GSI applications in Fraser River Sockeye Management: Confessions from a skeptic turned addict

Talk outline

1. **Historical context of stock ID**
2. **Assessment and management framework**
3. **Change from SPA to GSI (“soft” to “hard” stock ID)**
4. **Some examples of GSI applications**
   a. Individual identification & “Known-Unknown” mixtures
   b. Weak stock management
   c. Inter-sample variability
5. **Advice from “The Street”**

1. Historical context for stock ID

1. Extensive tagging programs (1930's-50's) provided data on migration timing and routes of individual stocks.
2. Systematic estimates of spawning escapement for most areas since 1948.
3. Estimates of stock proportions for all significant catches of Fraser sockeye since 1952.
4. 2&3 combined with age composition provide 60 years of spawner-recruit data for 19 stocks >95% of total production
5. Real time analysis of stock proportions and intra-season management since late 1950's
- In 1998 our scale lab "read" 54,000 scales, 43,000 for

The implementation of GSI occurred in the context of the most extensive salmon data set in the world!

2. Assessment framework

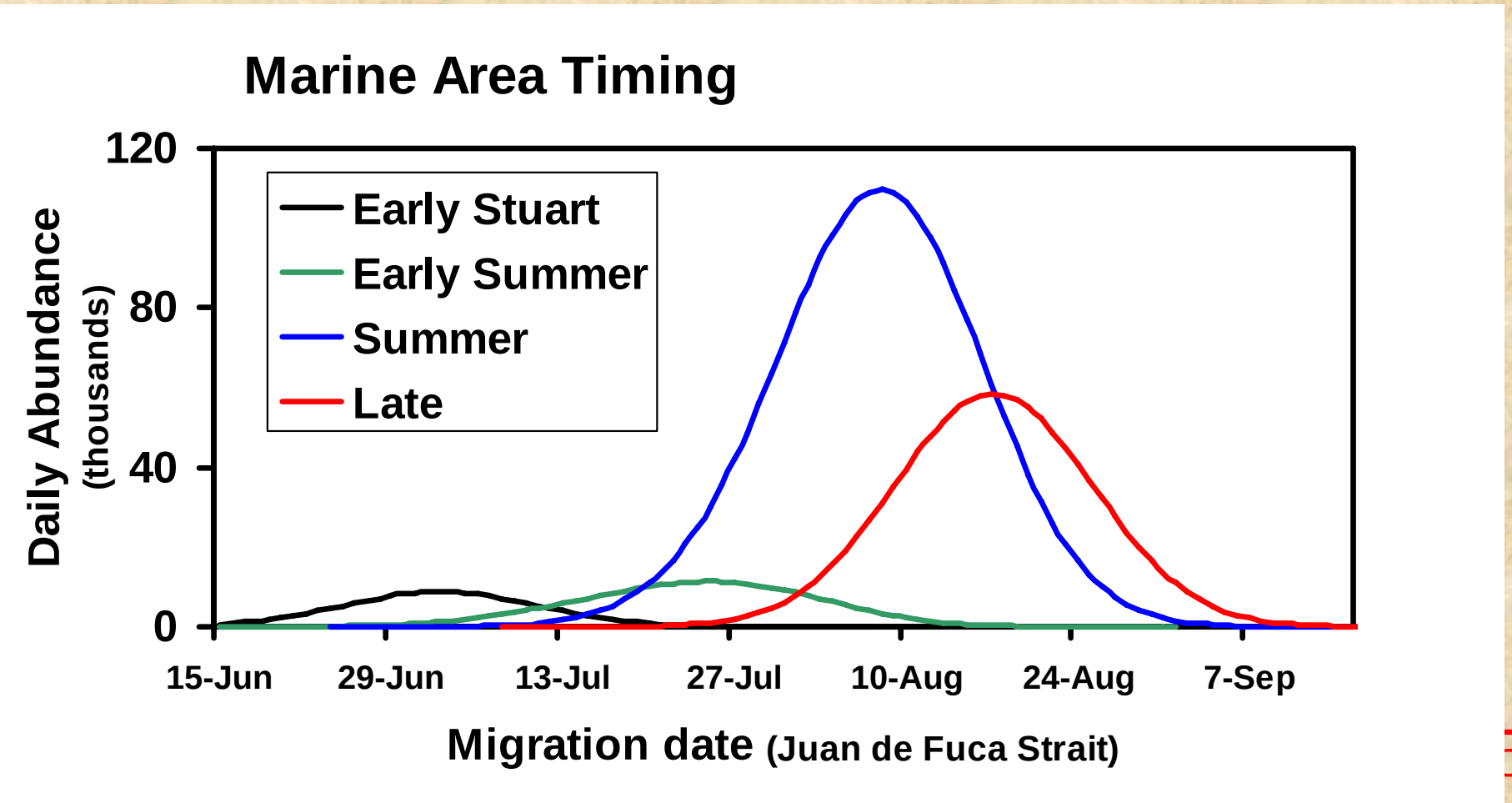
Pre-season

- **Forecasts** **(abundance and timing)**
- **Planning model** **(similar to FRAM models)**

