**Regional Information Report 5J12-20**

# Western Alaska Salmon Stock Identification Program Technical Document 13: Selection of a Prior for Mixed Stock Analysis

**by**

**James R. Jasper,**

**Sara M. Turner,**

**and**

**Christopher Habicht**

**October 2012**

**Alaska Department of Fish and Game** **Divisions of Sport Fish and Commercial Fisheries**

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**Weights and measures (metric)**

| | |
|---|---|
| centimeter | cm |
| deciliter | dL |
| gram | g |
| hectare | ha |
| kilogram | kg |
| kilometer | km |
| liter | L |
| meter | m |
| milliliter | mL |
| millimeter | mm |

**Weights and measures (English)**

| | |
|---|---|
| cubic feet per second | $ft^3/s$ |
| foot | ft |
| gallon | gal |
| inch | in |
| mile | mi |
| nautical mile | nmi |
| ounce | oz |
| pound | lb |
| quart | qt |
| yard | yd |

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| degrees kelvin | K |
| hour | h |
| minute | min |
| second | s |

**Physics and chemistry**

| | |
|---|---|
| all atomic symbols | |
| alternating current | AC |
| ampere | A |
| calorie | cal |
| direct current | DC |
| hertz | Hz |
| horsepower | hp |
| hydrogen ion activity (negative log of) | pH |
| parts per million | ppm |
| parts per thousand | ppt, ‰ |
| volts | V |
| watts | W |

**General**

| | |
|---|---|
| Alaska Administrative Code | AAC |
| all commonly accepted abbreviations | e.g., Mr., Mrs., AM, PM, etc. |
| all commonly accepted professional titles | e.g., Dr., Ph.D., R.N., etc. |
| at | @ |
| compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| copyright | © |
| corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| District of Columbia | D.C. |
| et alii (and others) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g. |
| Federal Information Code | FIC |
| id est (that is) | i.e. |
| latitude or longitude | lat. or long. |
| monetary symbols (U.S.) | $, ¢ |
| months (tables and figures): first three letters | Jan,...,Dec |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S.C. | United States Code |
| U.S. state | use two-letter abbreviations (e.g., AK, WA) |

**Mathematics, statistics**

| | |
|---|---|
| *all standard mathematical signs, symbols and abbreviations* | |
| alternate hypothesis | $H_A$ |
| base of natural logarithm | *e* |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, etc.) |
| confidence interval | CI |
| correlation coefficient (multiple) | R |
| correlation coefficient (simple) | r |
| covariance | cov |
| degree (angular ) | ° |
| degrees of freedom | df |
| expected value | *E* |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $log_2$, etc. |
| minute (angular) | ' |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| variance | |
| population | Var |
| sample | var |

*REGIONAL INFORMATION REPORT 5J12-20*

# WESTERN ALASKA SALMON STOCK IDENTIFICATION PROGRAM TECHNICAL DOCUMENT 13: SELECTION OF A PRIOR FOR MIXED STOCK ANALYSIS

by
James R. Jasper, Sara M. Turner, and Christopher Habicht
Alaska Department of Fish and Game, Division of Commercial Fisheries, Gene Conservation Laboratory, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

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*James R. Jasper, Sara M. Turner, and Christopher Habicht*
*Alaska Department of Fish and Game, Division of Commercial Fisheries,*
*333 Raspberry Road, Anchorage, Alaska, 99518-1565 USA*

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# ABSTRACT

Uncertainty about the magnitude, frequency, location, and timing of the nonlocal harvest of sockeye and chum salmon in Western Alaska fisheries was the impetus for the Western Alaska Salmon Stock Identification Program (WASSIP). The project was designed to use genetic data in mixed stock analysis (MSA) to reduce this uncertainty. We followed a Bayesian approach, the Pella-Masuda Model, in which prior information about the stock proportions of the fishery, or the prior probability distribution (referred to hereafter as a "prior") is critical to the outcome of the MSA. There is not a universally standard method for the selection of a prior in these types of analyses and we predicted the prior effect to be greater with weakly structured baseline stocks, making prior selection especially important. We presented 4 options—2 noninformative methods and 2 informative prior methods—that might be used alone or in combination to develop a prior for the initial fishery sample to the 4-member Technical Committee (TC), created to provide independent scientific review of WASSIP's analytical and statistical approaches. We described the advantages and disadvantages for each method. Our initial recommendation was to use flat (uniform) priors based on subregional reporting groups for all initial priors and the sequential prior approach for all subsequent strata. Among informative priors, subjective expert opinion from the WASSIP Advisory Panel had merit and it should be discussed to determine if this approach would provide sufficient basis for departing from flat priors. Based on TC input, our approach for determining priors was revised to a new 4-step method: 1) within each fishery, determine whether variation is lower within years across time strata or across years within time strata using $F_{ST}$; 2) calculate composition estimates for the combined strata groups with the smallest inter-strata variability, excluding the first stratum for each set; 3) use these estimates for the priors in the first stratum for each set; and 4) use sequential priors thereafter within each set of strata.



Key words: Western Alaska Salmon Stock Identification Program, WASSIP, mixed stock analysis, MSA, Bayesian analysis, Pella-Masuda, initial prior, sockeye salmon, chum salmon, *Oncorhynchus nerka*, *O. keta*


# 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 4 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 prior effect to be greater with weakly structured baseline stocks, making prior selection especially important.

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, subregional reporting group, and regional reporting group (Habicht et al. 2012).

**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 (Habicht et al. 2012).

**Subregional 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 subregional 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 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 subregional 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 subregional reporting group proportions is most stable.

Temporal variation in reporting group proportions within a fishery stratum may occur both intra- and interannually. 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 interannual 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 interannual variation is lower, then each interannual sampling effort is linked to the next (e.g. *A1*→ *A2*→ *A3*→ *A4*, Figure 1).

For sockeye salmon, the Gene Conservation Laboratory 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 interannual 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 interannual fluctuations are shown in Figure 2. The intra-annual absolute differences in subregional reporting group proportions of this fishery vary gradually, with the absolute difference across all reporting groups for all 4 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 interannual absolute differences in subregional reporting group proportions averaged 3.9% across the 4 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 interannual 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 subregional reporting groups (Appendix A) and for sockeye, there are 24 fishery strata with 25 subregional 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 1 of 2 ways: 1) a noninformative prior, or 2) an informative prior. A noninformative 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, subregional 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 nonstandardized sources that are organically synthesized (intuition).

Here we present 2 noninformative and 2 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.

## NONINFORMATIVE 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 $\alpha_i$ 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.[1] Because the Gene Conservation Laboratory reports estimates at the subregional 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 subregional 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.

### Subregional Reporting Group Flat Prior

A subregional reporting group flat prior attempts to apply the *principle of insufficient reason* to the subregional reporting group level (see Habicht et al. 2012 for subregional reporting groups for WASSIP). This prior presumes that the proportion of individuals found in the fishery is equal for each subregional 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 subregional reporting group $g$. Here, $G$ is the number of subregional 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 subregional 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.

[1] This sentence is commented on in the section entitled "Technical Committee Review and Comments."

Disadvantages: Assumes the best information available is that the expected proportions of fish from each subregional 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 subregional 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 is to estimate the relative abundance of each of these subregional 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:

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

Where $N_{\mathrm{e}}^{(i)}$is the effective population size and $m^{(i)}$ is the proportion of immigrants for population *i*. Local $F_{\mathrm{ST}}^{(i)}$ 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 $F_{\mathrm{ST}}^{(i)}$ is proportional to abundance, and the constant of proportionality is the same for all populations. The inverse of $F_{\mathrm{ST}}^{(i)}$ for each population would be summed within the subregion to estimate a surrogate for subregion abundance. These surrogates would then be standardized to sum to one. This calculation assumes that all populations within each subregion 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 subregional 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 2 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 the first 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 et al. 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 subregional reporting groups. For example, the AP could provide fishery estimates for those subregional reporting groups that are expected to comprise more than 10% of the fishery. For the remaining subregional reporting groups a flat prior would be assigned (i.e. the remaining proportion of the fishery would be split equally among all remaining subregions). A minimum of least 1% should

be assigned to each subregion 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 subregional 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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# REFERENCES CITED


Beacham, T. D., J. R. Candy, S. Sato, S. Urawa, K. D. Le, and M. Wetklo. 2009. Stock origins of chum salmon (*Oncorhynchus keta)* in the Gulf of Alaska during winter as estimated with microsatellites. North Pacific Anadromous Fish Commission Bulletin No. 5:15–23.

Falush, D., M. Stephens, and J. K. Pritchard. 2003. Inference of population structure using multilocus genotype data: linked loci and correlated allele frequencies. Genetics 164:1567–1587.

Gaggiotti, O. E., and M. Foll. 2010. Quantifying population structure using the *F*-model. Molecular Ecolology Resources 10:821–830.

Habicht, C., J. B. Olsen, L.Fair and J. E. Seeb. 2004. Smaller effective population sizes evidenced by loss of microsatellite alleles in tributary-spawning populations of sockeye salmon from the Kvichak River, Alaska drainage. Environmental Biology of Fishes 69:51–62.

Habicht, C., J. R. Jasper, T. H. Dann, N. Decovich, and W. D. Templin. 2012. Western Alaska Salmon Stock Identification Program Technical Document 11: Defining reporting groups. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 5J12-16, Anchorage.

Hard, J. J. and W. R. Heard 1999. Analysis of straying variation in Alaskan hatchery Chinook salmon (*Oncorhynchus tshawystcha*) following transplantation. Canadian Journal of Fisheries and Aquatic Sciences 56(4):578–589.

Hendry, A. P., V. Castric., M. T. Kinnison, and T. P. Quinn. 2004. The evolution of philopatry and dispersal homing versus straying in salmonids. [*In*] A. P. Hendry and S. C. Stearns, editors. Evolution Illuminated Salmon and Their Relatives. Oxford University Press, New York, NY.

Hilborn, R., T. P. Quinn, D. E. Schindler, and D. E. Rogers. 2003. Biocomplexity and fisheries sustainability. Proceedings of the National Academy of Sciences, USA. 100:6564–6568.

Kalinowski S. T., and R. S. Waples. 2002. The ratio of effective to census size in fluctuating populations. Conservation Biology 16:129–136.

Kass, R. E., and L. Wasserman. 1996. The selection of prior distributions by formal rules. Journal of the American Statistical Association 91(435):1343–1370.

Labelle, M. 1992. Straying patterns of coho salmon (*Oncorhynchus kisutch*) stocks from southeast Vancouver Island, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 49:1843–1855.

Michielsens, C. G. J., M. K. McAllister, S. Kuikka, S. Mantyniemi, A. Romakkaniemi, T. Pakarinen, L. Karlsson, and L. Uusitalo. 2008. Combining multiple Bayesian data analyses in a sequential framework for quantitative fisheries stock assessment. Canadian Journal of Fisheries and Aquatic Sciences 65:962–974.

Pella, J., and M. Masuda. 2001. Bayesian methods for analysis of stock mixtures from genetic characters. Fishery Bulletin 99:151–167.

Straty, R. R. 1975. Migratory routes of adult sockeye salmon, *Oncorhynchus nerka*, in the Eastern Bering Sea and Bristol Bay. NOAA Technical Report NMFS SSRF-690.

Tucker, S., M. Trudel, D. W. Welch, J. R. Candy, J. F. T. Morris, M. E. Thiess, C. Wallace, D. J. Teel, W. Crawford, E. V. Farley Jr., and T. D. Beacham. 2009. Seasonal stock-specific migrations of juvenile sockeye salmon along the west coast of North America: Implications for Growth. Transactions of American Fisheries Society 135:1458–1480.

Urawa, S., M. Kawana, T. Azumaya, P. A. Crane, and L. W. Seeb. 2005. Stock-specific ocean distribution of immature chum salmon in the summer and early fall of 2003: estimates by allozyme analysis. NPAFC Doc. 896. National Salmon Resources Center, Toyohira-ku, Sapporo 062-0922, Japan.

# QUESTIONS FOR 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

*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 $F_{ST}$. Populations with large $F_{ST}$ 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 $F_{ST}$ 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 $N_e/N$ 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 interannual 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.

## Comments on Specific Questions

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:

Page 4, 1st ¶, fourth sentence (note 1): 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 interannual variation to be expected.

# FIGURES

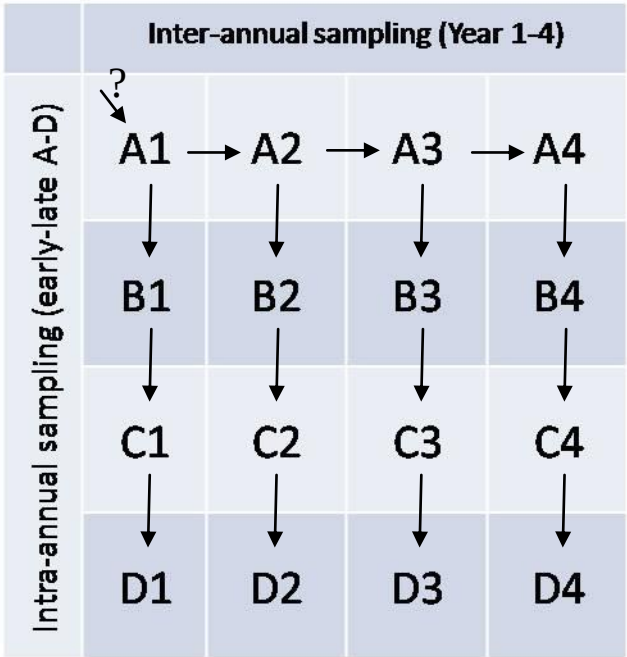



Figure 1.–Depiction of the temporal sampling within a year and between years. The arrows show the sequential prior method assuming that intra-annual variation is lower than interannual variation. The only stratum that needs a prior initiated is A1.

