Selection of a Prior for Mixed Stock Analysis
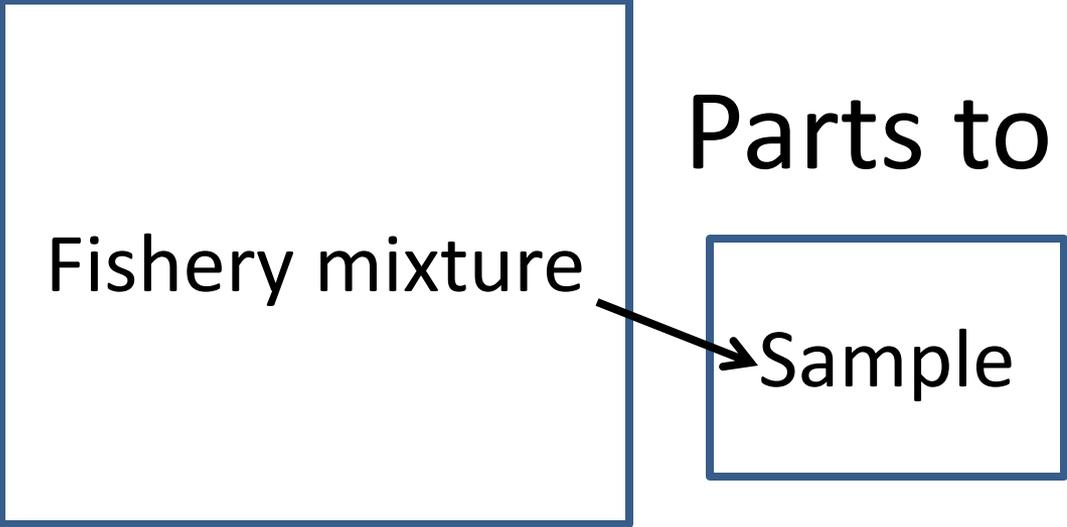
- Alaska Department of Fish and Game
- Gene Conservation Laboratory