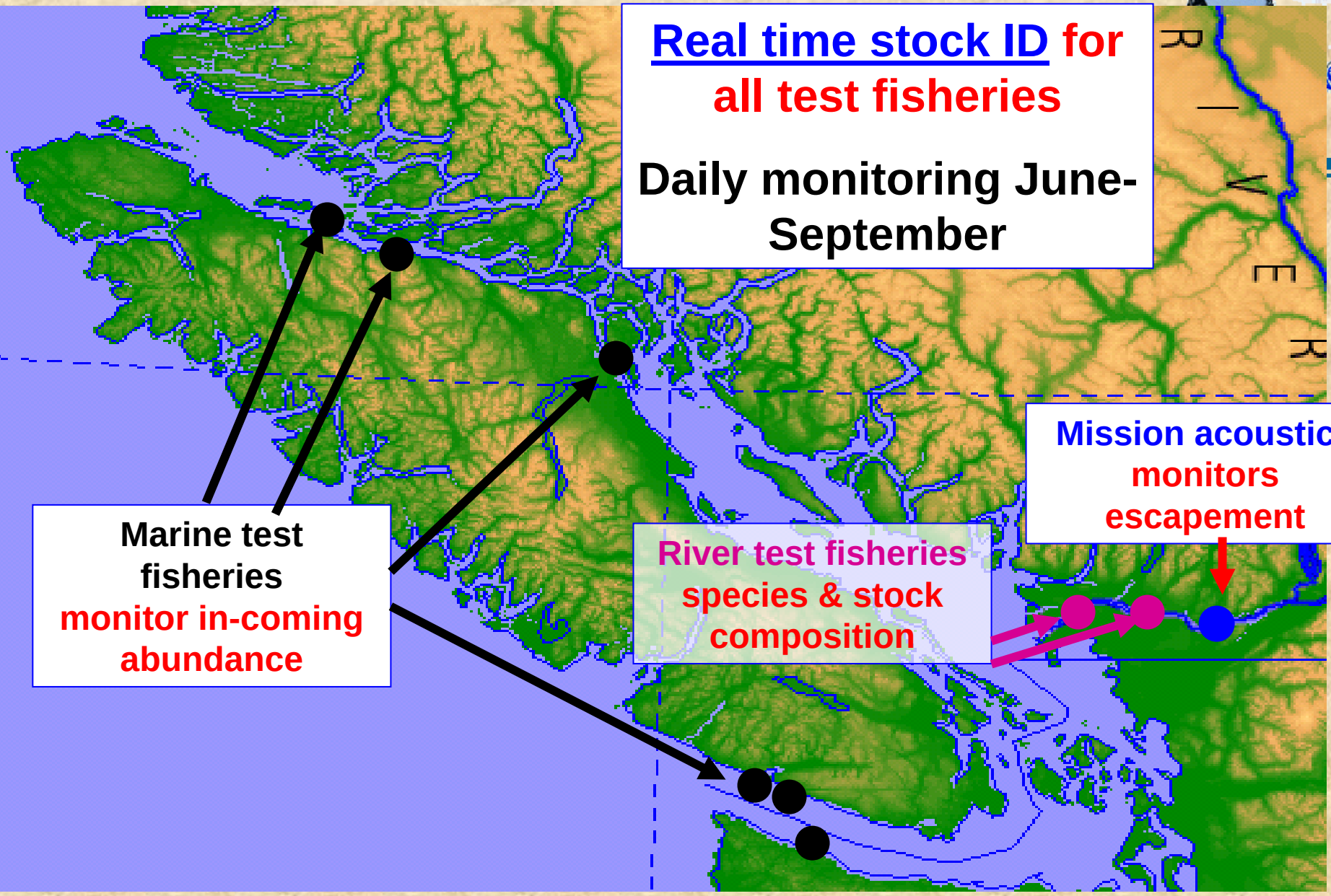
Used to initiate fisheries only

2. Assessment framework

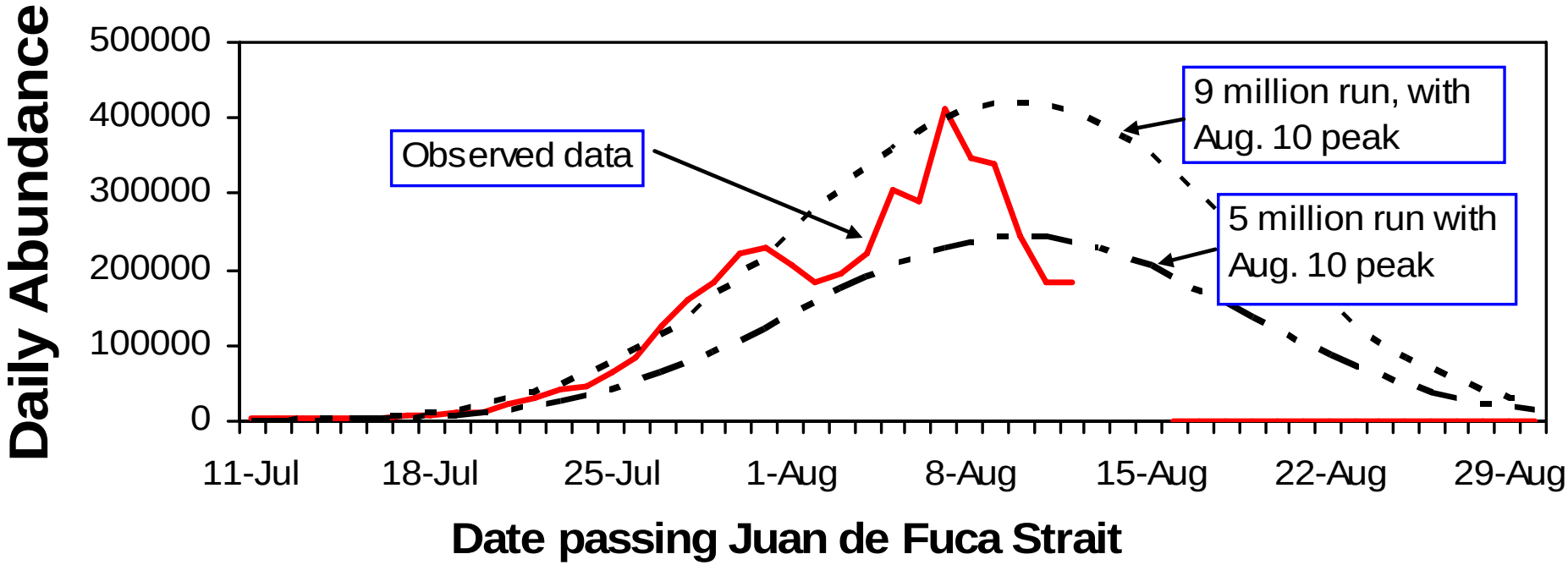
Pre-season expectations



Intra-seasonal Assessment



Intra-seasonal abundance and timing assessments