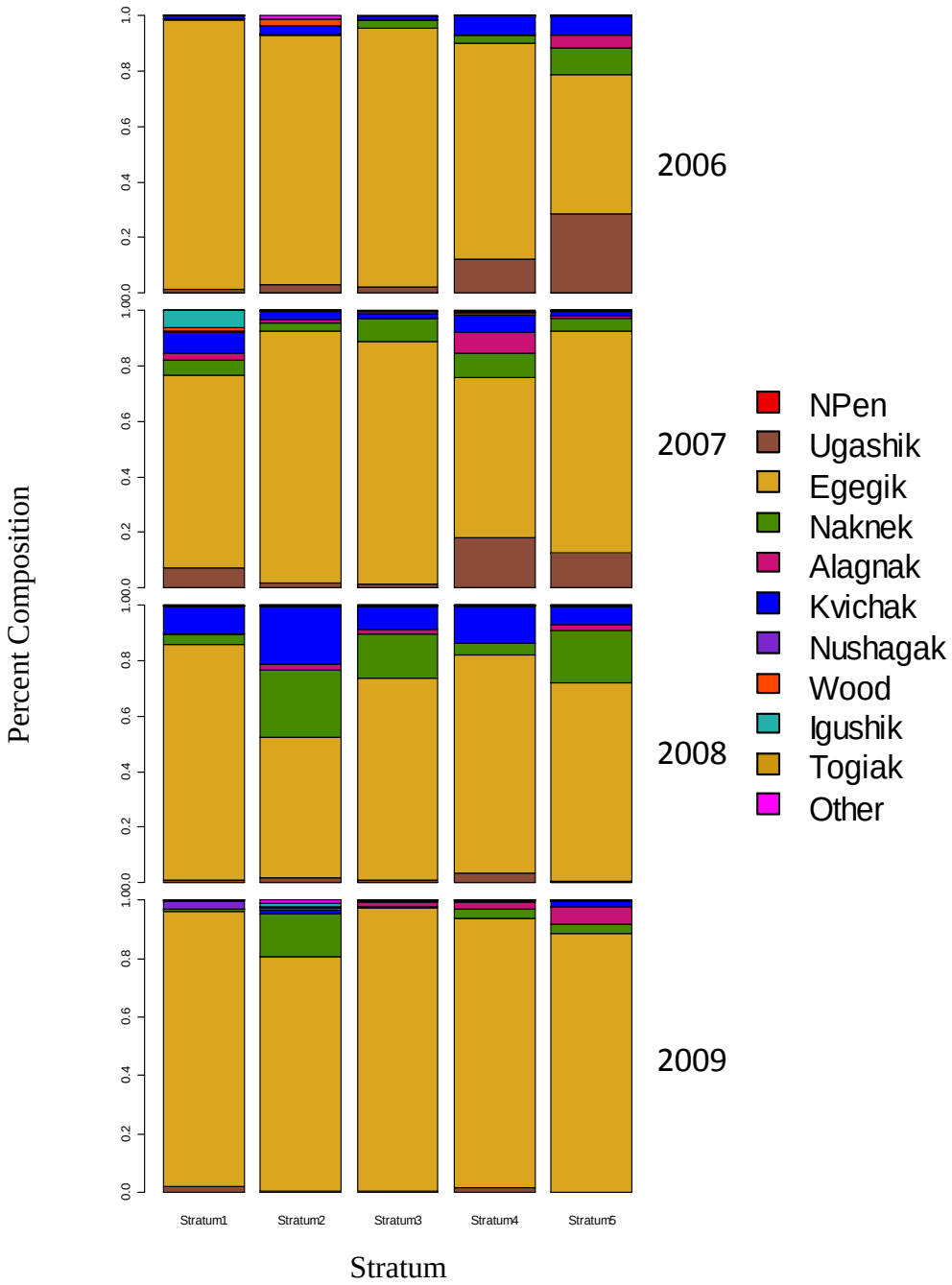
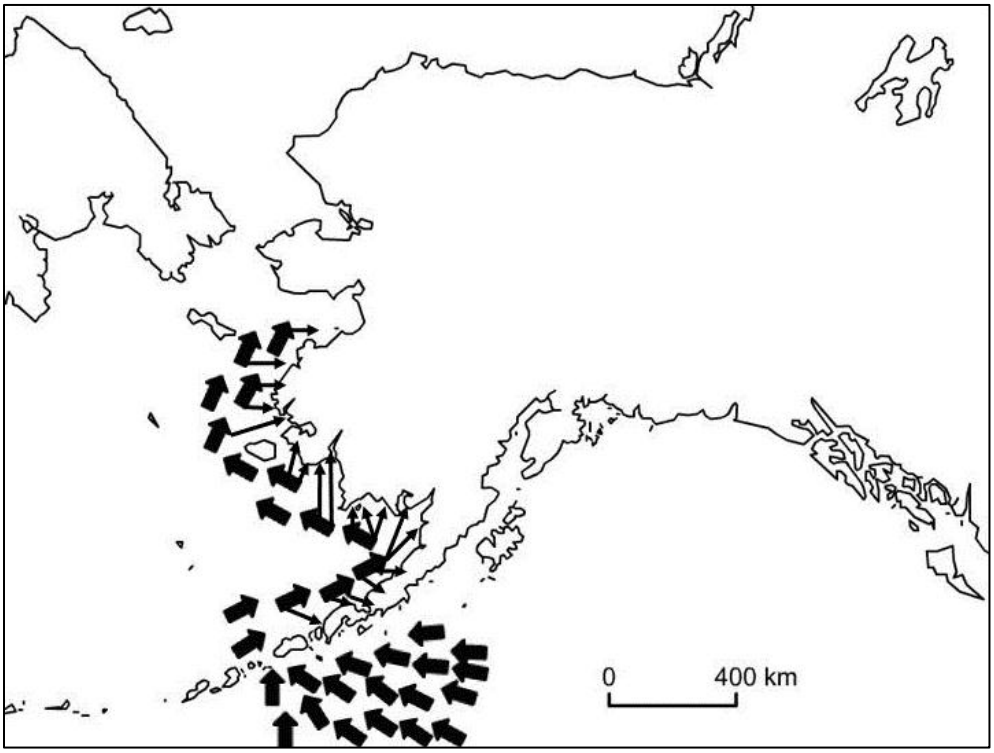



Figure 2.–Stock composition for sockeye salmon in the Egegik District of Bristol Bay from 2006 to 2009. The interannual (top to bottom) absolute differences in subregional reporting group proportions of this fishery were approximately 25% greater than the average intra-annual (left to right) difference.

a)




b)

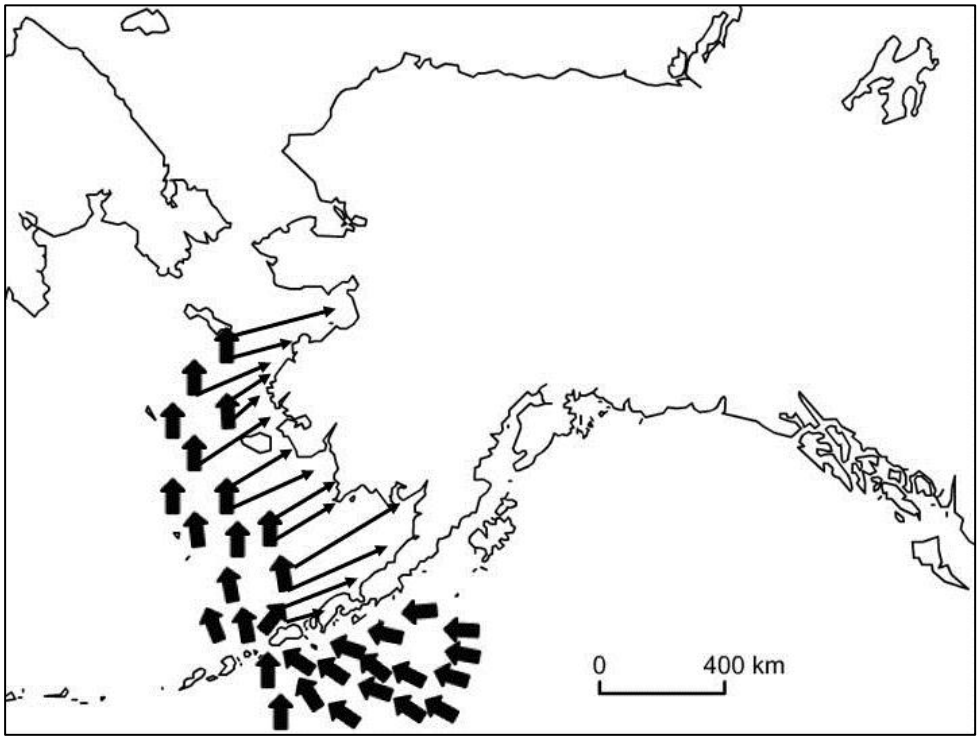



Figure 3.–The 2 possible migratory models: a) based on Straty (1975) fish move west and follow the shoreline to their home drainages, and b) based on Urawa et al. (2005) fish move north in the Bering Sea and then migrate eastwardly to their home stream.

# APPENDICES

Appendix A.–Initial prior matrix for chum salmon, showing the large number of strata requiring initiation. The columns represent the baseline subregional 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 | | | | | | | | | | | | | | | | | |

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Appendix A. Page 2 of 2.

| | | 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 |
| Yukon-Northern Area | District 1Scammon Bay, Black River Subsistence | | | | | | | | | | | | | | | | | |
| | Coastal District (Hooper Bay) Subsistence | | | | | | | | | | | | | | | | | |
| Norton Sound-Port Clarence Area | Subdistrict 6 Unalakleet Commercial | | | | | | | | | | | | | | | | | |
| | Subdistrict 5 Shaktoolik Commercial | | | | | | | | | | | | | | | | | |
| | Subdistrict 3 Moses Point Commercial | | | | | | | | | | | | | | | | | |
| | Subdistrict 2 Golovin Commercial | | | | | | | | | | | | | | | | | |
| | Stebbins area Subsistence | | | | | | | | | | | | | | | | | |
| | St. Michael area Subsistence | | | | | | | | | | | | | | | | | |
| | Subdistrict 5 Shaktoolik Subsistence | | | | | | | | | | | | | | | | | |
| | Subdistrict 3 Moses Point Subsistence | | | | | | | | | | | | | | | | | |
| | Nome area Subsistence | | | | | | | | | | | | | | | | | |
| | 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 subregional 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 | | | | | | | | | | | | | | | | | | | | | | | | |

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Appendix B. Page 2 of 2.

| | | 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 |
| Alaska Peninsula Area | 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 | | | | | | | | | | | | | | | | | | | | | | | | |
| | Egegik District | | | | | | | | | | | | | | | | | | | | | | | | |
| | Naknek-Kvichak District | | | | | | | | | | | | | | | | | | | | | | | | |
| | Nushagak District | | | | | | | | | | | | | | | | | | | | | | | | |
| | Togiak District | | | | | | | | | | | | | | | | | | | | | | | | |
| Kuskokwim Area | Kuskokwim Area | | | | | | | | | | | | | | | | | | | | | | | | |
| | District 5 Commercial | | | | | | | | | | | | | | | | | | | | | | | | |
| | District 4 Commercial | | | | | | | | | | | | | | | | | | | | | | | | |

Appendix C.–summary of discussion and proposed new method for prior choice with Technical Committee review and comments.

# Summary of discussion of prior choice

Technical Document 13 was presented to the joint Advisory Panel (AP) and Technical Committee (TC) on September 21, 2011 in Anchorage (see Appendix D, slides 1 – 40). TC members present included Robin Waples, Milo Adkison, and Tom Quinn. Representatives were present from all AP members with the exception of Kawerak (Charlie Lean was there as a member of the public).

During and after the presentation comments from AP and TC members included:

1) Request for a sensitivity analysis to investigate effects of the choice of priors on the estimates.
2) Some interest in using external priors (biology-based and expert opinion). E.g,
    a. Distance from fishery (Quinn)
    b. Use existing allozyme and other data (Martin)
    c. Use the "in" and "out" approach, maybe add another layer (see Appendix D, slides 41-49) (Eggers, Barrett)
3) Some interest in using internal priors (information from related strata). E.g.
    a. Hierarchical prior (Adkison)
    b. Use mean stock composition either across-years or within-years, depending on where variation is the lowest (Waples). **Note:** Be careful – not all fisheries have the same properties – some vary more within year, among temporal strata and other varied more among years within temporal strata (Witteveen)

During the meeting, Jim Jasper agreed to perform a sensitivity analysis overnight. Results for this analysis were not available in the morning, but ADFG presented an approach to selection of priors based on comments from the previous day (see Appendix D, slides 50 – 70).

Three criteria for selecting priors were set:

1) TC approval of the process or numbers;
2) the approach must be practical to implement;
3) AP approval of the process or numbers including;
    a. Understanding and satisfaction with the process or numbers and
    b. Consensus on the process or numbers.
    c.

**New proposed method**

Keeping these criteria in mind and incorporating comments from the TC, a new approach was developed and presented. This approach involves four steps:

1) Within each fishery, determine whether variation is lower within years across time strata or across years within time strata using $F_{ST}$;
2) Calculate composition estimates for the combined strata groups with the smallest inter-strata variability, excluding the first stratum for each set;
3) Use these estimates for the priors in the first stratum for each set;
4) Use sequential priors thereafter within each set of strata.

This process has been schematically presented in Appendix D (slides 56 - 66).

The advantages to this method are:

1) It is objective,

2) It does not require consensus on a set of numbers to be used for each prior for each fishery,
3) It is fairly simple to implement, and
4) It addresses differences in the patterns of variation within each fishery.

At the joint AP/TC meeting, AP members approved this method pending final review by the TC. If this process is determined to be adequate by the TC, it will be implemented by the Department for WASSIP fishery estimates. If the process is acceptable, but requires minor modification, the modified process will be implemented for WASSIP. If the process is not adequate, the TC will provide suggestions to substantially improve it, and the new methods will be resubmitted to the AP for final approval.

## Technical Committee review and comments for new proposed method

*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.*

We believe the proposed method in the Addendum is a reasonable way to develop priors for A1. It should lead to better results than simply using a flat prior (1a or 1b). The first step is to quantify variation in stock composition estimates both across years and across seasons within years. This might have to be done separately for each fishery. It seems logical that if stock composition estimates from different strata are strongly correlated, then allele frequencies in the overall mixtures being compared should also be strongly correlated. Quantifying allele frequency differences among mixtures using an $F_{ST}$-like quantity should be simple and informative.