Parts to Bayesian MSA

Fishery mixture

Sample

Parts to Bayesian MSA

Fishery mixture → Sample

Sample → Model

Parts to Bayesian MSA

Fishery mixture → Sample

Sample → Model

Baseline → Model

Parts to Bayesian MSA

Fishery mixture → Sample

Sample → Model

Prior → Model

Baseline → Model

Parts to Bayesian MSA

Fishery mixture → Sample

Sample → Model

Prior → Model

Baseline → Model

Model = Estimate

Parts to Bayesian MSA

Fishery mixture → Sample

Sample → Model

Prior → Model

Baseline → Model

Model = Estimate
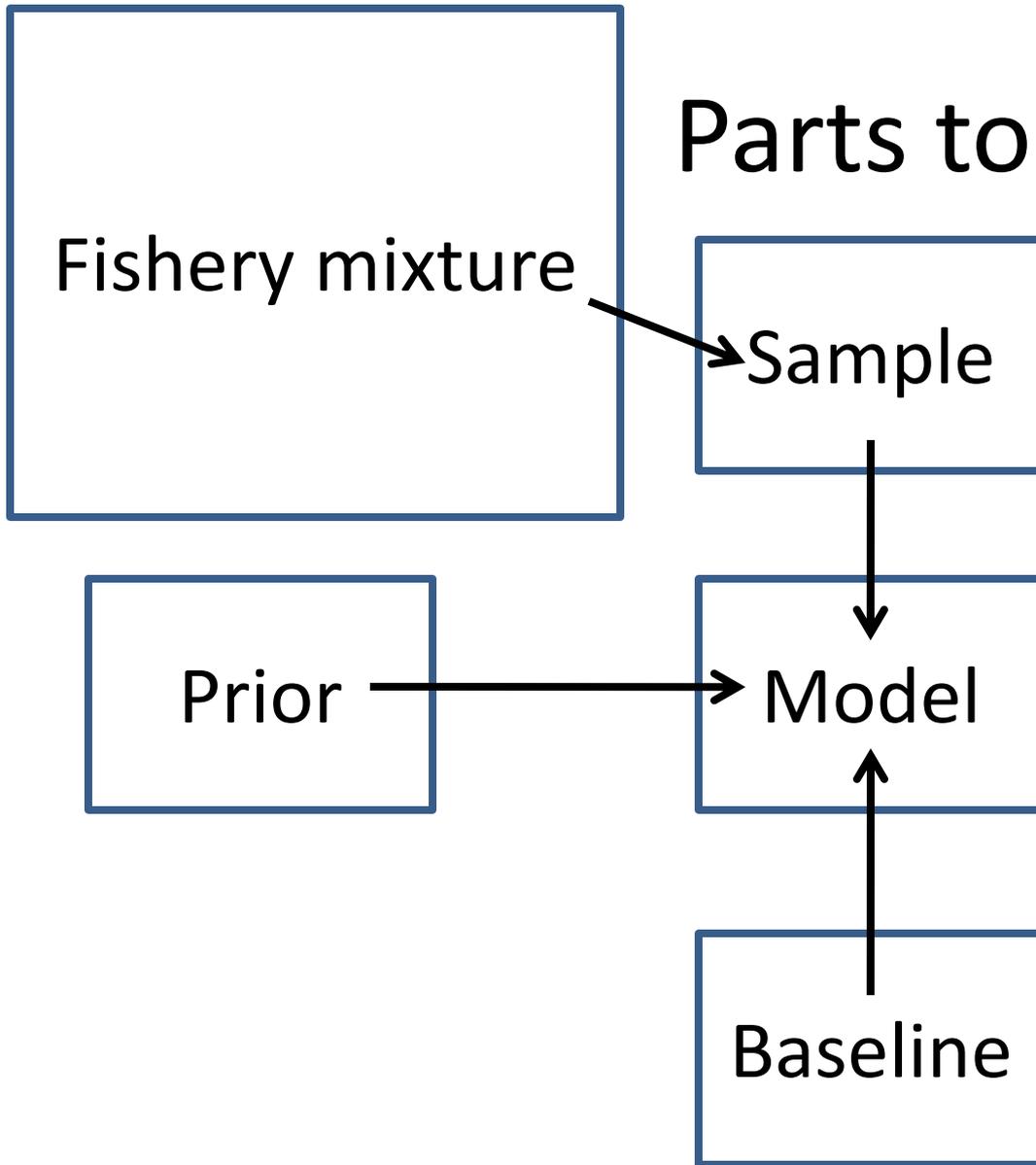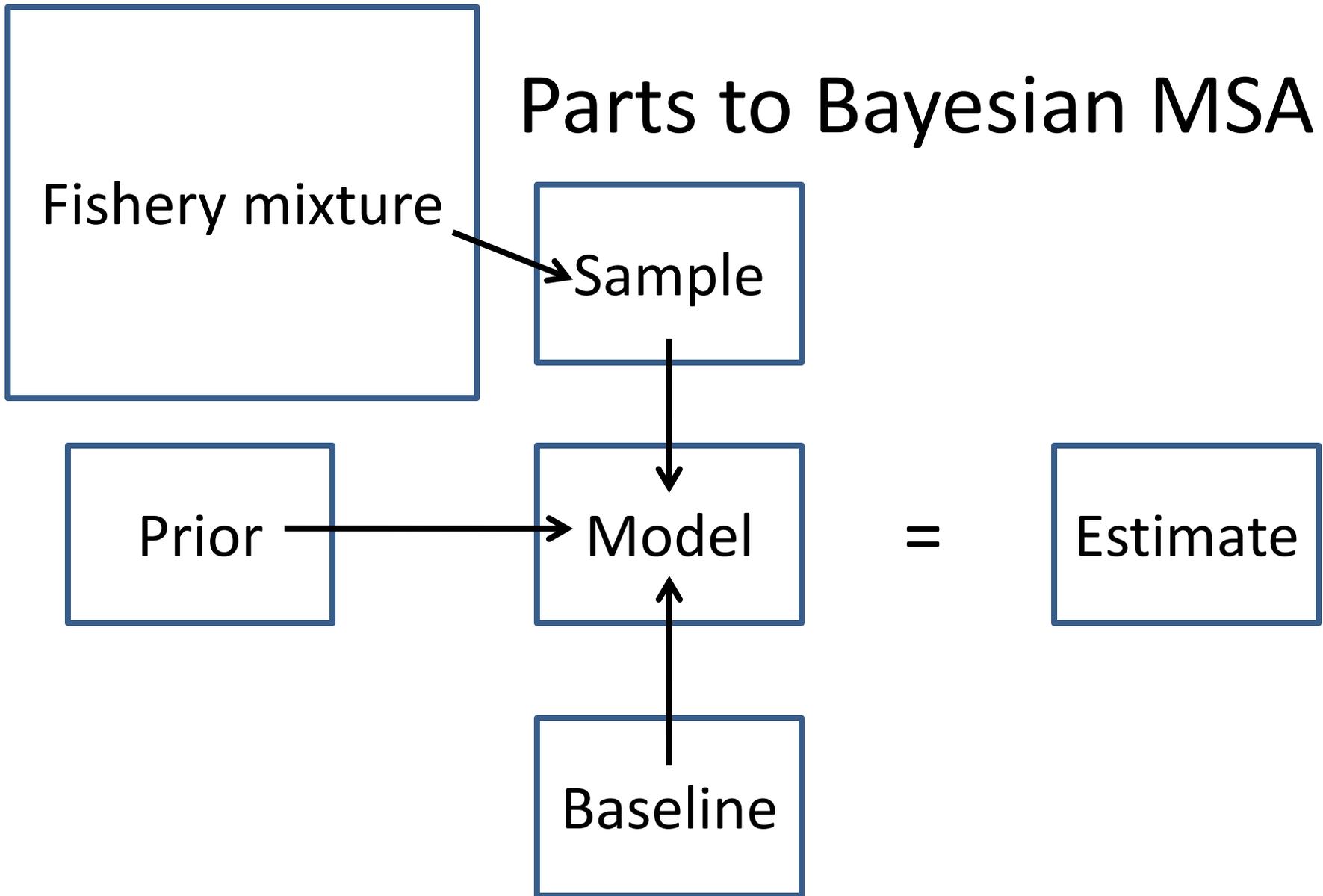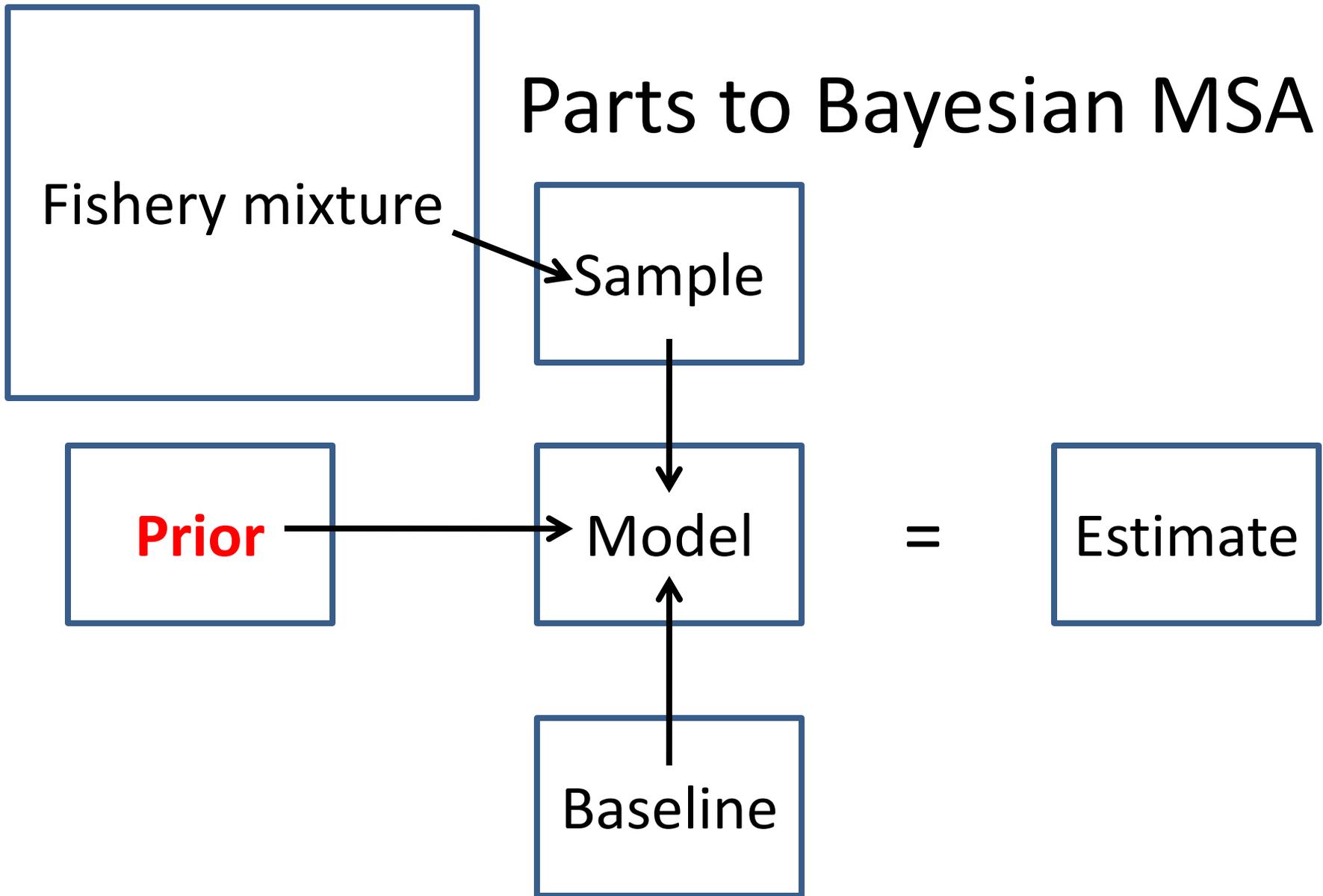
What is the Prior?
(For statisticians)

- Dirichlet probability distribution

- Parameters sum to *K*

- Interpreted as adding *K* individuals to the fishery sample

- Typically held at 1 (Pella and Masuda, 2001)

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

Options for priors

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

Types of uniform priors

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

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*

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*

Types of Informative Priors

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

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*

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.

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.
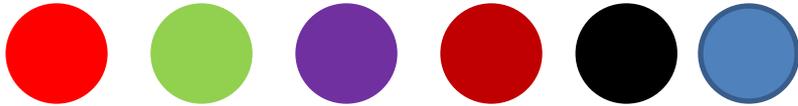
Potential biases due to priors

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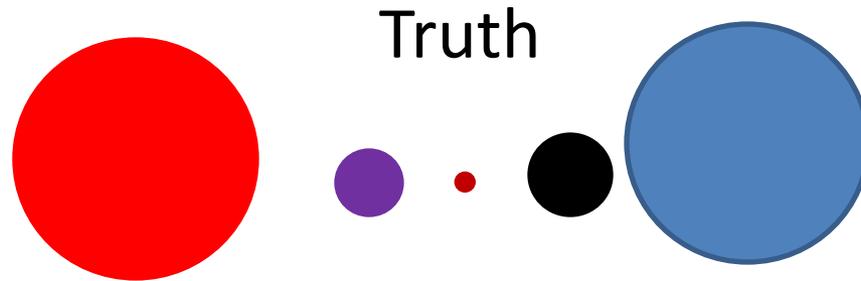
This is the true proportions of six reporting groups within a sample.

