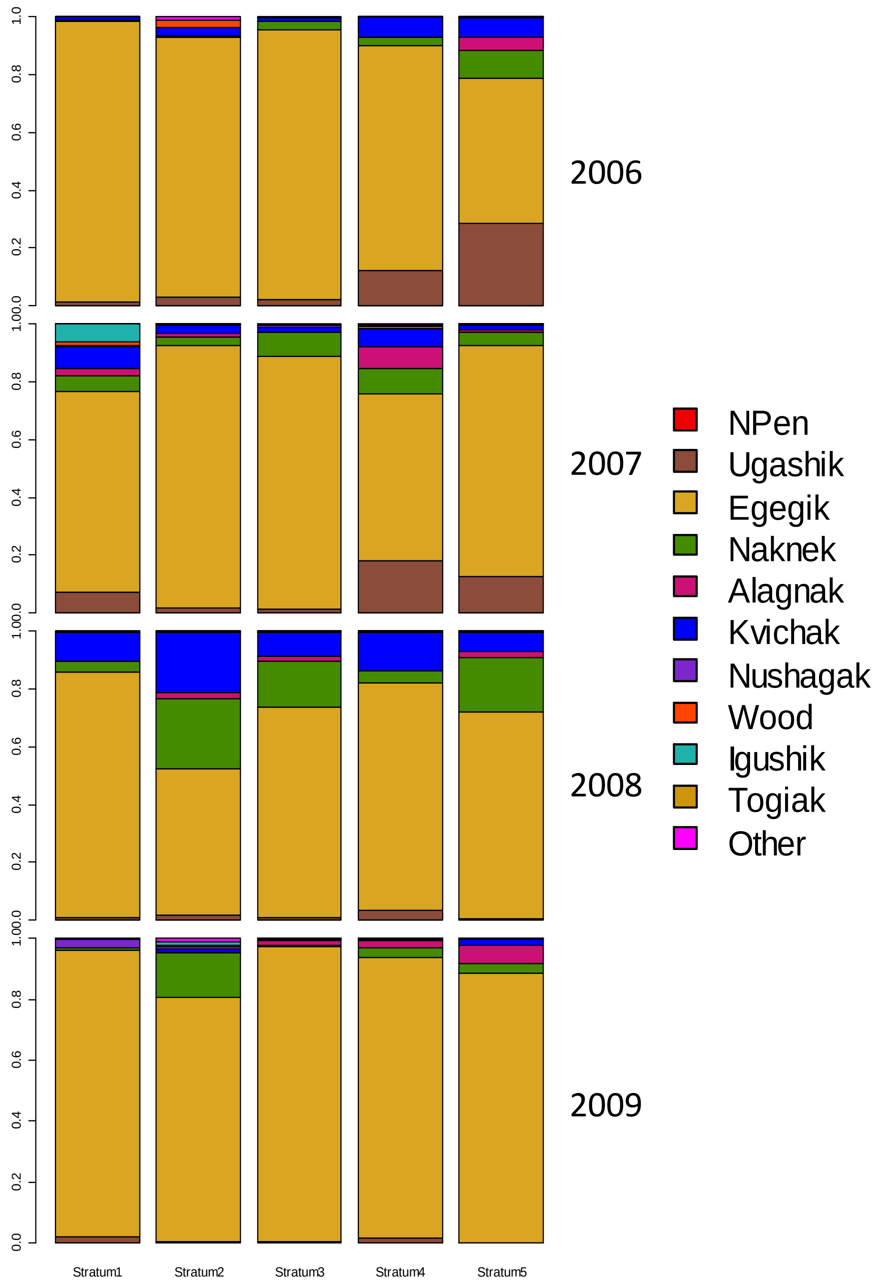

Figure 2. Stock composition for sockeye salmon in the Egegik District of Bristol Bay from 2006-2009. The inter-annual (top to bottom) absolute differences in sub-regional reporting group proportions of this fishery were approximately 25% greater than the average intra-annual (left to right) difference.