As noted above, an optimal method would use some type of hierarchical approach to maximize use of all available information, but most of these options are not feasible for the current application. One option that might be considered if time is available would take advantage of the fact that $F_{ST}$ is a type of variance and use the $F_{ST}$ values calculated as proposed in the Addendum to weight estimates from prior years vs prior seasons within years. However, we suspect that the majority of the improvements in the priors would be achieved by use of at least some prior stock composition information (as proposed in Appendix C), and any marginal improvements from a more sophisticated hierarchical approach would be relatively small. Given the tight constraints on time, we think it is reasonable to allow ADFG staff some flexibility in implementing the proposed method within the general framework outlined in the Addendum.

**Summary:** The TC concludes that the approach outlined in Technical Document 13 and the Addendum is a reasonable approach to obtaining priors under WASSIP. Once results of the sensitivity analyses are in, it should be possible to begin to evaluate the marginal benefits from incorporating additional sources of information into the priors. However, that is a longer-term project.

WASSIP Technical Committee

Milo Adkison, Tom Quinn, Bruce Weir, Robin Waples (Chair)

Appendix D.–Slideshow shown to the Advisory Panel and Technical Committee on prior choice.

# Selection of a Prior for Mixed Stock Analysis

- Alaska Department of Fish and Game
- Gene Conservation Laboratory

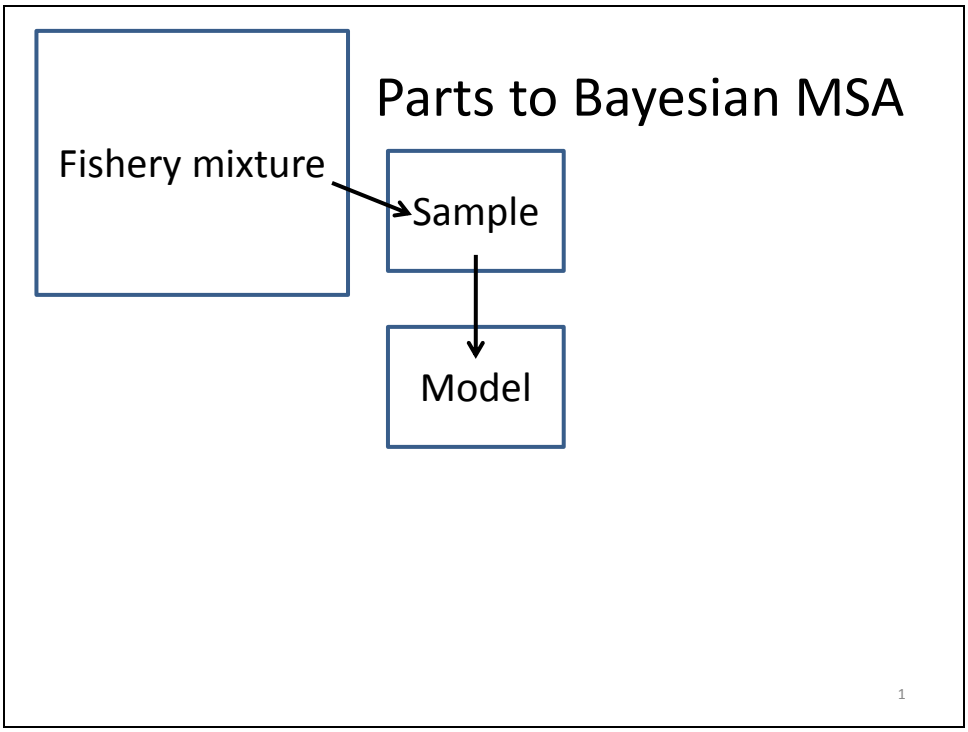
Technical Document 13

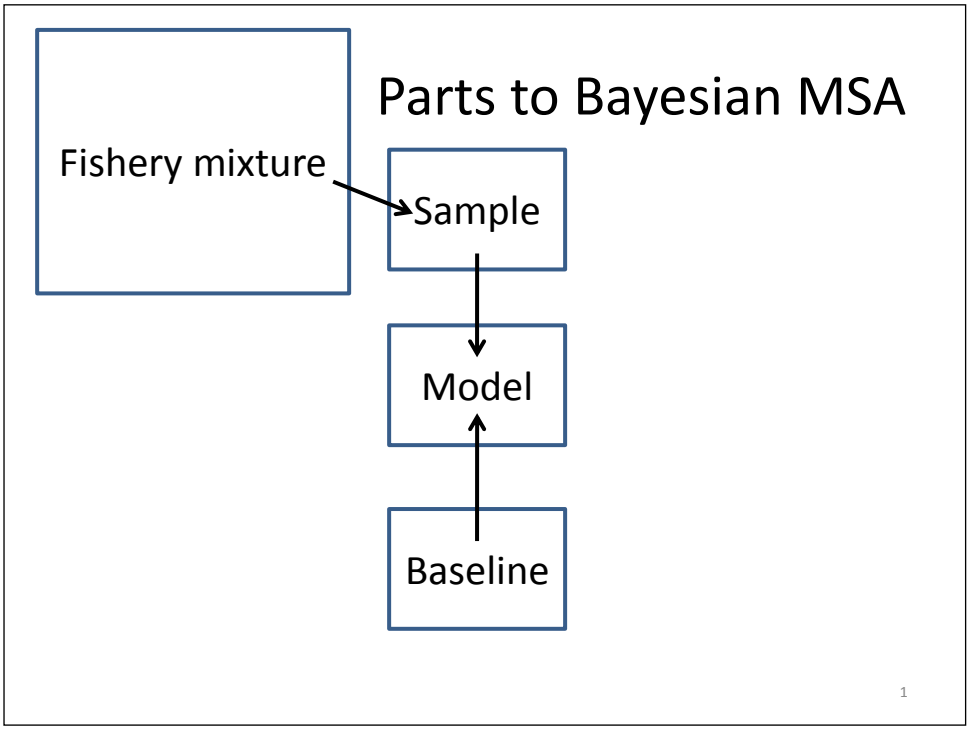
1

## Parts to Bayesian MSA

Fishery mixture → Sample

1


Parts to Bayesian MSA
Fishery mixture
Sample
Model
1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Fishery mixture
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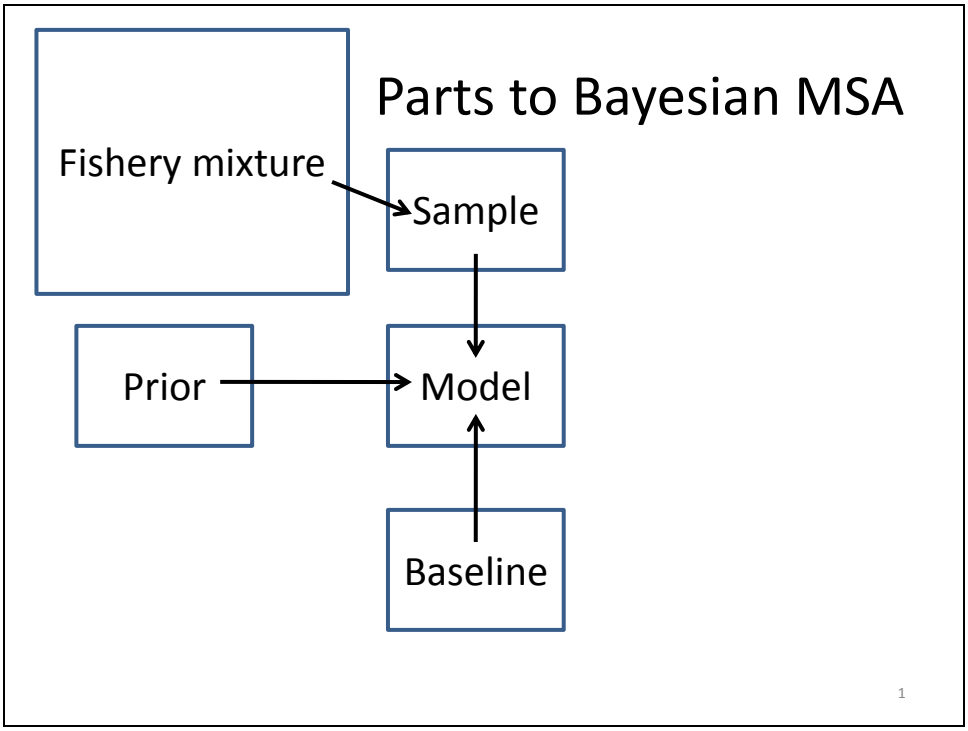
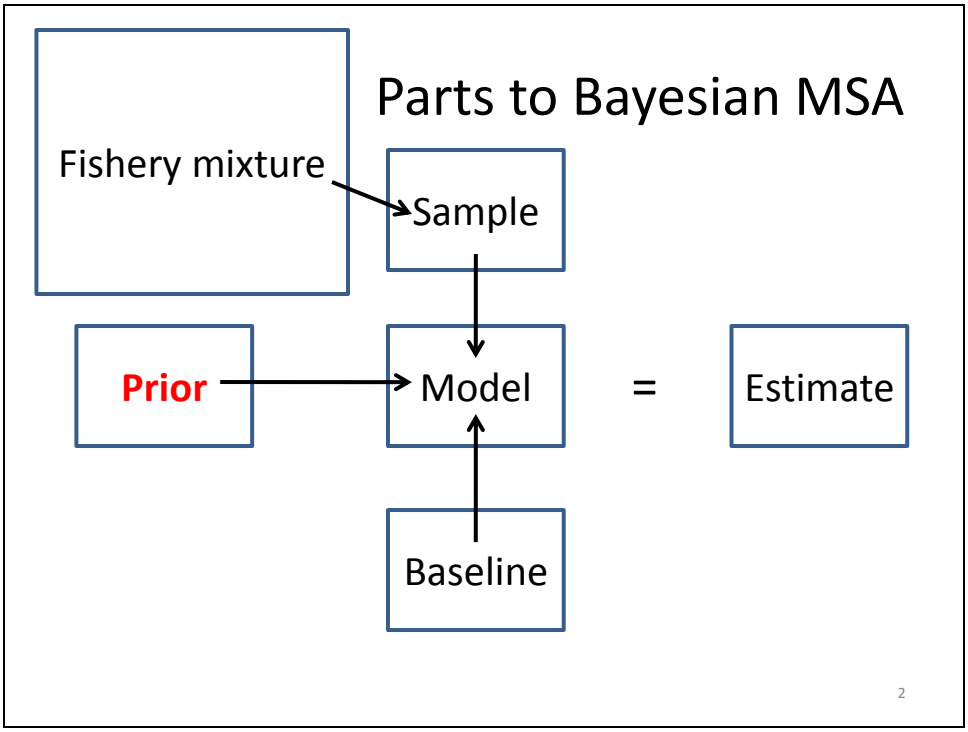
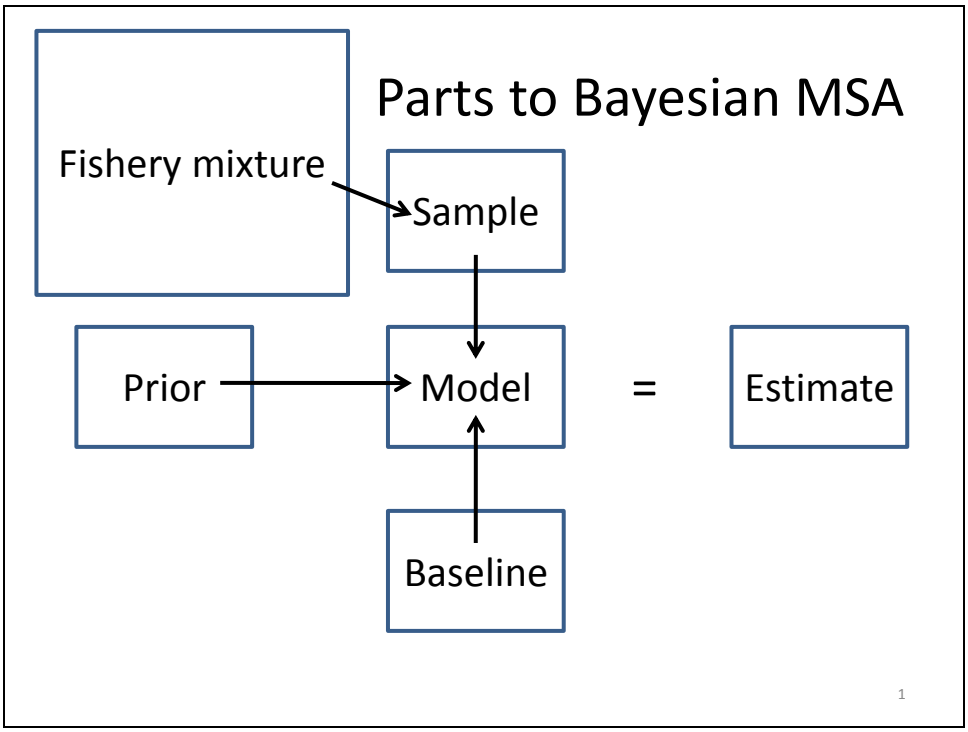

Parts to Bayesian MSA
Fishery mixture
Sample
Prior
Model
Baseline
1


Parts to Bayesian MSA
Fishery mixture
Sample
Prior
Model
=
Estimate
Baseline
2




## What is the Prior?
## (For statisticians)

- Dirichlet probability distribution
- Parameters sum to *K*
- Interpreted as adding *K* individuals to the fishery sample
- Typically held at 1 (Pella and Masuda, 2001)

1

## What is the Prior?
## (For the rest of us)

- Required for Bayesian analyses
- Based on information available outside the new data
- Used to inform the model
- Like adding 1 fish to the mixture
- Can reduce bias

1

## Options for priors

- Uniform
  - Assume all equally probable
- Informative
  - Associated estimates (“sequential prior”)
  - Abundance
  - Migration pathways
  - Proximity
  - Expert opinion
  - Intuition
- Combination

1

# Types of uniform priors

- ***Population***
- ***Sub-Regional Reporting Group***

1

# Types of uniform priors

- ***Population***
  - All populations get the same prior
  - Simple to implement; objective
  - *Disadvantages:*
    - *Reporting group weight based on number of populations*
    - *All fisheries the same*

1

# Types of uniform priors

- ***Population***
- ***Sub-Regional Reporting Group***
  - All Sub-regional reporting groups get the same prior
  - Simple to implement; objective
  - *Disadvantages:*
    - *Reporting group weight same for all fisheries*

1

# Types of Informative Priors

- ***Sequential***
- ***Biology-Based***
- ***Subjective***

1

## Types of Informative Priors

- ***Sequential***
  - Use information from a previous stratum
  - Simple to implement; objective
  - *Assumes that associated strata have useful information*
  - *Disadvantage:*
    - *Not available for the first stratum*

1

## Types of Informative Priors

- ***Sequential***
- ***Biology-Based***
  - *Abundance*
  - *Migration*
  - *Proximity*
  - *Multiple variables in combination*
- *Advantages:* Objective, once base assumptions are made; uses biological information.
- *Disadvantages:* Difficult to establish base assumptions due to lack of information.