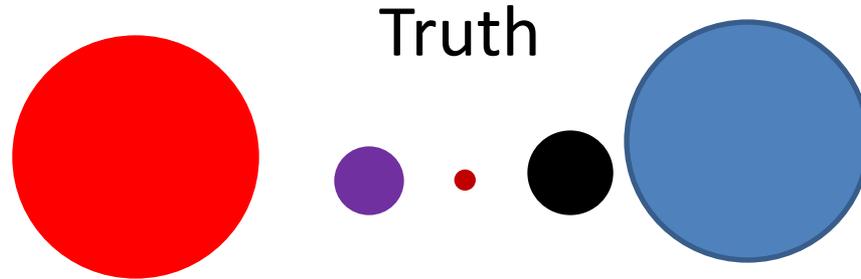# Potential biases due to priors
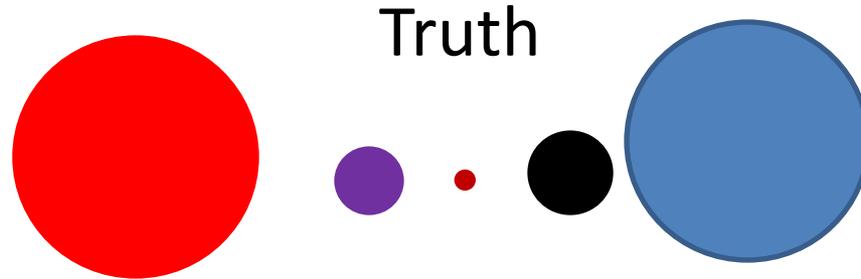
Truth

Uniform prior

Potential biases due to priors

Truth

Uniform prior

Potential biases due to priors

Potential biases due to priors

Truth
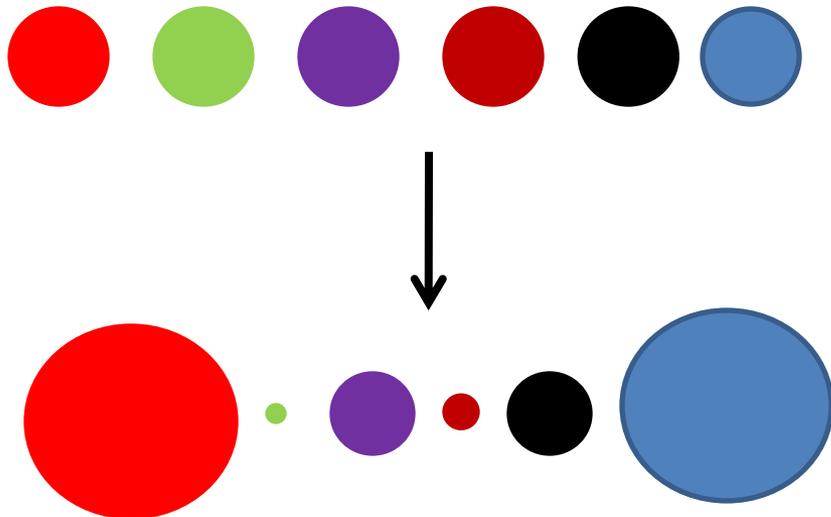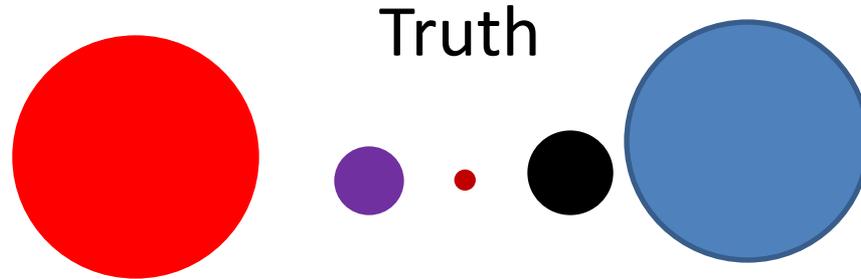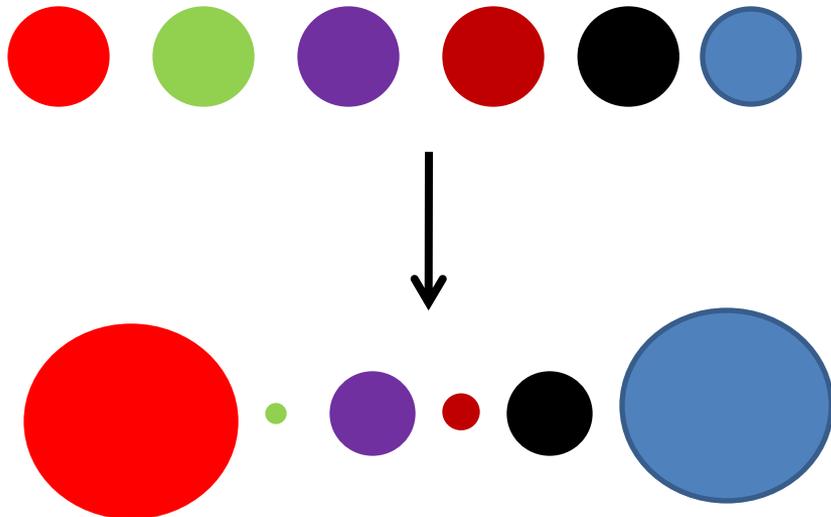
Uniform prior
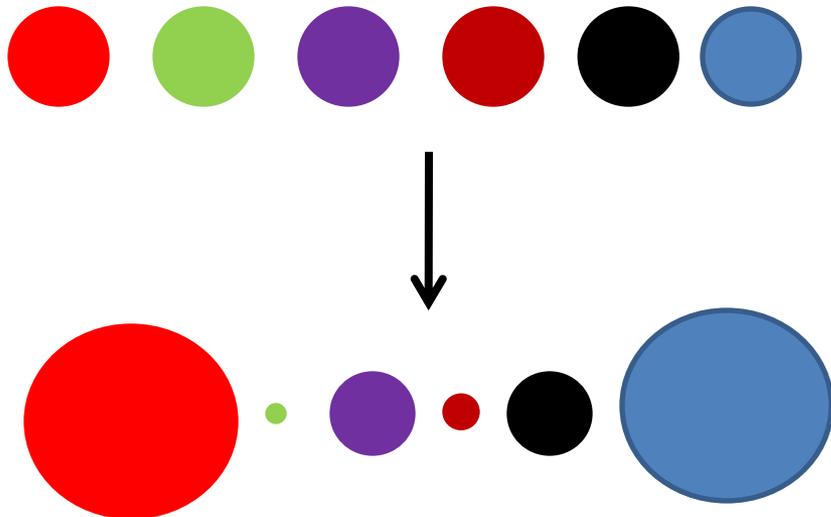
Informed prior
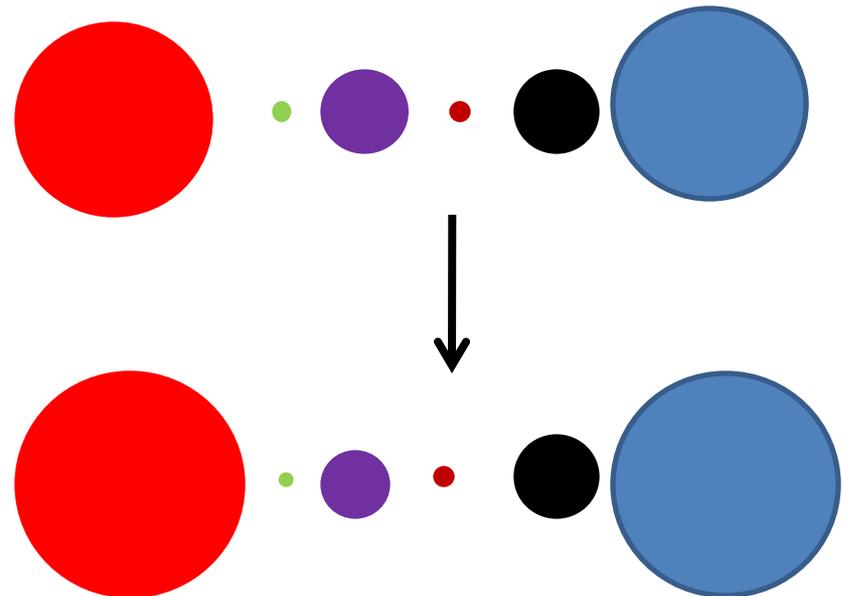
What is standard?