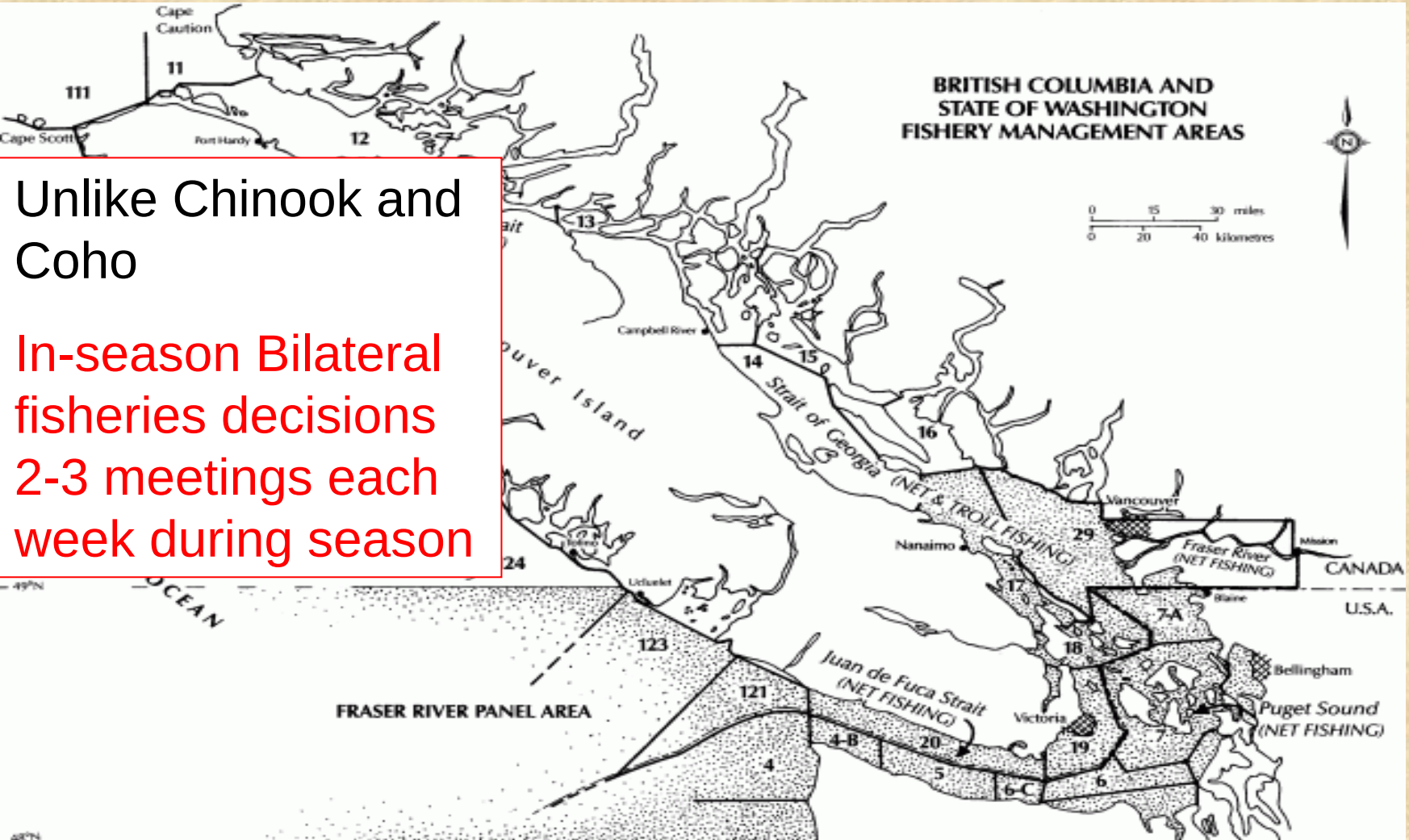


Assessments for each stock aggregate

Management Jurisdiction of Fraser River Panel

Unlike Chinook and Coho

In-season Bilateral fisheries decisions 2-3 meetings each week during season



3. Change for SPA (scale patterns) to GSI: Motivation