1

# Types of Informative Priors

- ***Sequential***
- ***Biology-Based***
- ***Subjective***
  - Expert opinion or intuition
    - *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.

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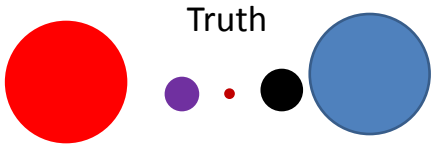
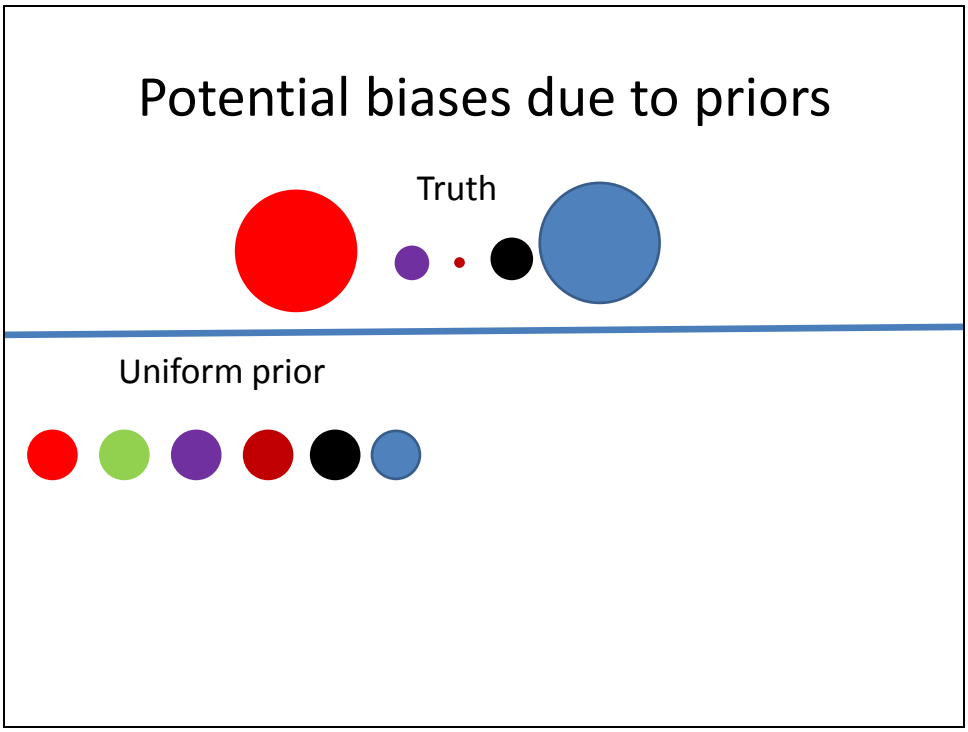
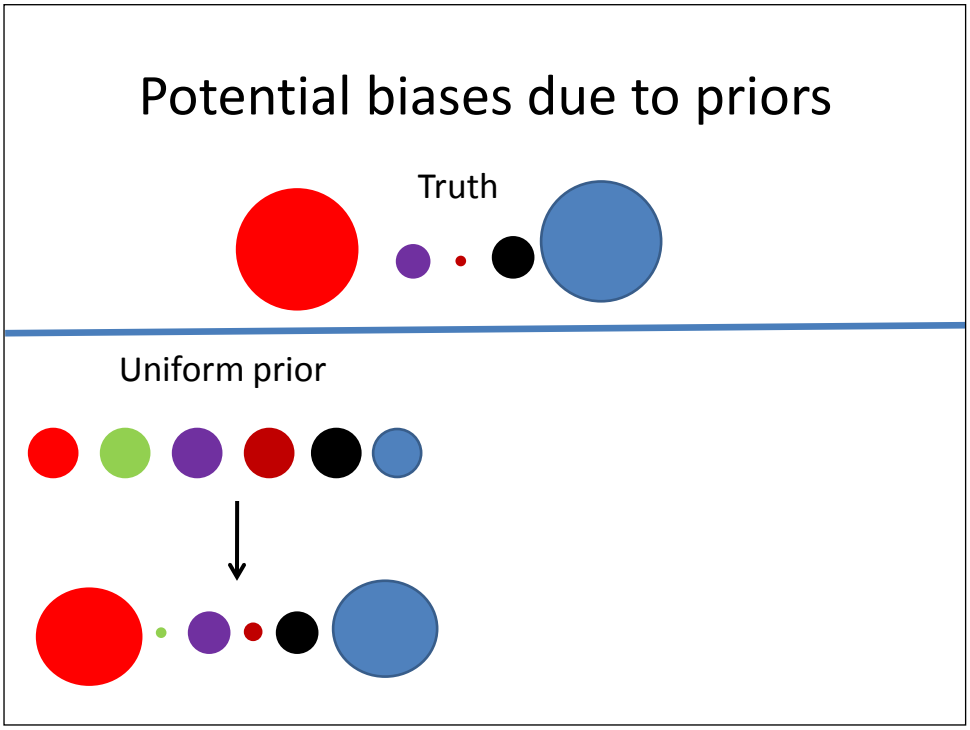
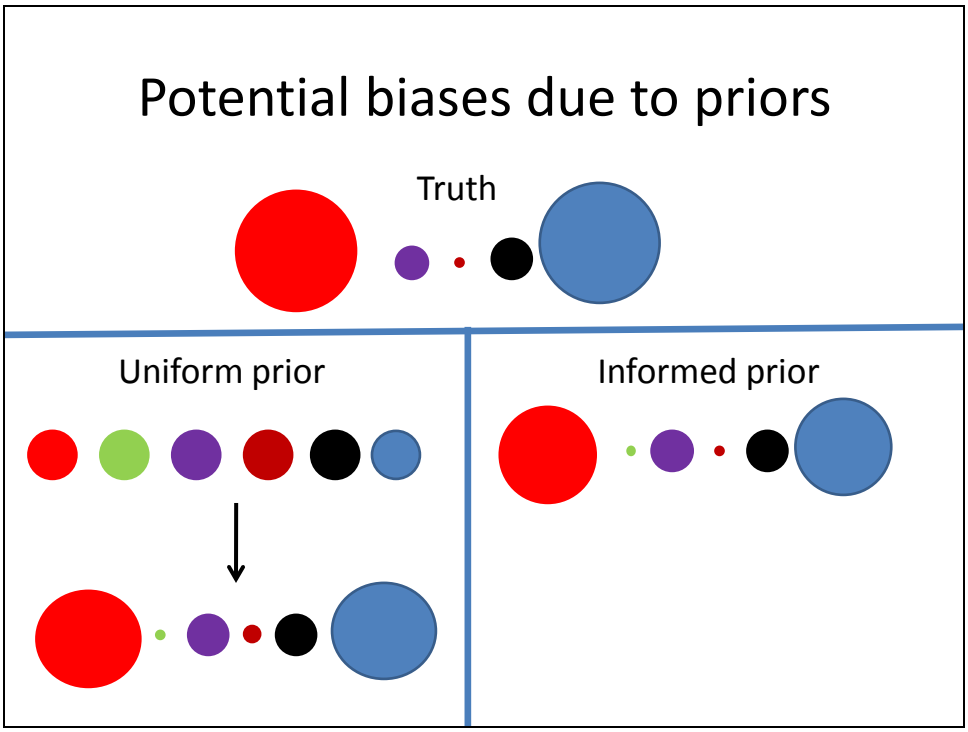
# Potential biases due to priors

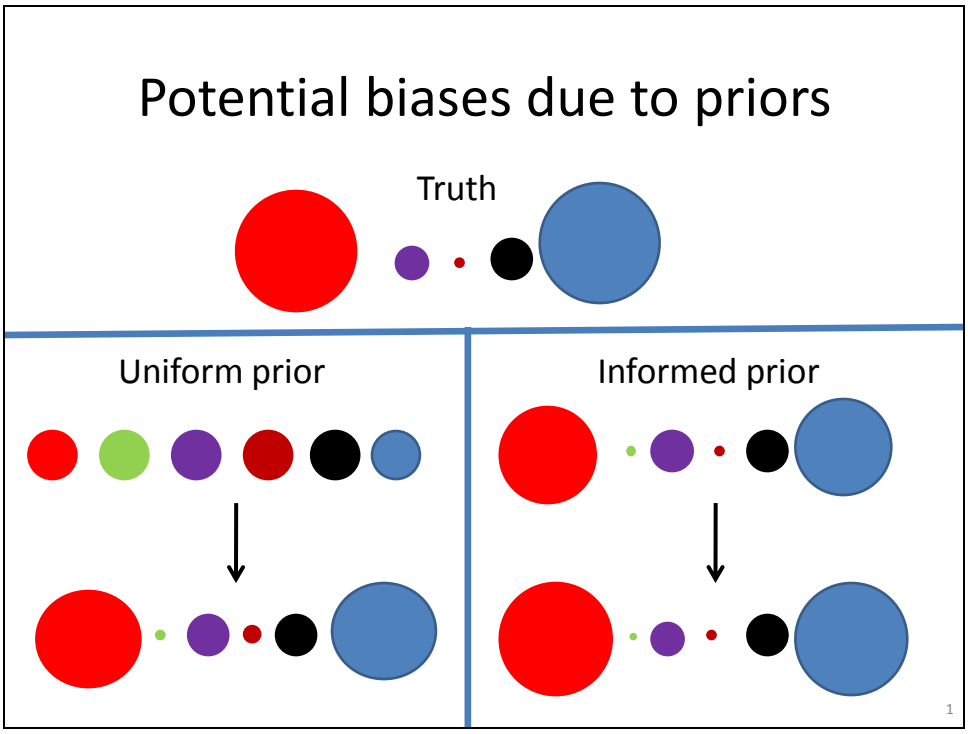



This is the true proportions of six reporting groups within a sample.


Potential biases due to priors
Truth
Uniform prior


Potential biases due to priors
Truth
Uniform prior


Potential biases due to priors
Truth
Uniform prior
Informed prior


Potential biases due to priors
Truth
Uniform prior
Informed prior
1

## What is standard?

- No universally standard method
  - Uniform prior recommended in the absence of information
  - ADFG has used:
    - Expert opinion
    - Sequential
    - Uniform

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## What is standard?

- No universally standard method
- Influence of the prior may be limited to that of a single fish

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## What is standard?

- No universally standard method
- Influence of the prior may be limited to that of a single fish
- But magnitude of this effect on the analysis depends on the strength of the structure among the stocks being resolved

1

## What is standard?

- No universally standard method
- Influence of the prior may be limited to that of a single fish
- But magnitude of this effect on the analysis depends on the strength of the structure among the stocks being resolved
- Small with strongly structured baseline stocks, greater with weakly structured baseline stocks

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## Department's initial recommendation

- Initial strata: sub-regional reporting group uniform priors
- Subsequent strata: sequential priors
- Example to follow…