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

What is standard?

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

What is standard?

- No universally standard method
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- But magnitude of this effect on the analysis depends on the strength of the structure among the stocks being resolved

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

Department's initial recommendation

- Initial strata: sub-regional reporting group uniform priors

- Subsequent strata: sequential priors

- Example to follow...

Uniform and then sequential prior
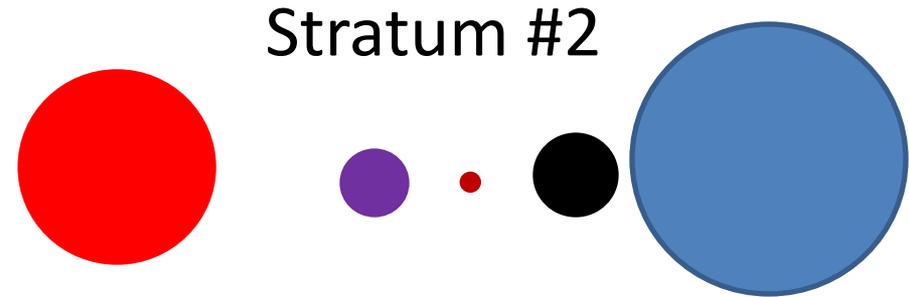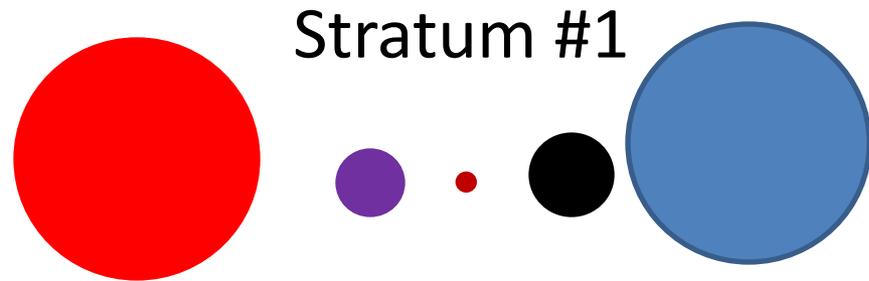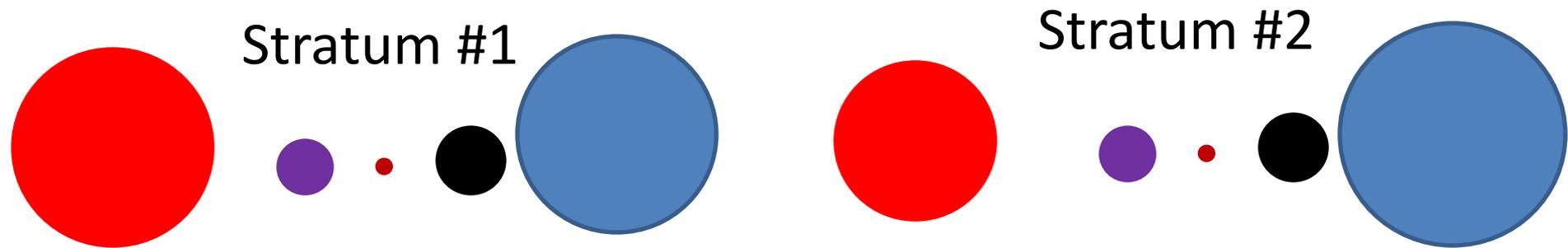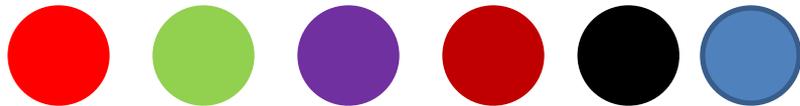
Uniform and then sequential prior

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
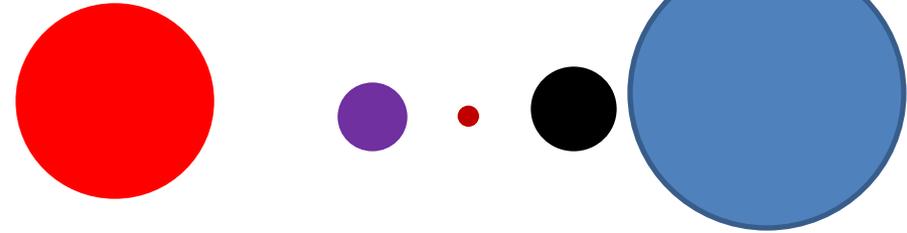
Uniform prior
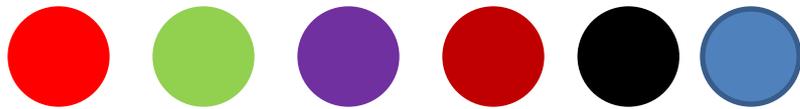
Sequential prior
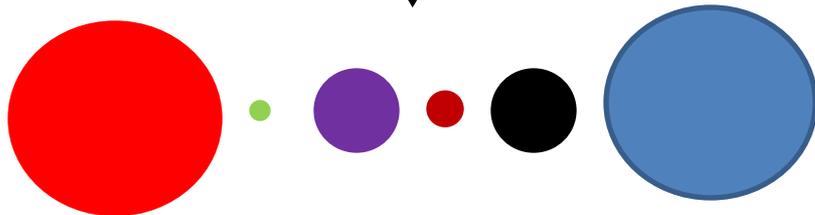
Sequential Prior