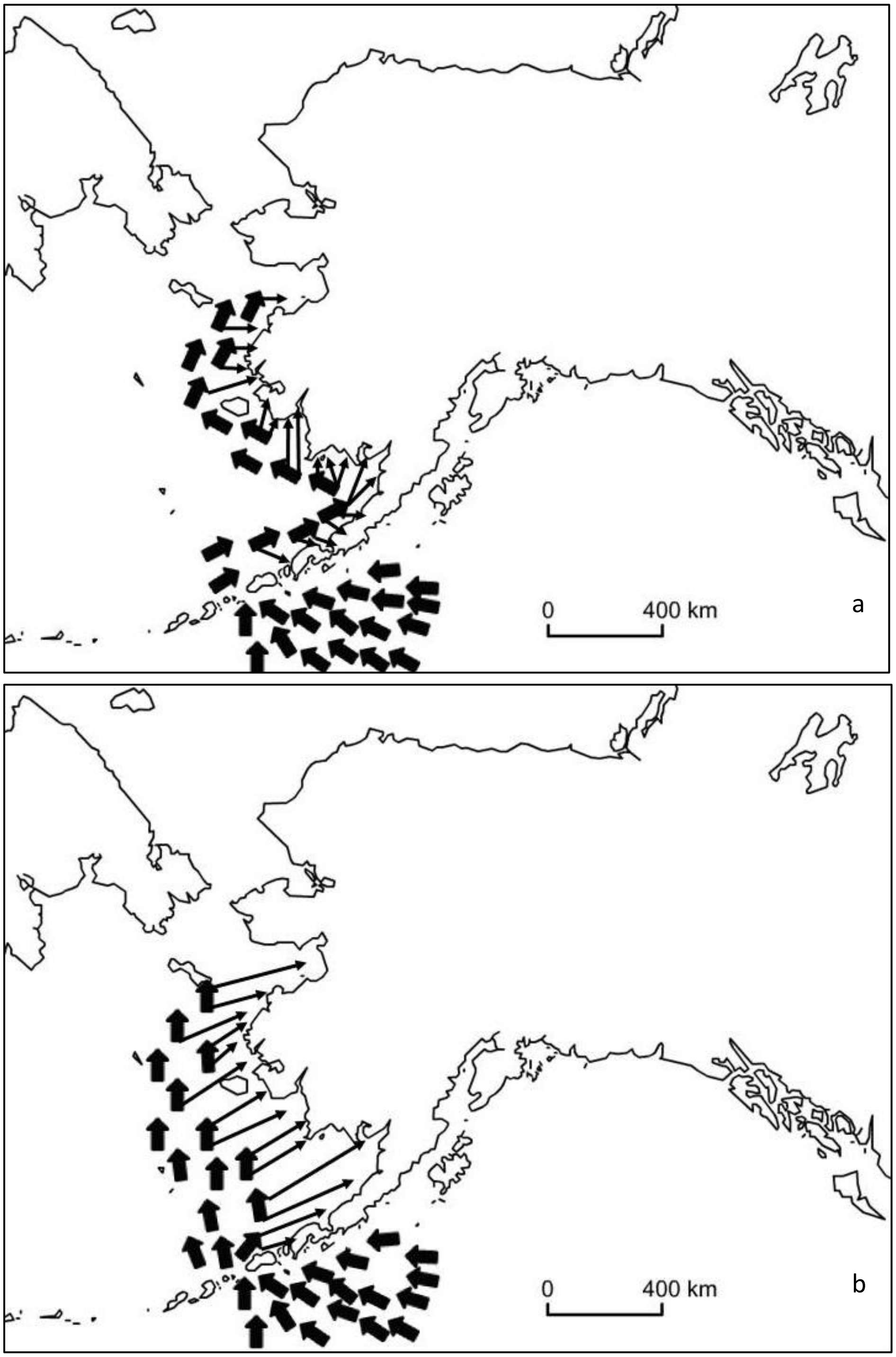

Figure 3. Two possible migratory models; a) based on Straty (1975) fish move west and follow the shoreline to their home drainages, and b) based on Urawa (2005) fish move north in the Bering Sea and then migrate eastwardly to their home stream.

Appendix A.—Initial prior matrix for chum salmon, showing the large number of strata requiring initiation. The columns represent the baseline sub-regional reporting groups and the rows represent the fisheries.