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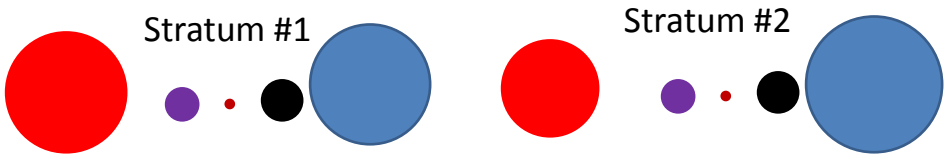
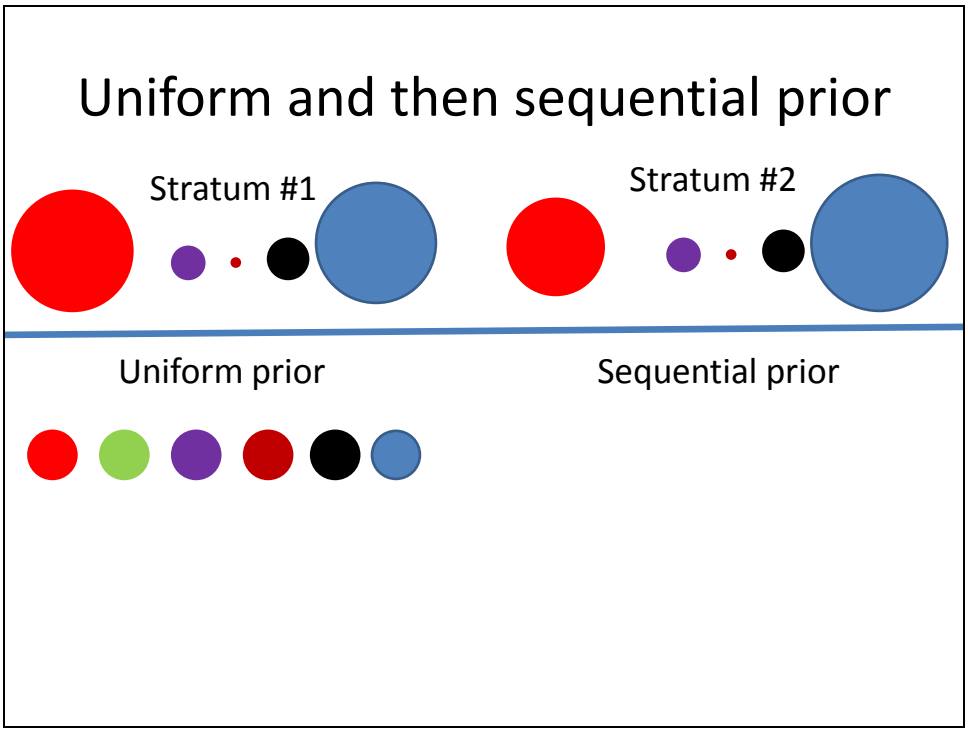
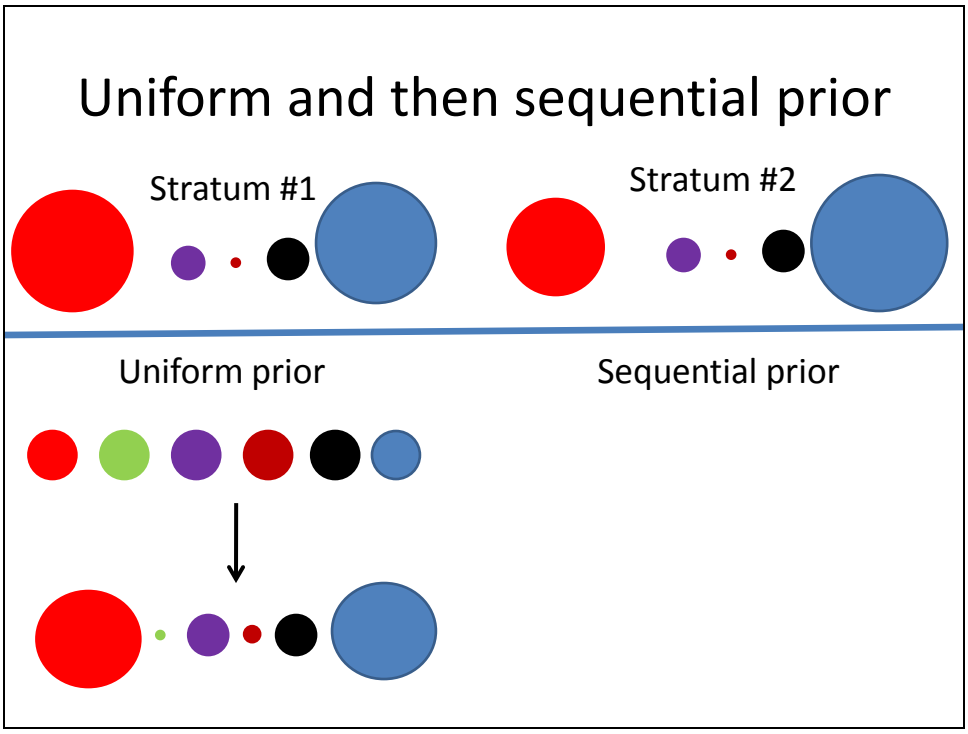
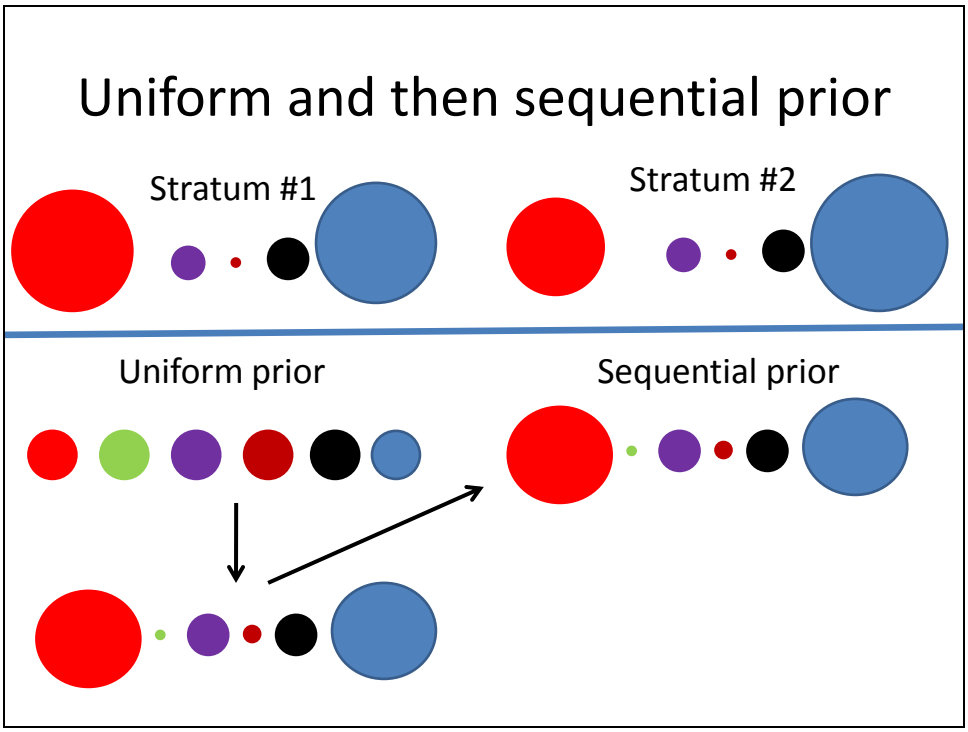
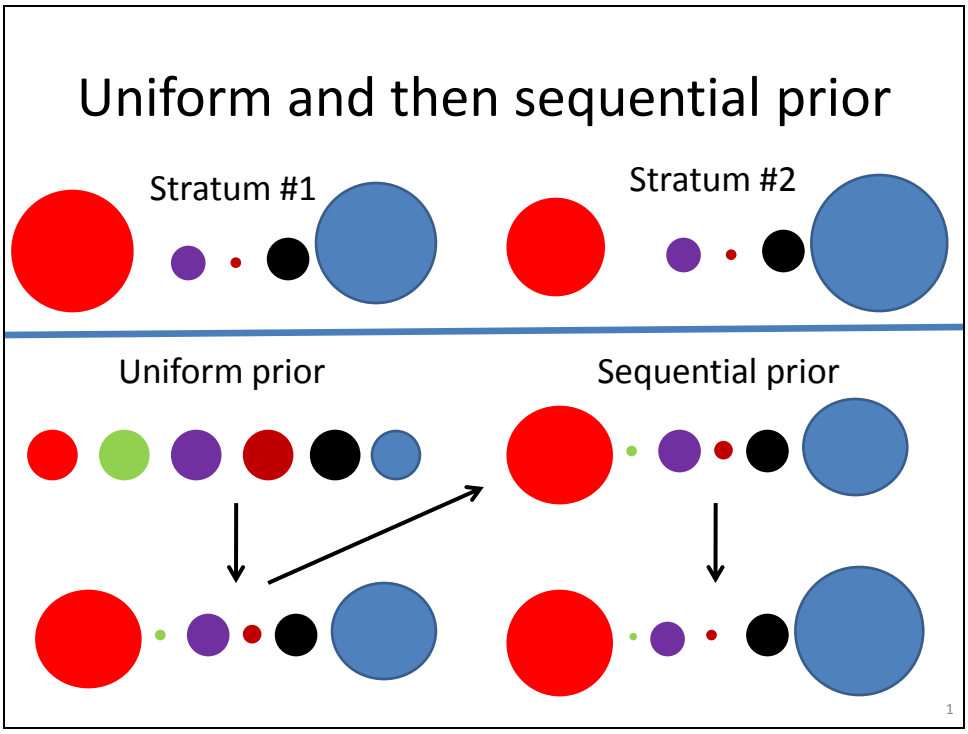
## Uniform and then sequential prior




Uniform and then sequential prior
Stratum #1
Stratum #2
Uniform prior
Sequential prior


Uniform and then sequential prior
Stratum #1
Stratum #2
Uniform prior
Sequential prior


Uniform and then sequential prior
Stratum #1
Stratum #2
Uniform prior
Sequential prior


Uniform and then sequential prior
Stratum #1
Stratum #2
Uniform prior
Sequential prior
1

.

## Sequential Prior

| | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| | Inter-annual sampling (Year 1-4) | | | |
| Early ↓ Late (Intra-annual sampling (early-late A-D)) | A1 | A2 | A3 | A4 |
| | B1 | B2 | B3 | B4 |
| | C1 | C2 | C3 | C4 |
| | D1 | D2 | D3 | D4 |

1

Uniform prior used for the first time strata for the first year

## Sequential Prior

| | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| | Inter-annual sampling (Year 1-4) | | | |
| Early ↓ Late (Intra-annual sampling (early-late A-D)) | A1 | A2 | A3 | A4 |
| | B1 | B2 | B3 | B4 |
| | C1 | C2 | C3 | C4 |
| | D1 | D2 | D3 | D4 |

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Sequential prior used for the next time strata for the first year

## Sequential Prior

| | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| | Inter-annual sampling (Year 1-4) | | | |
| Early ↓ Late (Intra-annual sampling (early-late A-D)) | A1 | A2 | A3 | A4 |
| | B1 | B2 | B3 | B4 |
| | C1 | C2 | C3 | C4 |
| | D1 | D2 | D3 | D4 |

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Sequential prior used for the next time strata for the first year

## Sequential Prior

| | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| | Inter-annual sampling (Year 1-4) | | | |
| Early ↓ Late (Intra-annual sampling (early-late A-D)) | A1 | A2 | A3 | A4 |
| | B1 | B2 | B3 | B4 |
| | C1 | C2 | C3 | C4 |
| | D1 | D2 | D3 | D4 |

1

Sequential prior used for the first strata for the following year

## Sequential Prior

| | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| | Inter-annual sampling (Year 1-4) | | | |
| Early | A1 → | A2 | A3 | A4 |
| ↓ | B1 | B2 | B3 | B4 |
| ↓ | C1 | C2 | C3 | C4 |
| Late | D1 | D2 | D3 | D4 |

Intra-annual sampling (early-late A-D)

1

Sequential prior used for the next time strata for the year

## Sequential Prior

| | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| | Inter-annual sampling (Year 1-4) | | | |
| Early | A1 → | A2 | A3 | A4 |
| ↓ | B1 | B2 | B3 | B4 |
| ↓ | C1 | C2 | C3 | C4 |
| Late | D1 | D2 | D3 | D4 |

Intra-annual sampling (early-late A-D)

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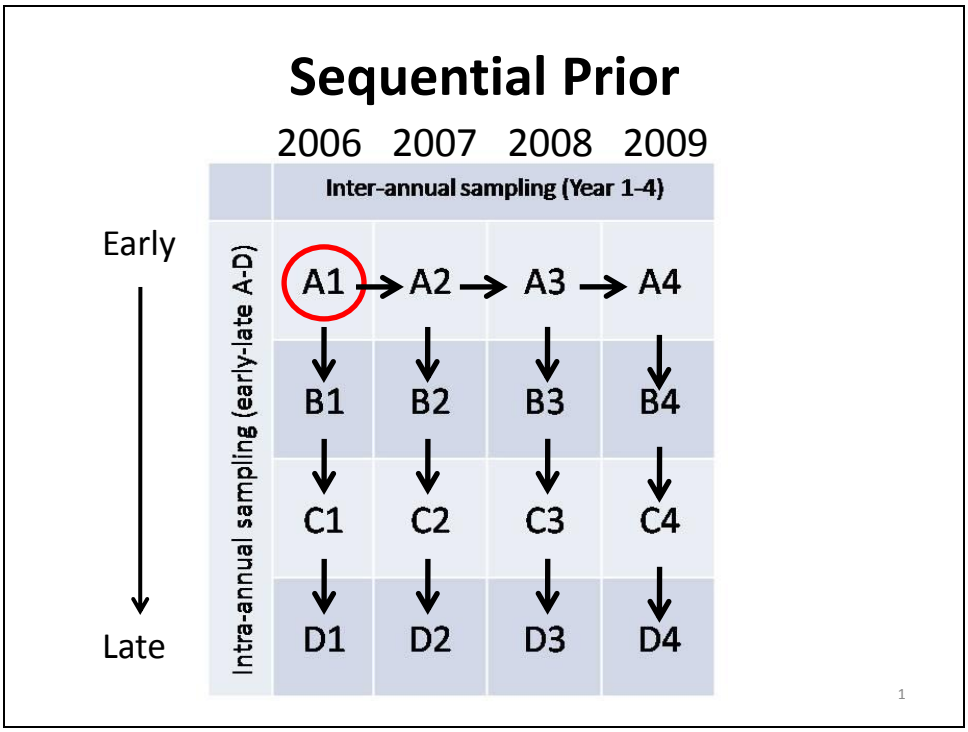
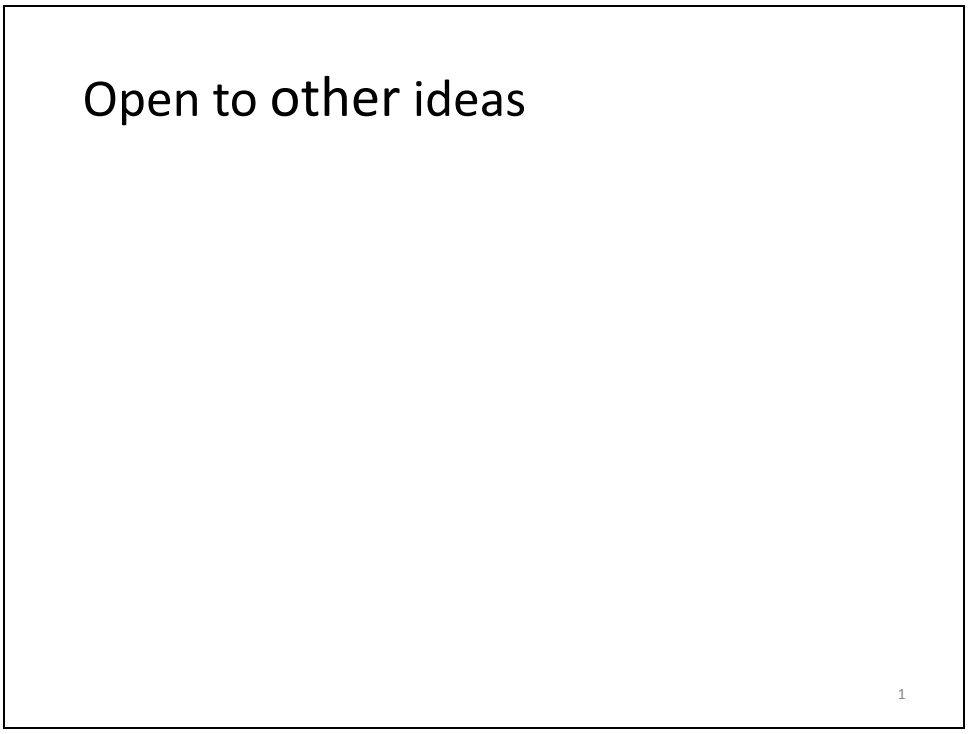