	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
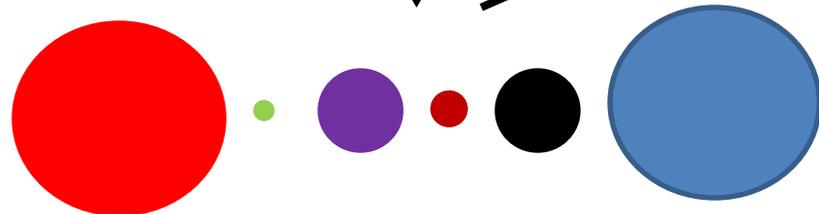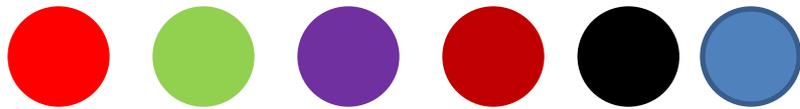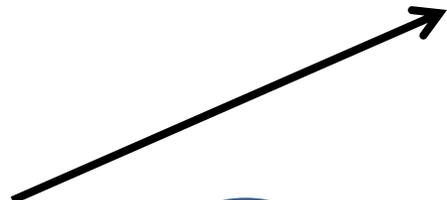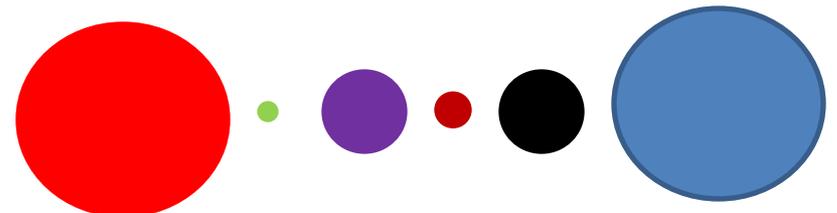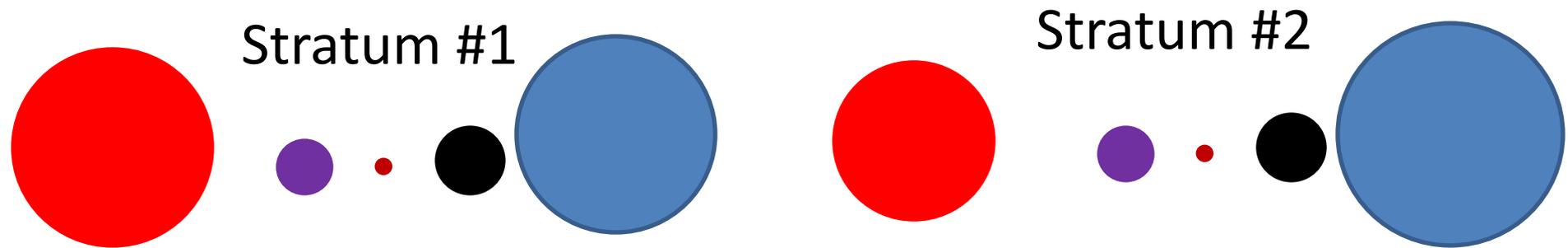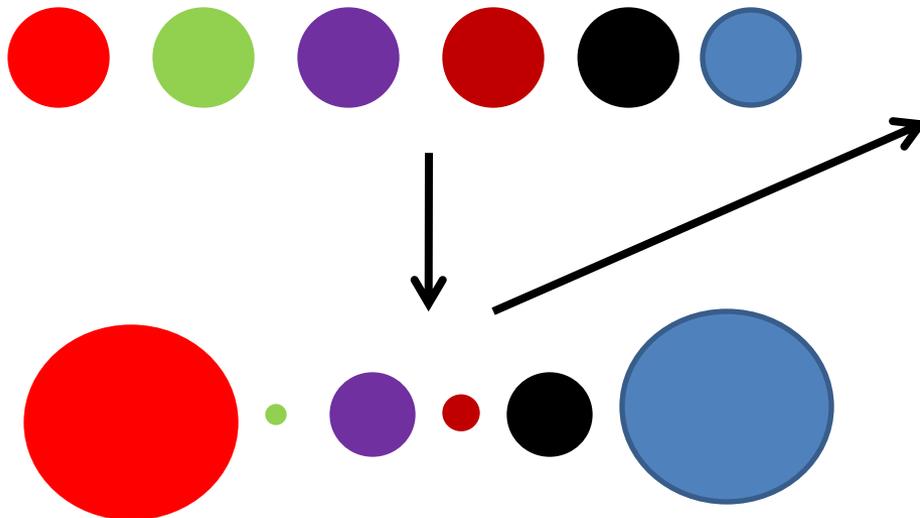
Intra-annual sampling (early-late A–D)
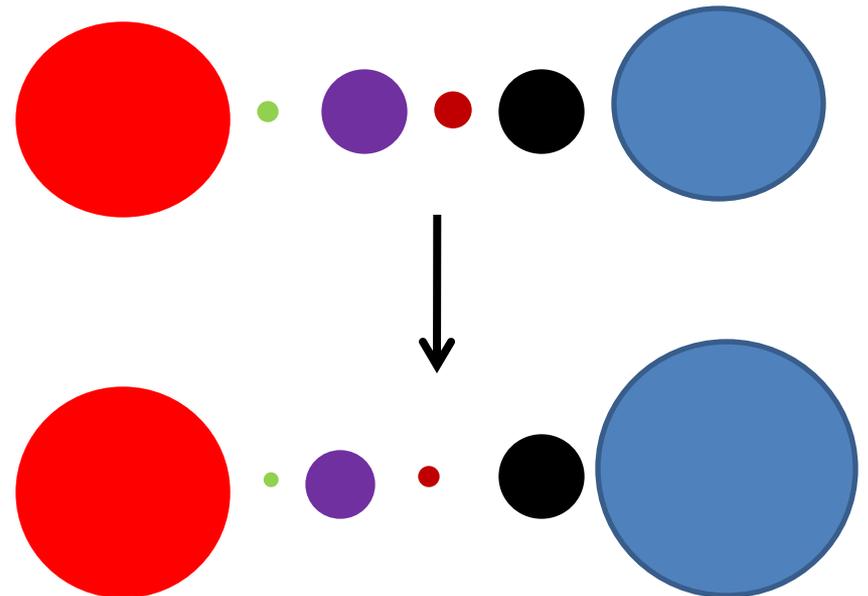
Sequential Prior

2006 2007 2008 2009

Early

Late

Inter-annual sampling (Year 1–4)

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

	2006	2007	2008	2009
Early	A1	A2	A3	A4
	B1	B2	B3	B4
	C1	C2	C3	C4
Late	D1	D2	D3	D4

Sequential Prior

2006 2007 2008 2009

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

Sequential Prior

Sequential Prior

Sequential prior used for the next time strata for the year

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Sequential Prior
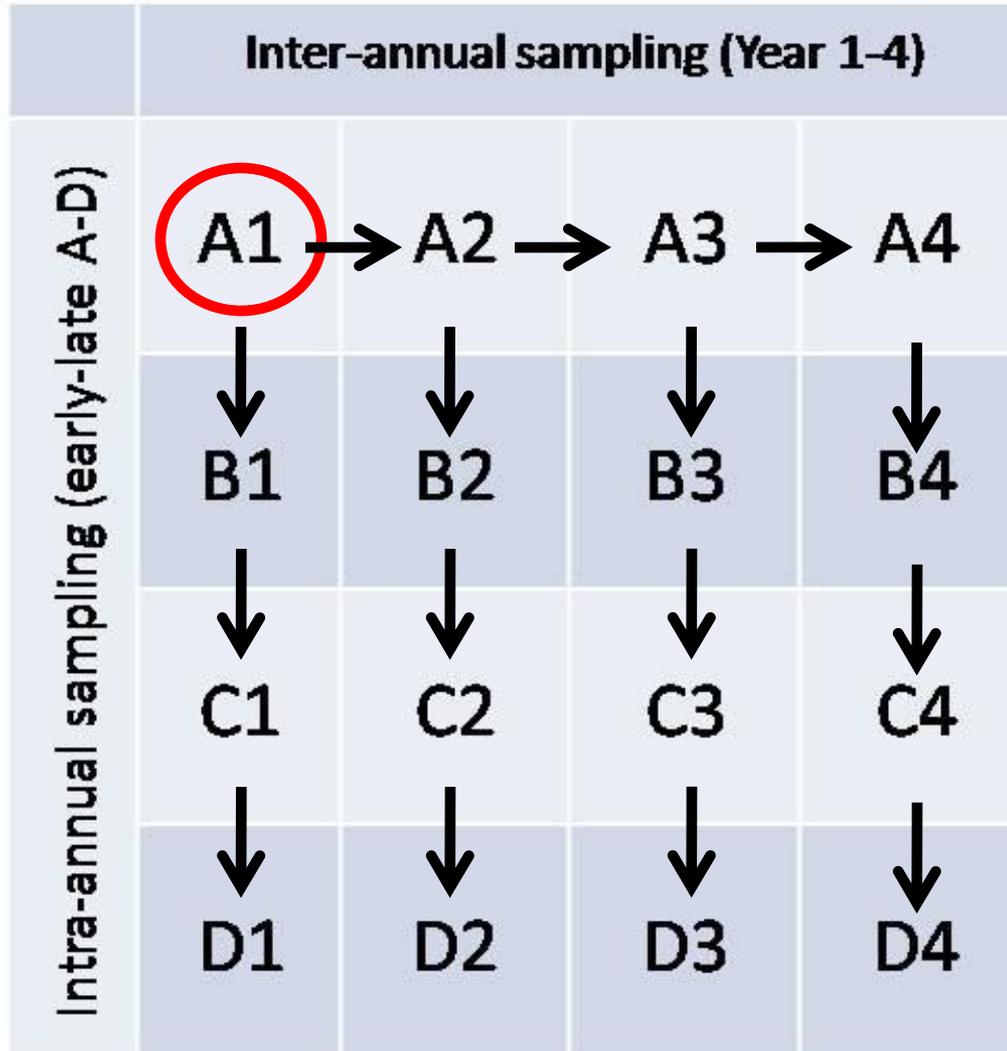
Open to other ideas