		Reporting Group																		
	Fishery Strata	Asia	Kotzebue Sound	Nome/ Port Clarence	Golovin/Elim	Norton Bay/ Shaktoolik/ Unalakleet	Lower Yukon River	Nunivak/ Kanektok/ Goodnews/ Upper & Lower Kuskokwim River (Fall)	Togiak	Nushagak	Eastern Bristol Bay	Middle Yukon	Upper Yukon	Northern District	Northwestern District	South Peninsula	Chignik	East of WASSIP
Chignik Area	Eastern District																	
	Central District																	
	Western and Perryville District																	
Alaska Peninsula	SEDM																	
	Shumagin Islands Section																	
	Ikatan area																	
	Unimak District																	
	Bear River Section																	
	Three Hills and Ilnik sections																	
Bristol Bay Area	Eastside districts																	
	Nushagak District																	
	Togiak District																	
Kuskokwim Area	District 5 Commercial																	
	District 4 Commercial																	
	District 1 Commercial																	
	Toksook Bay Subsistence																	
Yukon-Northern Area	District 1 Commercial marine areas excluding Black River																	
	District 1 Commercial Black River only																	
	District 1Scammon Bay, Black River Subsistence																	

		Reporting Group																
	Fishery Strata	Asia	Kotzebue Sound	Nome/ Port Clarence	Golovin/Elim	Norton Bay/ Shaktoolik/ Unalakleet	Lower Yukon River	Nunivak/ Kanektok/ Goodnews/ Upper & Lower Kuskokwim River (Fall)	Togiak	Nushagak	Eastern Bristol Bay	Middle Yukon	Upper Yukon	Northern District	Northwestern District	South Peninsula	Chignik	East of WASSIP
	Coastal District (Hooper Bay) Subsistence																	
Norton Sound-Port Clarence Area	Subdistrict 6 Unalakleet Commercial																	
Norton Sound-Port Clarence Area	Subdistrict 5 Shaktoolik Commercial																	
Norton Sound-Port Clarence Area	Subdistrict 3 Moses Point Commercial																	
Norton Sound-Port Clarence Area	Subdistrict 2 Golovin Commercial																	
Norton Sound-Port Clarence Area	Stebbins area Subsistence																	
Norton Sound-Port Clarence Area	St. Michael area Subsistence																	
Norton Sound-Port Clarence Area	Subdistrict 5 Shaktoolik Subsistence																	
Norton Sound-Port Clarence Area	Subdistrict 3 Moses Point Subsistence																	
Norton Sound-Port Clarence Area	Nome area Subsistence																	
Norton Sound-Port Clarence Area	Pt. Clarence District Subsistence																	
Kotzebue Area	Kotzebue Area																	

Appendix B.--Initial prior matrix for sockeye salmon, showing the large number of strata requiring initiation. The columns represent the baseline sub-regional reporting groups and the rows represent the fisheries.

	Reporting Group																							
	Fishery Strata	Seward Peninsula	Kuskokwim River	Kanektok	Goodnews	Togiak	Igushik/Snake	Wood	Nushagak	Kvichak	Alagnak	Naknek	Egegik	Ugashik	Cinder	Meshik	Ilnik	Bear River	Sandy River	Nelson River	Northwestern Dist./ Aleutian Islands	South Peninsula	Black Lake	Chignik Lake	East of WASSIP
Chignik Area	Eastern District																								
	Central District																								
	Chignik Bay District																								
	Western and Perryville District																								
Alaska Peninsula Area	East Stepovak and Stepovak Flats Sections																								
	Northwest Stepovak Section																								
	Southwest Stepovak, Balboa Bay, and Beaver Bay Sections																								
	Shumagin Islands Section																								
	Dolgoi Island area																								
	Ikatan area																								
	Unimak District																								

	Fishery Strata	Seward Peninsula	Kuskokwim River	Kanektok	Goodnews	Togiak	Igushik/Snake	Wood	Nushagak	Kvichak	Alagnak	Naknek	Egegik	Ugashik	Cinder	Meshik	Ilnik	Bear River	Sandy River	Nelson River	Northwestern Dist./ Aleutian Islands	South Peninsula	Black Lake	Chignik Lake	East of WASSIP
		Reporting Group																							
	Bear River Section																								
	Three Hills Section																								
	Ilnik Section southern statistical area																								
	Ilnik Section northern statistical area																								
	Outer Port Heiden Section																								
Bristol Bay Area	Ugashik District																								
Bristol Bay Area	Egegik District																								
Bristol Bay Area	Naknek-Kvichak District																								
Bristol Bay Area	Nushagak District																								
Bristol Bay Area	Togiak District																								
Kuskokwim Area	Kuskokwim Area																								
Kuskokwim Area	District 5 Commercial																								
Kuskokwim Area	District 4 Commercial																								