Sequential Prior
2006 2007 2008 2009
Inter-annual sampling (Year 1-4)
Intra-annual sampling (early-late A-D)
Early
Late
A1 A2 A3 A4
B1 B2 B3 B4
C1 C2 C3 C4
D1 D2 D3 D4
1


Open to other ideas
1

# Open to other ideas – here is one…

- Uniform priors do not reflect knowledge
- Informative priors are difficult to establish
- Method for a compromise:
  - Decide on what stocks are likely present for each fishery (Yes/No)
  - Set binary uniform priors

  Example to follow…

1

# Binary Uniform

Sockeye

Fishery

| Reporting Group | Kuskokwim Area | Togiak | Nushagak | Naknek-Kvichak | Egegik | Ugashik | North Peninsula | South Peninsula June | South Peninsula Post-June | SEDM | Chignik |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Seward Peninsula | I | I | I | O | O | O | O | I | O | O | O |
| Kuskokwim River | I | I | I | O | O | O | O | I | O | O | O |
| Kanektok River | I | I | I | O | O | O | O | I | O | O | O |
| Goodnews River | I | I | I | O | O | O | O | I | O | O | O |
| Togiak River | I | I | I | I | I | I | I | I | O | O | O |
| Igushik River | I | I | I | I | I | I | I | I | O | O | O |
| Wood River | I | I | I | I | I | I | I | I | O | O | O |
| Nushagak River | I | I | I | I | I | I | I | I | O | O | O |
| Kvichak | O | O | O | I | I | I | I | I | O | I | O |
| Alagnak | O | O | O | I | I | I | I | I | O | I | O |
| Naknek | O | O | O | I | I | I | I | I | O | I | O |
| Egegik | O | O | O | I | I | I | I | I | O | I | O |
| Ugashik | O | O | O | I | I | I | I | I | I | I | O |
| Cinder River | O | O | O | O | I | I | I | I | I | I | O |
| Meshik River | O | O | O | O | I | I | I | I | I | I | O |
| Ilnik River | O | O | O | O | I | I | I | I | I | I | O |
| Sandy River | O | O | O | O | I | I | I | I | I | I | O |
| Bear River | O | O | O | O | I | I | I | I | I | I | O |
| Nelson Lagoon | O | O | O | O | I | I | I | I | I | I | O |
| Aleutians - Northern District - Black Hills | O | O | O | O | I | I | I | I | I | I | O |
| South Alaska Peninsula | O | O | O | O | O | O | I | I | I | I | I |
| Black Lake | O | O | O | O | O | O | O | I | I | I | I |
| Chignik Lake | O | O | O | O | O | O | O | I | I | I | I |
| East of WASSIP | O | O | O | O | O | O | O | I | I | I | I |

1

# Binary Uniform

## Sockeye Fishery

| Reporting Group | Kuskokwim Area | Togiak | Nushagak | Naknek-Kvichak | Egegik | Ugashik | North Peninsula | South Peninsula June | South Peninsula Post-June | SEDM | Chignik |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Seward Peninsula | I | I | I | O | O | O | O | I | O | O | O |
| Kuskokwim River | I | I | I | O | O | O | O | I | O | O | O |
| Kanektok River | I | I | I | O | O | O | O | I | O | O | O |
| Goodnews River | I | I | I | O | O | O | O | I | O | O | O |
| Togiak River | I | I | I | I | I | I | I | I | O | O | O |
| Igushik River | I | I | I | I | I | I | I | I | O | O | O |
| Wood River | I | I | I | I | I | I | I | I | O | O | O |
| Nushagak River | I | I | I | I | I | I | I | I | O | O | O |
| Kvichak | O | O | O | I | I | I | I | I | O | I | O |
| Alagnak | O | O | O | I | I | I | I | I | O | I | O |
| Naknek | O | O | O | I | I | I | I | I | O | I | O |
| Egegik | O | O | O | I | I | I | I | I | O | I | O |
| Ugashik | O | O | O | I | I | I | I | I | I | I | O |
| Cinder River | O | O | O | O | I | I | I | I | I | I | O |
| Meshik River | O | O | O | O | I | I | I | I | I | I | O |
| Ilnik River | O | O | O | O | I | I | I | I | I | I | O |
| Sandy River | O | O | O | O | I | I | I | I | I | I | O |
| Bear River | O | O | O | O | I | I | I | I | I | I | O |
| Nelson Lagoon | O | O | O | O | I | I | I | I | I | I | O |
| Aleutians - Northern District - Black Hills | O | O | O | O | I | I | I | I | I | I | O |
| South Alaska Peninsula | O | O | O | O | O | O | I | I | I | I | I |
| Black Lake | O | O | O | O | O | O | O | I | I | I | I |
| Chignik Lake | O | O | O | O | O | O | O | I | I | I | I |
| East of WASSIP | O | O | O | O | O | O | O | I | I | I | I |

# Binary Uniform

## Sockeye Fishery

| Reporting Group | Kuskokwim Area | Togiak | Nushagak | Naknek-Kvichak | Egegik | Ugashik | North Peninsula | South Peninsula June | South Peninsula Post-June | SEDM | Chignik |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Seward Peninsula | I | I | I | O | O | O | O | I | O | O | O |
| Kuskokwim River | I | I | I | O | O | O | O | I | O | O | O |
| Kanektok River | I | I | I | O | O | O | O | I | O | O | O |
| Goodnews River | I | I | I | O | O | O | O | I | O | O | O |
| Togiak River | I | I | I | I | I | I | I | I | O | O | O |
| Igushik River | I | I | I | I | I | I | I | I | O | O | O |
| Wood River | I | I | I | I | I | I | I | I | O | O | O |
| Nushagak River | I | I | I | I | I | I | I | I | O | O | O |
| Kvichak | O | O | O | I | I | I | I | I | O | I | O |
| Alagnak | O | O | O | I | I | I | I | I | O | I | O |
| Naknek | O | O | O | I | I | I | I | I | O | I | O |
| Egegik | O | O | O | I | I | I | I | I | O | I | O |
| Ugashik | O | O | O | I | I | I | I | I | I | I | O |
| Cinder River | O | O | O | O | I | I | I | I | I | I | O |
| Meshik River | O | O | O | O | I | I | I | I | I | I | O |
| Ilnik River | O | O | O | O | I | I | I | I | I | I | O |
| Sandy River | O | O | O | O | I | I | I | I | I | I | O |
| Bear River | O | O | O | O | I | I | I | I | I | I | O |
| Nelson Lagoon | O | O | O | O | I | I | I | I | I | I | O |
| Aleutians - Northern District - Black Hills | O | O | O | O | I | I | I | I | I | I | O |
| South Alaska Peninsula | O | O | O | O | O | O | I | I | I | I | I |
| Black Lake | O | O | O | O | O | O | O | I | I | I | I |
| Chignik Lake | O | O | O | O | O | O | O | I | I | I | I |
| East of WASSIP | O | O | O | O | O | O | O | I | I | I | I |

# Binary Uniform

## Sockeye Fishery

| Reporting Group | Kuskokwim Area | Togiak | Nushagak | Naknek-Kvichak | Egegik | Ugashik | North Peninsula | South Peninsula June | South Peninsula Post-June | SEDM | Chignik |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Seward Peninsula | | | | O | | | | | | | |
| Kuskokwim River | | | | O | | | | | | | |
| Kanektok River | | | | O | | | | | | | |
| Goodnews River | | | | O | | | | | | | |
| Togiak River | | | | I | | | | | | | |
| Igushik River | | | | I | | | | | | | |
| Wood River | | | | I | | | | | | | |
| Nushagak River | | | | I | | | | | | | |
| Kvichak | | | | I | | | | | | | |
| Alagnak | | | | I | | | | | | | |
| Naknek | | | | I | | | | | | | |
| Egegik | | | | I | | | | | | | |
| Ugashik | | | | I | | | | | | | |
| Cinder River | | | | O | | | | | | | |
| Meshik River | | | | O | | | | | | | |
| Ilnik River | | | | O | | | | | | | |
| Sandy River | | | | O | | | | | | | |
| Bear River | | | | O | | | | | | | |
| Nelson Lagoon | | | | O | | | | | | | |
| Aleutians - Northern District - Black Hills | | | | O | | | | | | | |
| South Alaska Peninsula | | | | O | | | | | | | |
| Black Lake | | | | O | | | | | | | |
| Chignik Lake | | | | O | | | | | | | |
| East of WASSIP | | | | O | | | | | | | |

# Binary Uniform

## Sockeye Fishery

| Reporting Group | Kuskokwim Area | Togiak | Nushagak | Naknek-Kvichak | Egegik | Ugashik | North Peninsula | South Peninsula June | South Peninsula Post-June | SEDM | Chignik |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Seward Peninsula | | | | 1% | | | | | | | |
| Kuskokwim River | | | | 1% | | | | | | | |
| Kanektok River | | | | 1% | | | | | | | |
| Goodnews River | | | | 1% | | | | | | | |
| Togiak River | | | | | | | | | | | |
| Igushik River | | | | | | | | | | | |
| Wood River | | | | | | | | | | | |
| Nushagak River | | | | | | | | | | | |
| Kvichak | | | | | | | | | | | |
| Alagnak | | | | | | | | | | | |
| Naknek | | | | | | | | | | | |
| Egegik | | | | | | | | | | | |
| Ugashik | | | | | | | | | | | |
| Cinder River | | | | 1% | | | | | | | |
| Meshik River | | | | 1% | | | | | | | |
| Ilnik River | | | | 1% | | | | | | | |
| Sandy River | | | | 1% | | | | | | | |
| Bear River | | | | 1% | | | | | | | |
| Nelson Lagoon | | | | 1% | | | | | | | |
| Aleutians - Northern District - Black Hills | | | | 1% | | | | | | | |
| South Alaska Peninsula | | | | 1% | | | | | | | |
| Black Lake | | | | 1% | | | | | | | |
| Chignik Lake | | | | 1% | | | | | | | |
| East of WASSIP | | | | 1% | | | | | | | |

15 groups get 1% each
15 X 1% = 15%

1

# Binary Uniform

## Sockeye Fishery

| Reporting Group | Kuskokwim Area | Togiak | Nushagak | Naknek-Kvichak | Egegik | Ugashik | North Peninsula | South Peninsula June | South Peninsula Post-June | SEDM | Chignik |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Seward Peninsula | | | | 1% | | | | | | | |
| Kuskokwim River | | | | 1% | | | | | | | |
| Kanektok River | | | | 1% | | | | | | | |
| Goodnews River | | | | 1% | | | | | | | |
| Togiak River | | | | 9.4% | | | | | | | |
| Igushik River | | | | 9.4% | | | | | | | |
| Wood River | | | | 9.4% | | | | | | | |
| Nushagak River | | | | 9.4% | | | | | | | |
| Kvichak | | | | 9.4% | | | | | | | |
| Alagnak | | | | 9.4% | | | | | | | |
| Naknek | | | | 9.4% | | | | | | | |
| Egegik | | | | 9.4% | | | | | | | |
| Ugashik | | | | 9.4% | | | | | | | |
| Cinder River | | | | 1% | | | | | | | |
| Meshik River | | | | 1% | | | | | | | |
| Ilnik River | | | | 1% | | | | | | | |
| Sandy River | | | | 1% | | | | | | | |
| Bear River | | | | 1% | | | | | | | |
| Nelson Lagoon | | | | 1% | | | | | | | |
| Aleutians - Northern District - Black Hills | | | | 1% | | | | | | | |
| South Alaska Peninsula | | | | 1% | | | | | | | |
| Black Lake | | | | 1% | | | | | | | |
| Chignik Lake | | | | 1% | | | | | | | |
| East of WASSIP | | | | 1% | | | | | | | |

15 groups get 1% each
15 X 1% = 15%

9 groups get rest (85%)
85% / 9 = 9.4%

1

# Binary Uniform

## Chum Fishery

| Reporting Group | Norton Sound/Kotzebue | Yukon River | Kuskokwim Area | Togiak | Nushagak | Nushagak | Naknek-Kvichak | Egegik | Ugashik | North Peninsula | South Peninsula June | South Peninsula Post-June | SEDM | Chignik |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asia | I | I | I | I | I | I | O | O | O | O | I | I | I | I |
| CWAK | I | I | I | I | I | I | I | I | I | I | I | O | I | O |
| Upper Yukon/Kuskokwim | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Northern District - N. Peninsula | O | O | O | O | O | O | I | I | I | I | I | I | I | I |
| Northwest District - N. Peninsula | O | O | O | O | O | O | I | I | I | I | I | I | I | I |
| South Peninsula | O | O | O | O | O | O | O | O | O | O | I | I | I | I |
| Chignik /Kodiak | O | O | O | O | O | O | O | O | O | O | I | I | I | I |
| East of Kodiak | O | O | O | O | O | O | O | O | O | O | I | I | I | I |

1

# Binary Uniform

Chum Fishery

| Reporting Group | Norton Sound/Kotzebue | Yukon River | Kuskokwim Area | Togiak | Nushagak | Nushagak | Naknek-Kvichak | Egegik | Ugashik | North Peninsula | South Peninsula June | South Peninsula Post-June | SEDM | Chignik |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asia | I | I | I | I | I | I | O | O | O | O | I | I | I | I |
| CWAK | I | I | I | I | I | I | I | I | I | I | I | O | I | O |
| Upper Yukon/Kuskokwim | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Northern District - N. Peninsula | O | O | O | O | O | O | I | I | I | I | I | I | I | I |
| Northwest District - N. Peninsula | O | O | O | O | O | O | I | I | I | I | I | I | I | I |
| South Peninsula | O | O | O | O | O | O | O | O | O | O | I | I | I | I |
| Chignik /Kodiak | O | O | O | O | O | O | O | O | O | O | I | I | I | I |
| East of Kodiak | O | O | O | O | O | O | O | O | O | O | I | I | I | I |

1

# What I heard yesterday…

- Sensitivity analysis needed to see how much the prior affects estimates . If there is an effect then either:

2

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- Use external priors (Biology-based and expert opinion)
  - Distance from fishery (Quinn)
  - Use existing allozyme and other data (Martin and others)
  - Use the "in" and "out" approach, maybe add another layer (Barrett)