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…

Binary Uniform

Sockeye Fishery

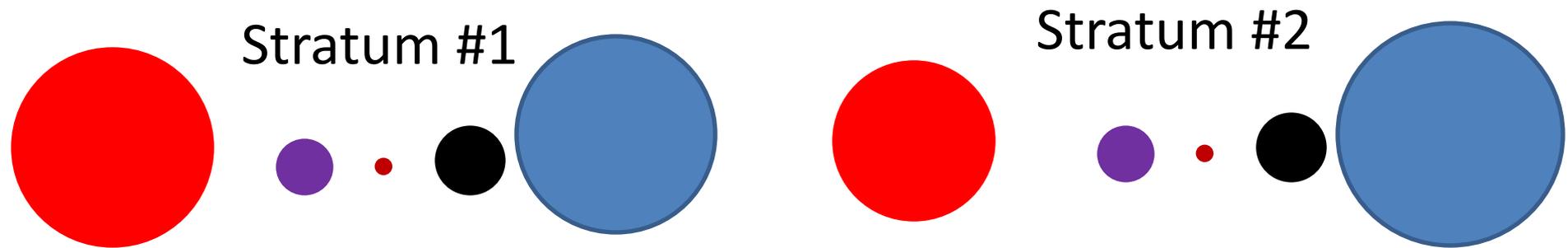| Reporting Group	Kuskokwim Area	Togiak	Nushagak	Naknek-Kvichak	Egegik	Ugashik	North Peninsula	South Peninsula June	South Peninsula Post-June	SEDM	Chignik
Seward Peninsula	I	I	I	O	O	O	O	I	O	O	O
Kuskokwim River	I	I	I	O	O	O	O	I	O	O	O
Kanektok River	I	I	I	O	O	O	O	I	O	O	O
Goodnews River	I	I	I	O	O	O	O	I	O	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	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%

46

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%

47

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

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

What I heard yesterday…

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

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  - 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)

Criteria to establish priors

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

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

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

Waples/Adkison Sequential Prior

	2006	2007	2008
	Inter-annual sampling (Yea		
Early	A1	A2	A3
	B1	B2	B3
	C1	C2	C3
Late	D1	D2	D3

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

Waples/Adkison Sequential Prior

Calculate variation in allele frequencies:
1) Across years within strata

Waples/Adkison Sequential Prior

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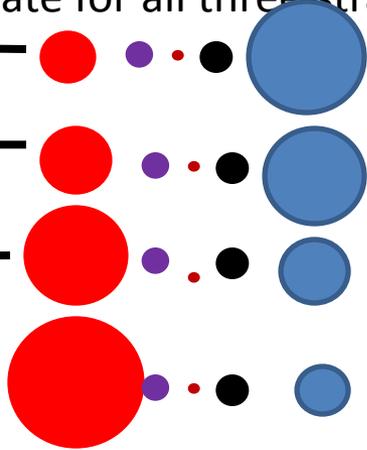2) Within years across strata

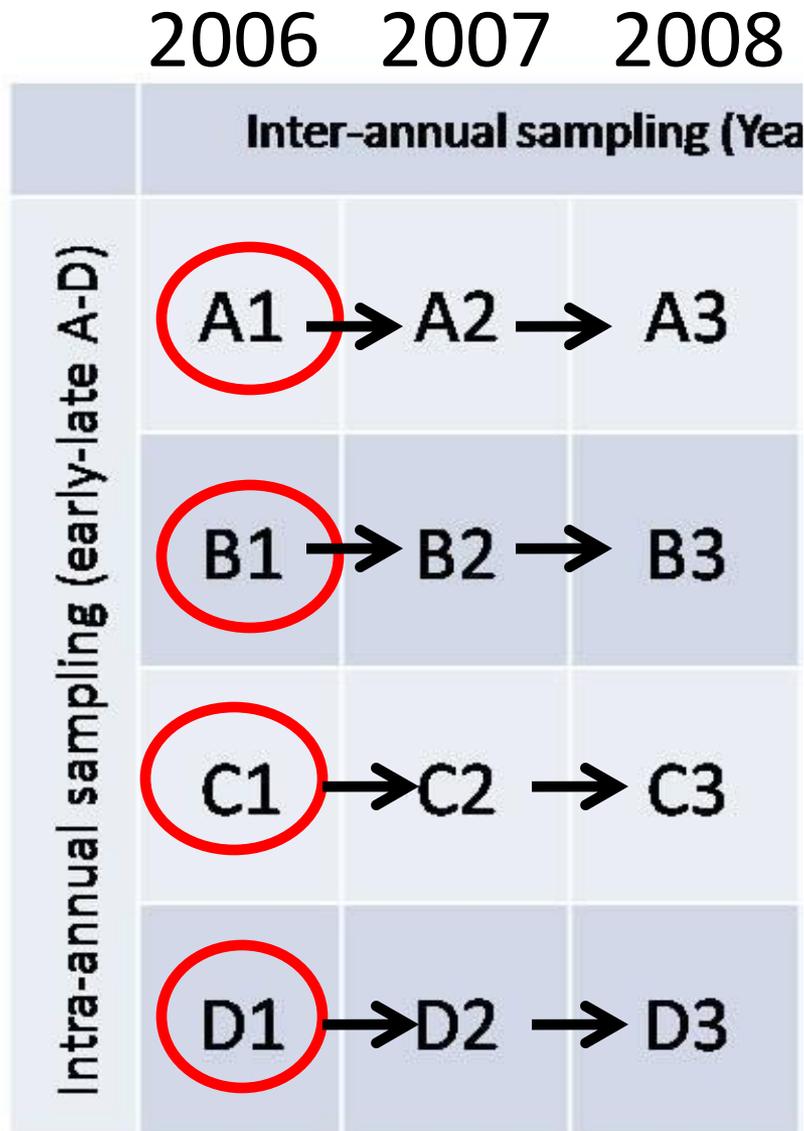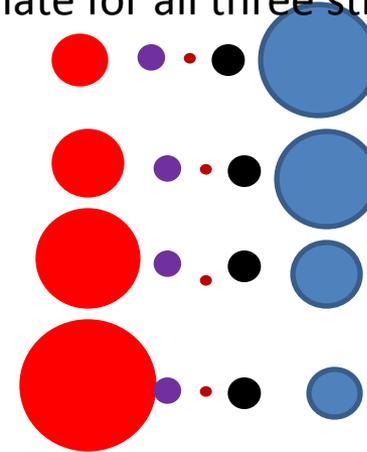# Waples/Adkison Sequential Prior

Calculate variation in allele frequencies:
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Which one has less variation?

Waples/Adkison Sequential Prior

2006   2007   2008

Inter-annual sampling (Yea

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

Early

A1	A2	A3
B1	B2	B3
C1	C2	C3
D1	D2	D3

Late

Calculate variation in allele frequencies:
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2) Within years across strata

Which one has less variation?

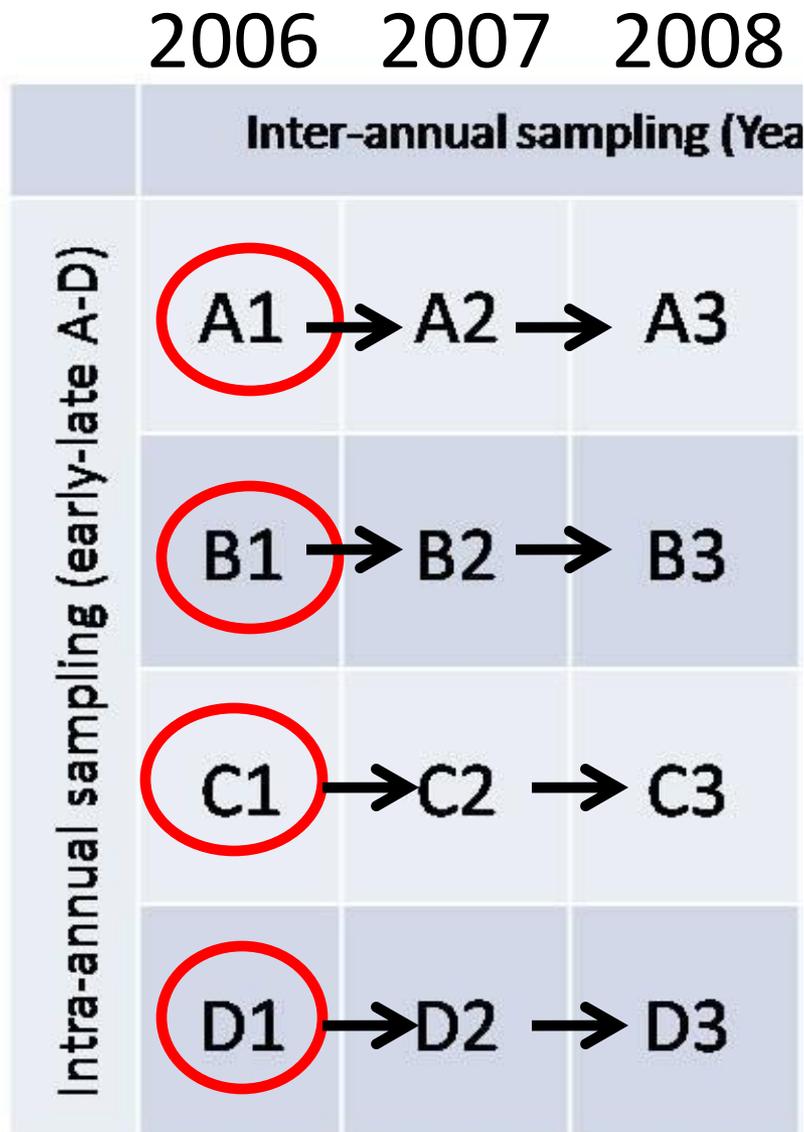If 1), then calculate stock composition estimate for all three strata.

Waples/Adkison Sequential Prior

Calculate variation in allele frequencies:
1) Across years within strata
2) Within years across strata

Which one has less variation?

If 1), then calculate stock composition estimate for all three strata.

Use the estimate from these as the prior for A1, A2, A3, and A4.

Waples/Adkison Sequential Prior

2006   2007   2008

Early

Late

Calculate variation in allele frequencies:
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Sequential priors across years.
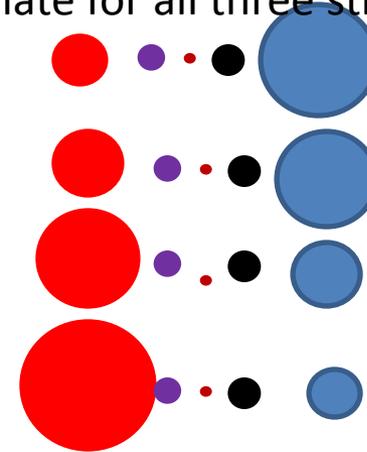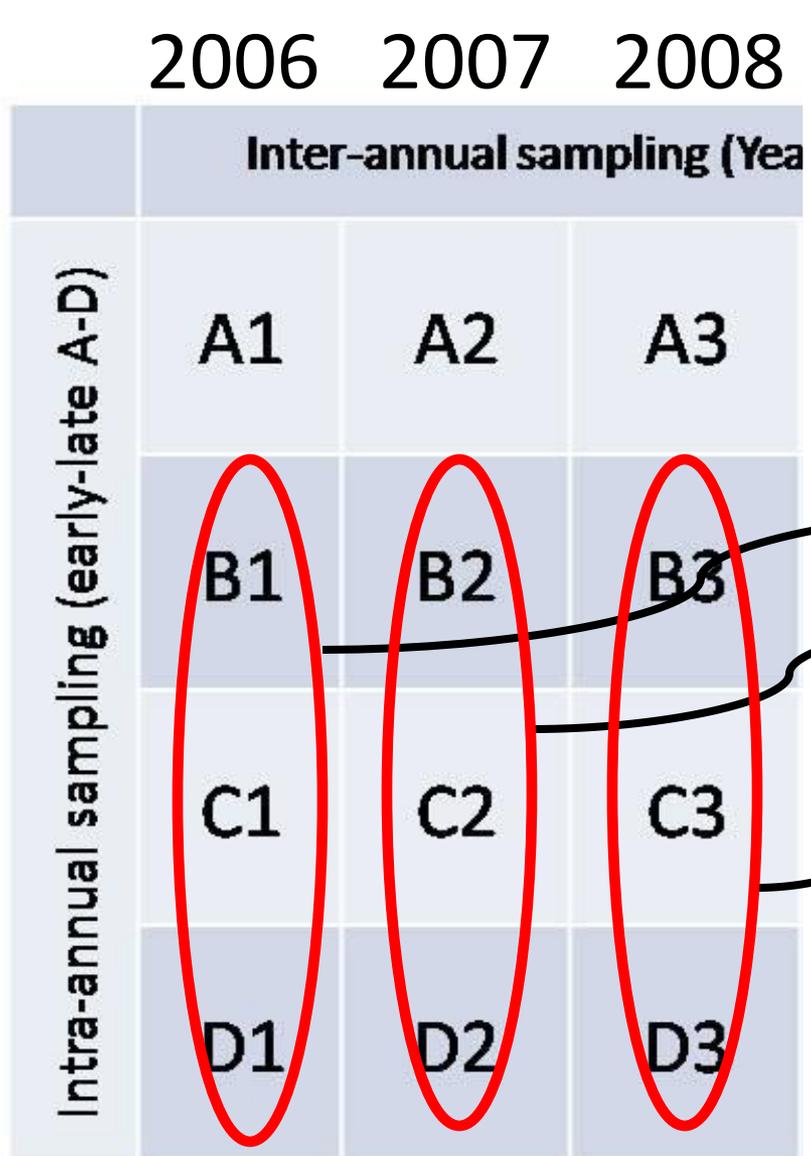
Waples/Adkison Sequential Prior

2006   2007   2008

Early

Late

Calculate variation in allele frequencies:
1) Across years within strata
2) Within years across strata

Which one has less variation?

If 1), then calculate stock composition estimate for all three strata.

Use the estimate from these as the prior for A1, B1, C1, and D1.