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  - Use the "in" and "out" approach, maybe add another layer. (Barrett)
- Use internal priors (information from related strata)
  - Hieratical prior (Adkison)
  - Use mean of either across-year or within-year, depending on where variation is least (Waples)
  - Be careful – not all fisheries have the same properties (Witteveen)

2

## Criteria to establish priors

- Technical Committee approval
- Stakeholders comfortable
  - Satisfied
  - Consensus
- Practical to implement

2

## Approach most likely to succeed:

- Use internal priors (information from related strata)
  - Avoids subjective evaluation (variables and methods)
  - Avoids consensus on evaluation (numbers)
  - Uses data from the fishery samples
- Keep it simple
  - No development of complex methods
  - Minimize computational power

2

## Incorporating these two – new proposal (Waples and Adkison):

1. Within each fishery, determine if variation is smaller:
   - Within years across time strata
   - Across years within time strata
2. Calculate composition estimate within these strata groups
3. Use this estimate for the prior in the first strata
4. Use sequential priors thereafter based on #1

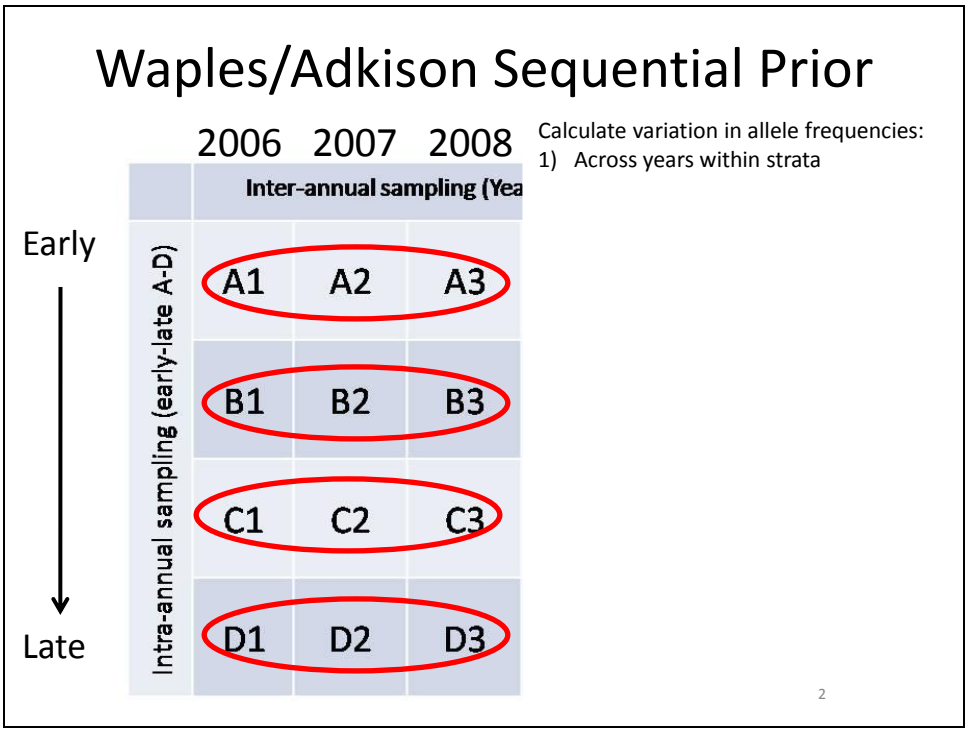
2

## Waples/Adkison Sequential Prior

| | 2006 | 2007 | 2008 |
|---|---|---|---|
| | Inter-annual sampling (Yea | | |
| Intra-annual sampling (early-late A-D) | A1 | A2 | A3 |
| | B1 | B2 | B3 |
| | C1 | C2 | C3 |
| | D1 | D2 | D3 |