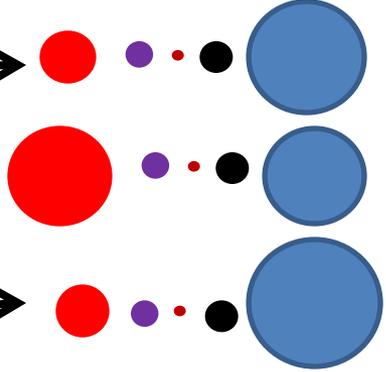Sequential priors across years.
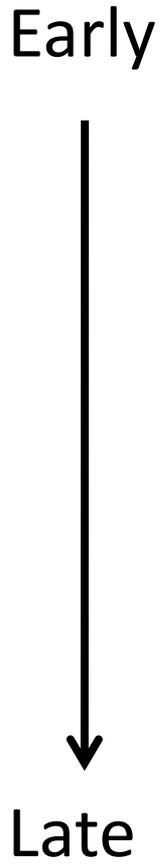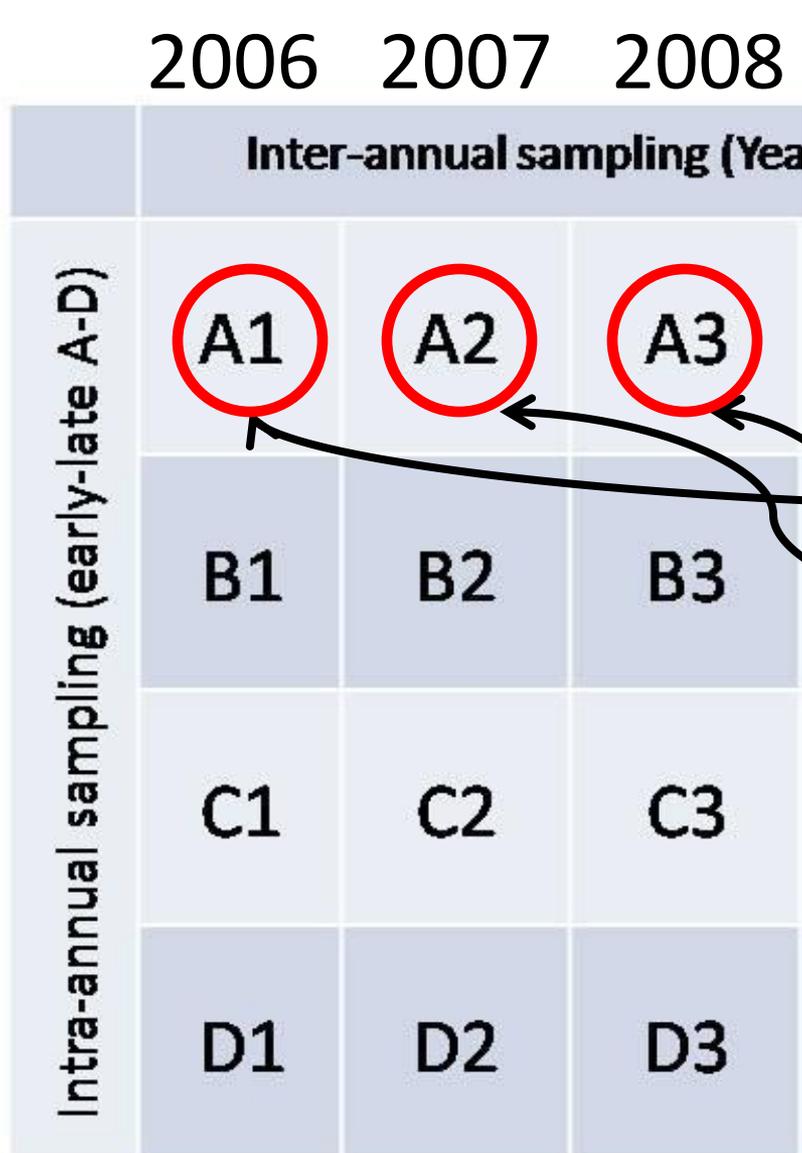
Waples/Adkison Sequential Prior

2006 2007 2008

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.
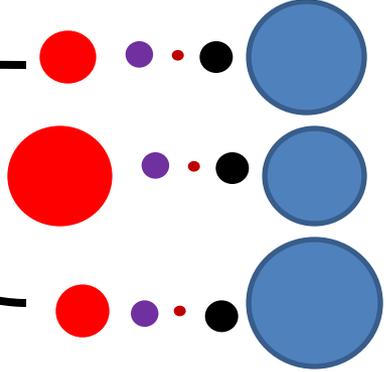
Waples/Adkison Sequential Prior

2006   2007   2008

Inter-annual sampling (Yea

Early

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

A1	A2	A3
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Calculate variation in allele frequencies:
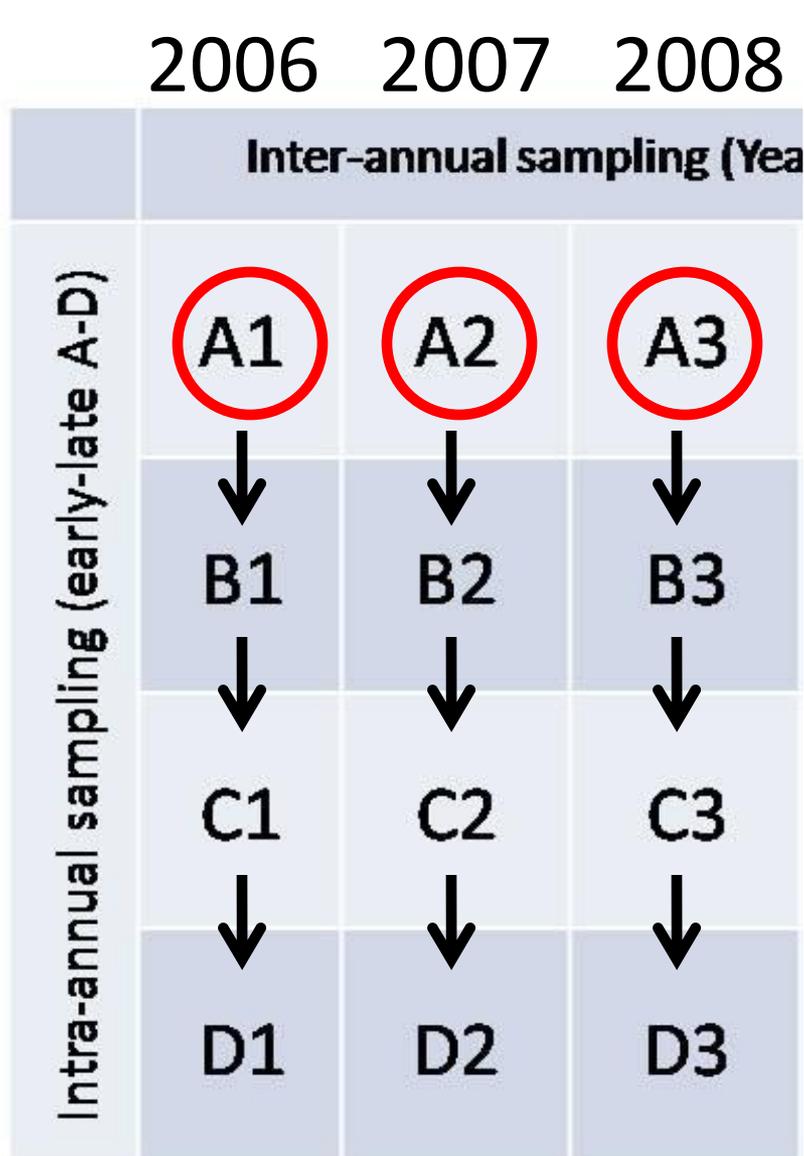1) Across years within strata
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Which one has less variation?

If 2), then calculate stock composition estimate for all three strata.

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Waples/Adkison Sequential Prior

2006   2007   2008

Inter-annual sampling (Yea

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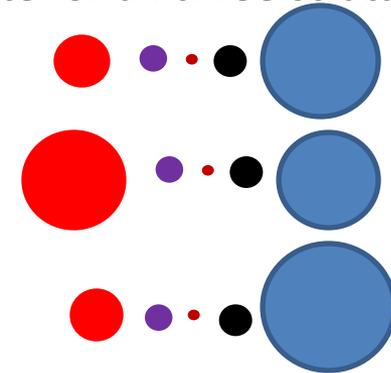
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Sequential priors within years.

Advantages

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