Early ↓ Late

2


Waples/Adkison Sequential Prior
2006 2007 2008
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Late
Intra-annual sampling (early-late A-D)
A1 A2 A3
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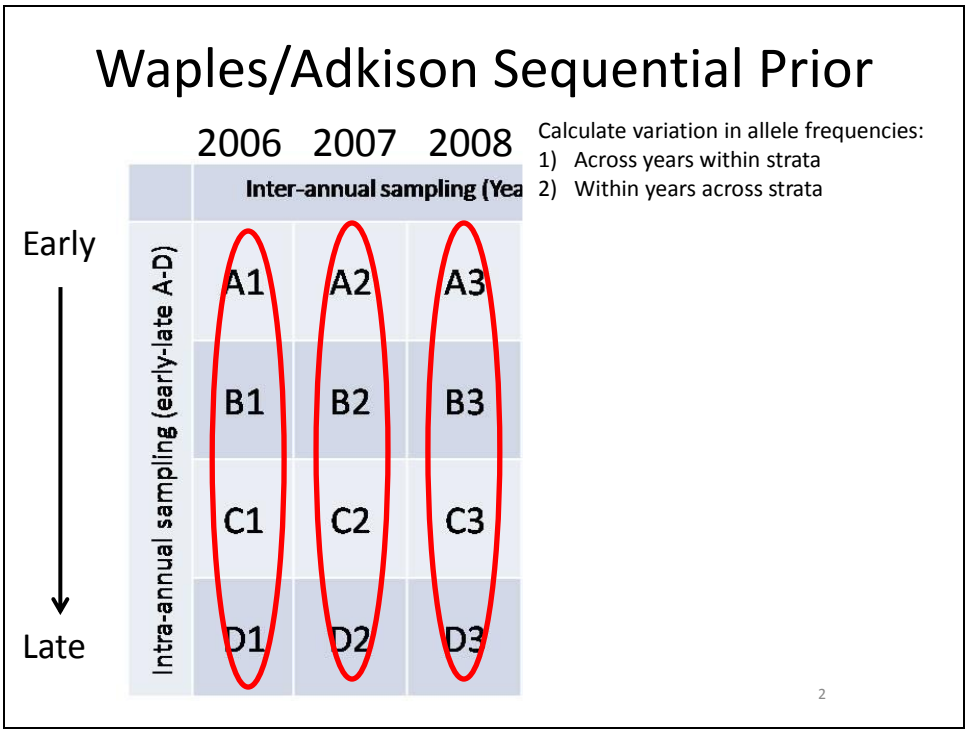
D1 D2 D3
Calculate variation in allele frequencies:
1) Across years within strata
2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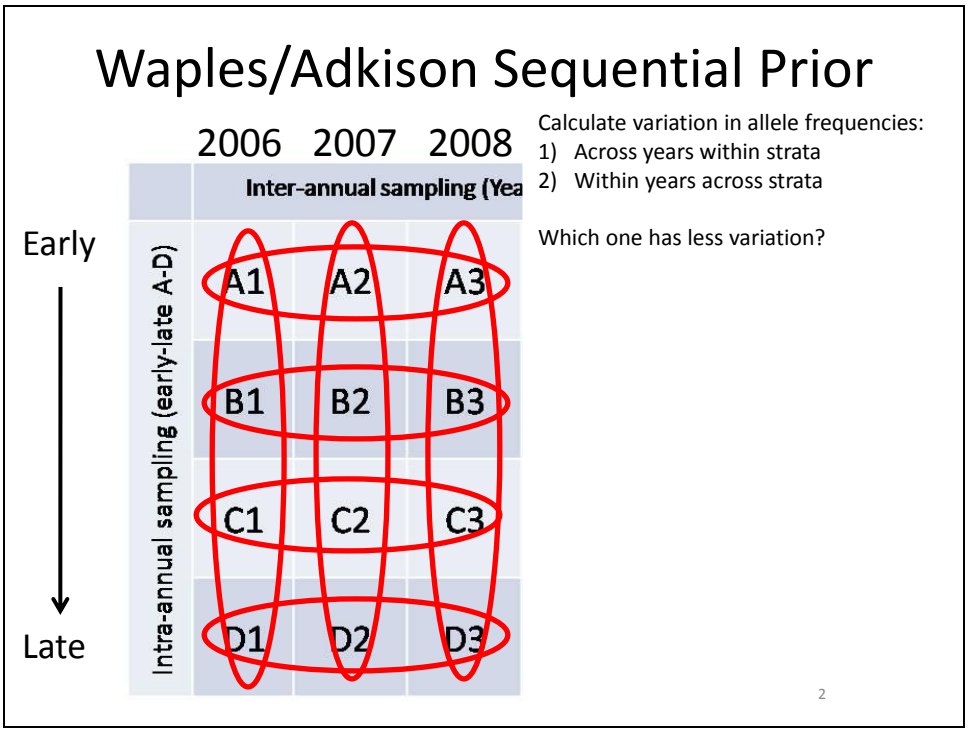
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Calculate variation in allele frequencies:
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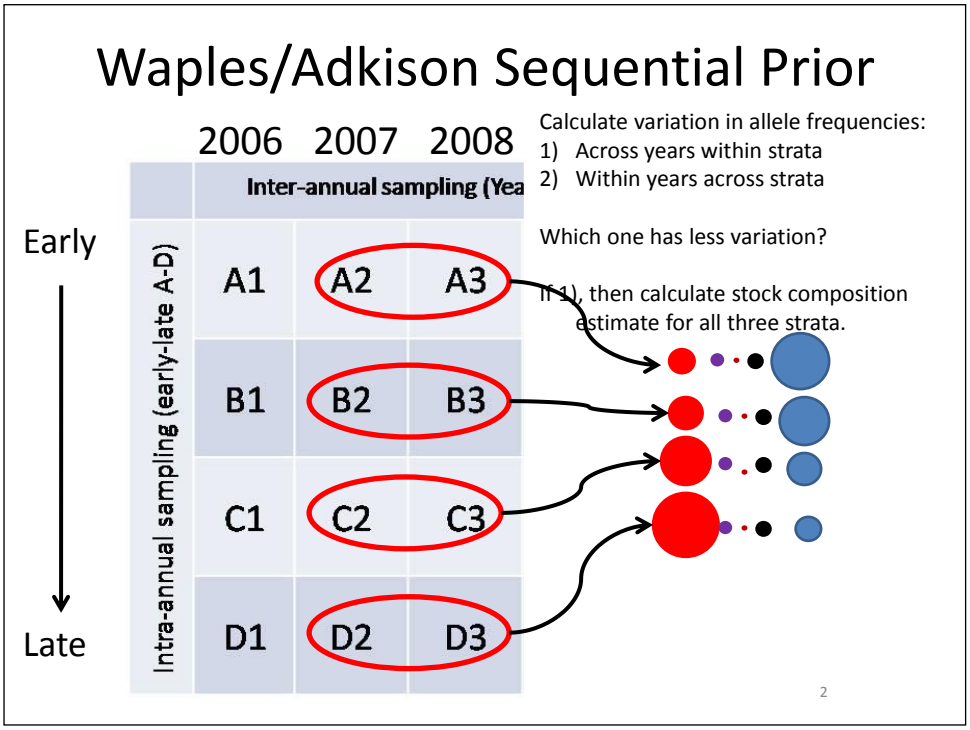
2) Within years across strata
Which one has less variation?
2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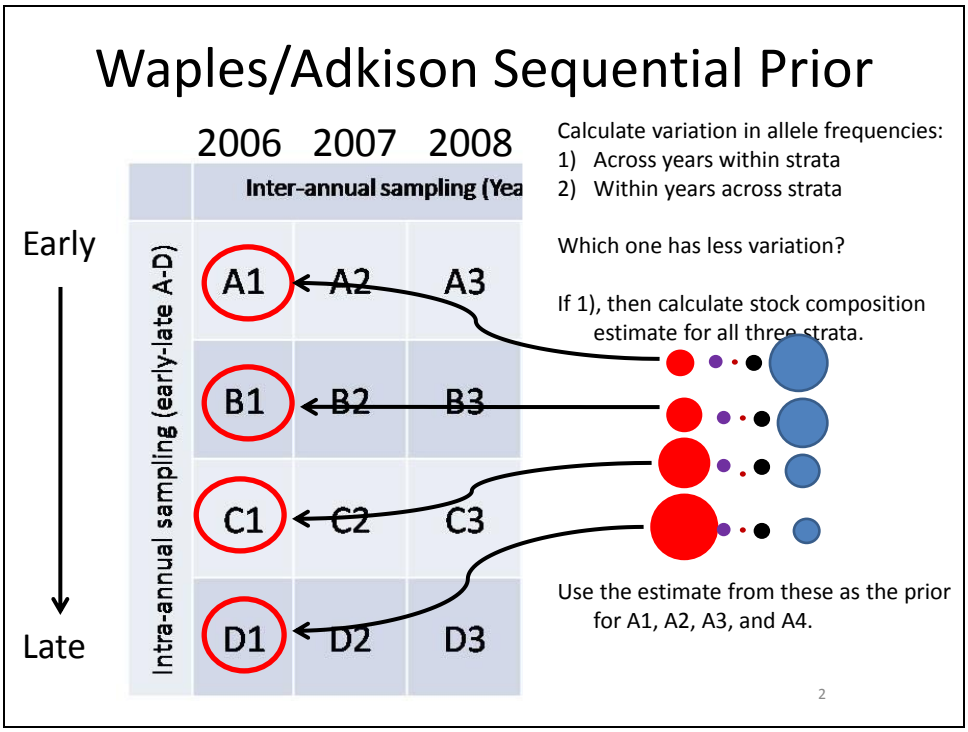
If 1), then calculate stock composition estimate for all three strata.
2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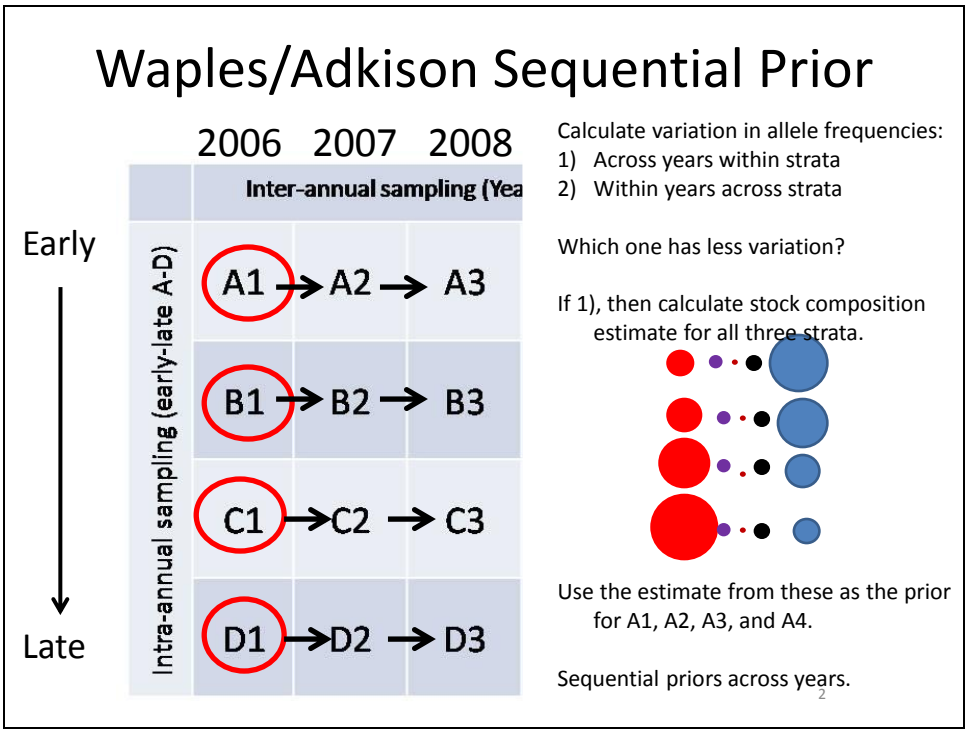
2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Sequential priors across years.
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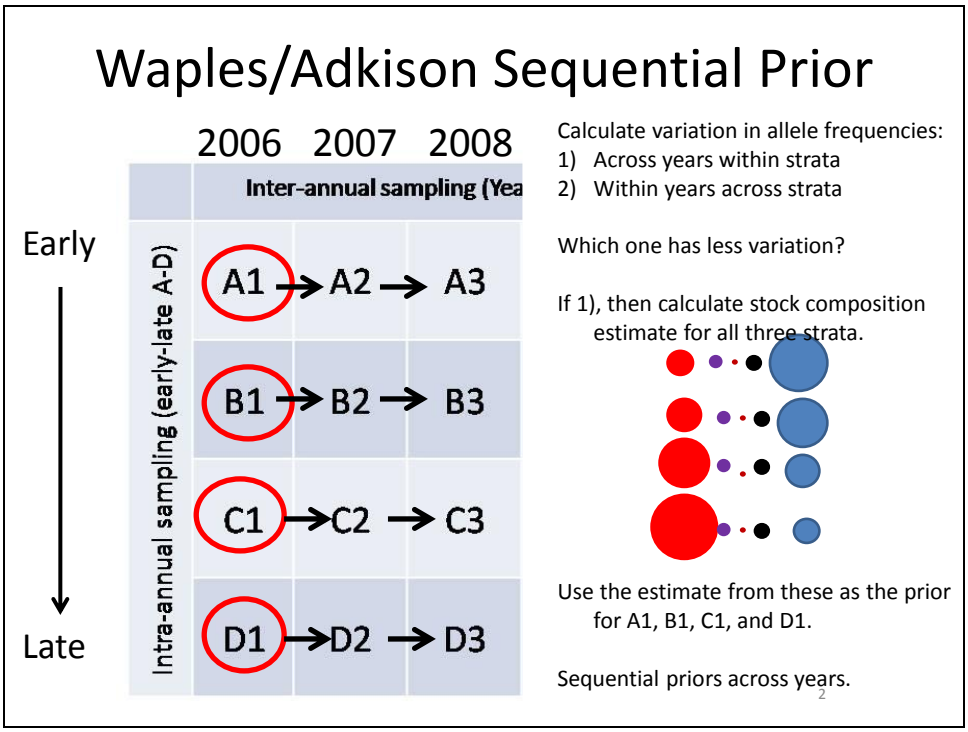
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Sequential priors across years.
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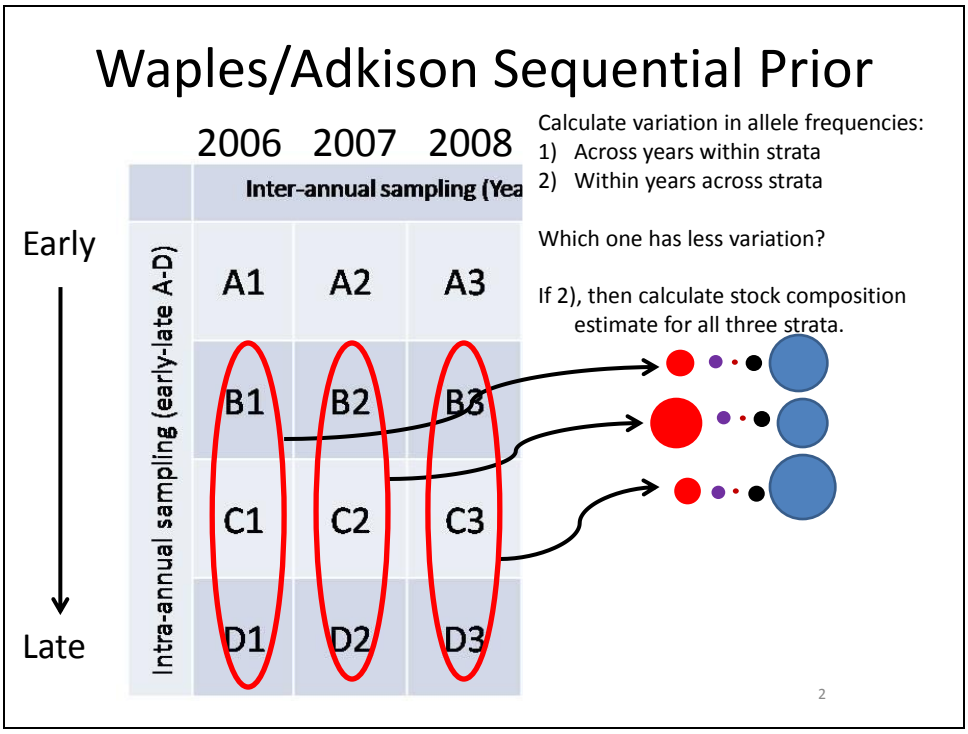
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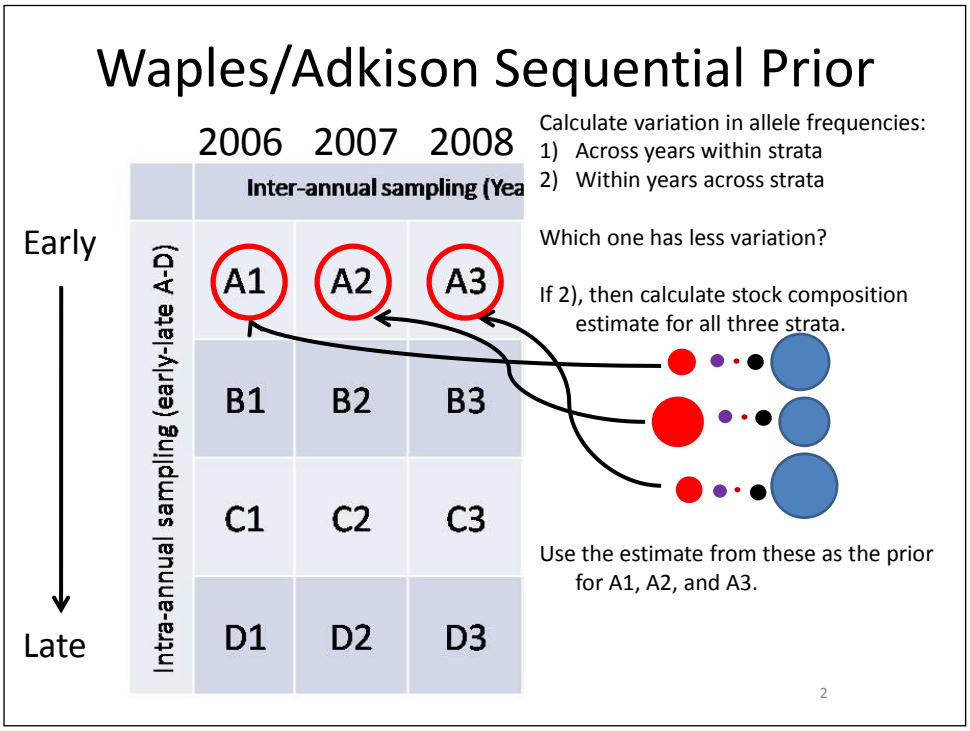
Calculate variation in allele frequencies:
1) Across years within strata
2) Within years across strata
Which one has less variation?
If 2), then calculate stock composition estimate for all three strata.
2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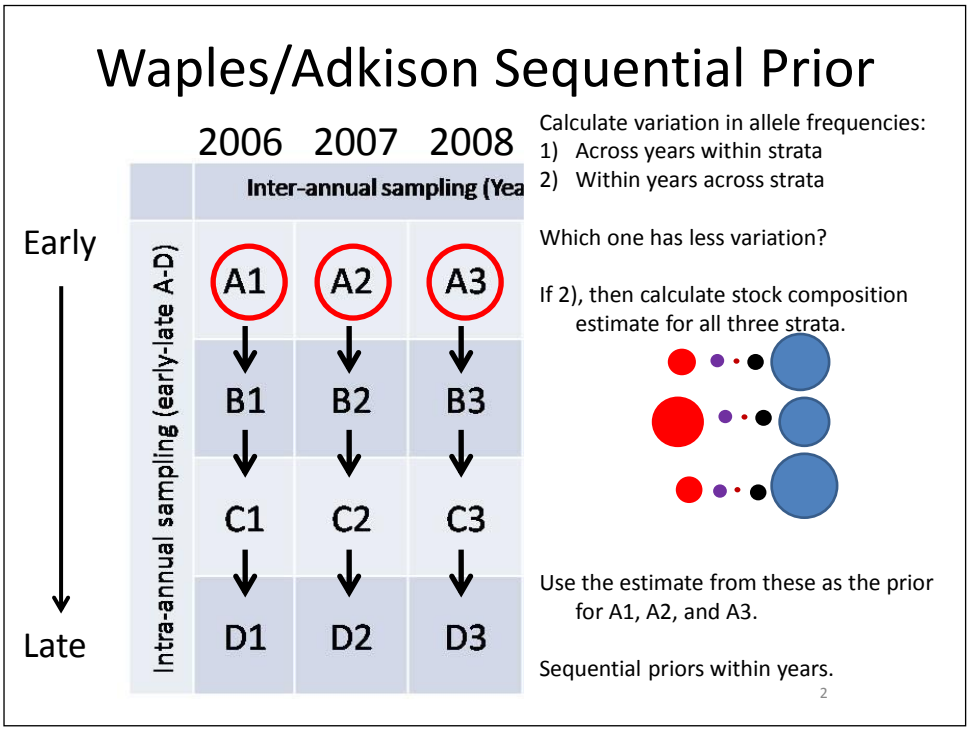
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Use the estimate from these as the prior for A1, A2, and A3.
Sequential priors within years.
2

# Advantages

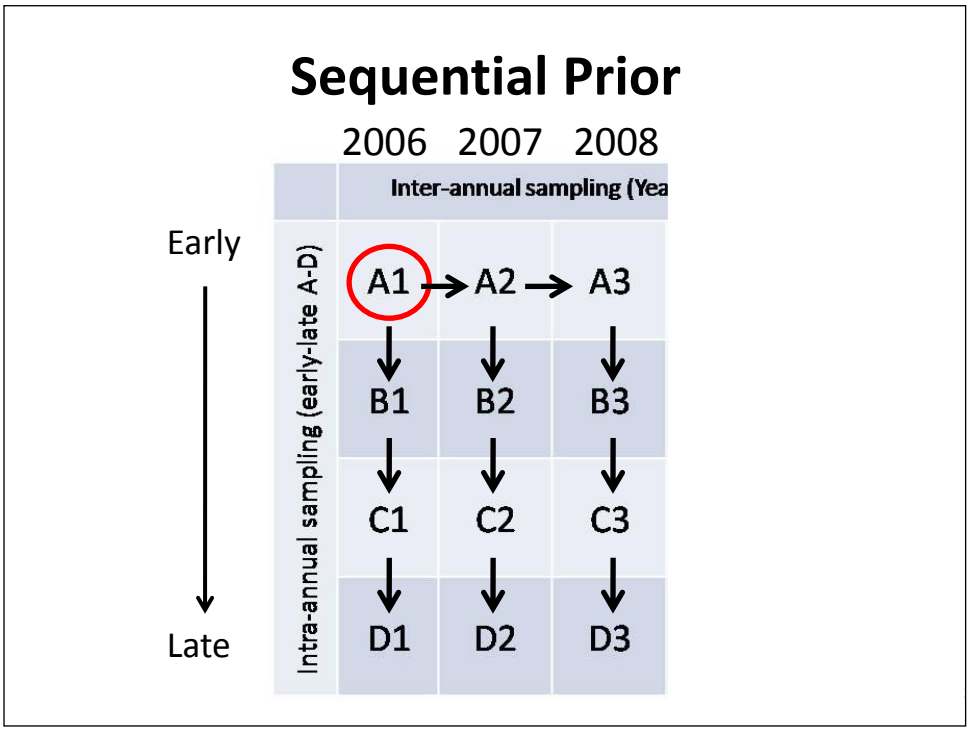
- Objective
- Agree on method, not numbers
- Simple to implement
- Handles variation among fisheries

2

# Calculation of variation in allele frequencies

| Strata | Locus (common allele frequency) | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | … | 96 | |
| 1 | 0.61 | 0.55 | 0.98 | … | 0.58 | |
| 2 | 0.72 | 0.43 | 0.96 | … | 0.59 | |
| 3 | 0.50 | 0.70 | 1.00 | … | 0.54 | |
| ABS (1 - 2) | 0.11 | 0.12 | 0.01 | … | 0.02 | |
| ABS (1 - 3) | 0.11 | 0.15 | 0.04 | … | 0.02 | |
| ABS (2 - 3) | 0.22 | 0.27 | 0.05 | … | 0.04 | |
| | | | | | | Grand mean |
| Average | 0.15 | 0.18 | 0.03 | … | 0.03 | 0.10 |

2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