1. Decline in jack abundance

fewer jacks for baseline

2. Increased overlap in scale patterns among stocks

e.g. Chilko and Adams in 1999

3. More accuracy needed in future

e.g. Emphasis on single stocks

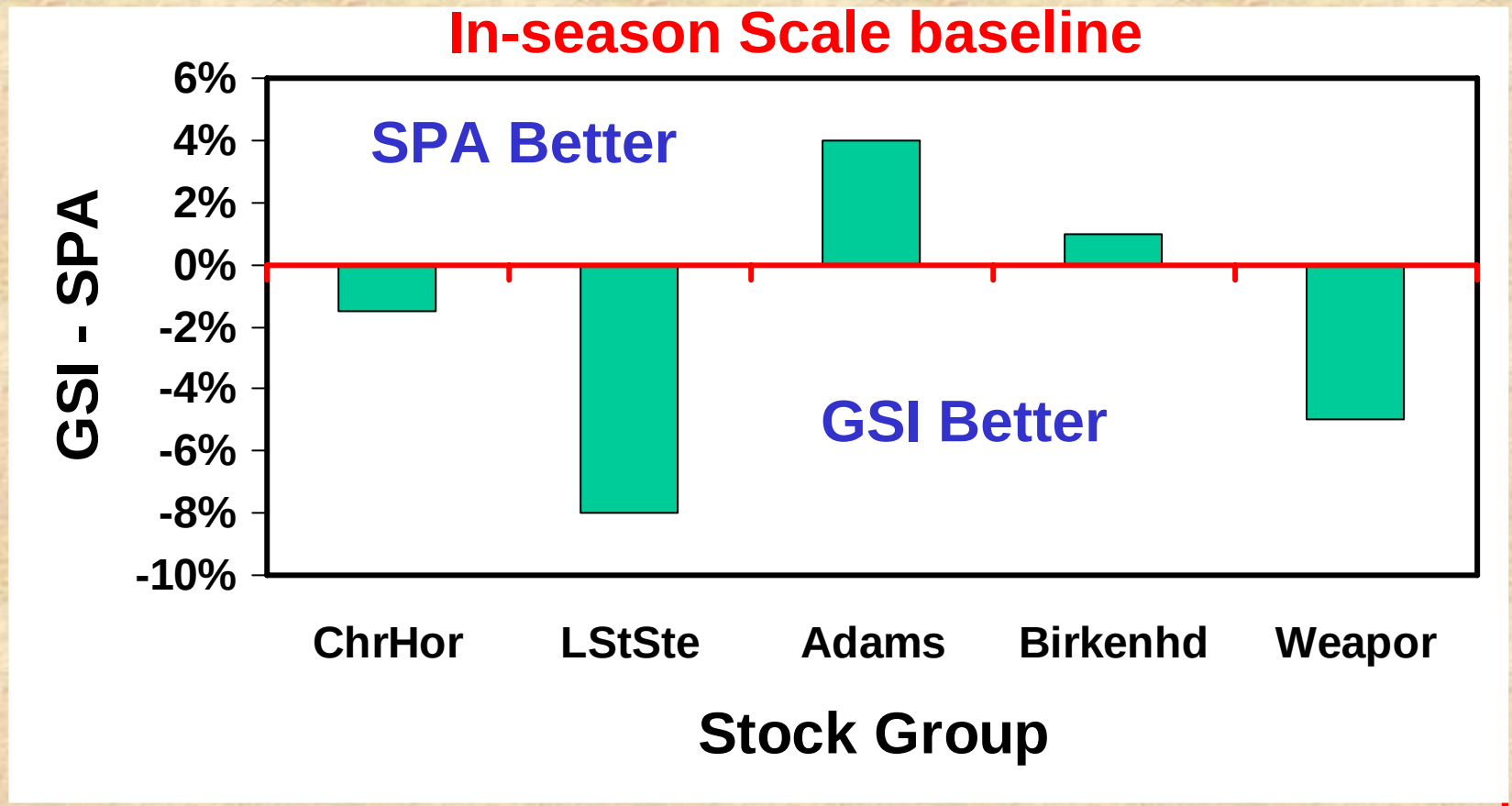
3. Change for SPA (scale patterns) to GSI: Early work

1. **Scored 1150 fish from 10 stocks at 6 microsatellite loci (1998 data)**

2. **5 “known unknown” mixtures. (n=200) (Accuracy)**

3. **Matching scale data (scales vs. GSI)**

GSI vs. SPA: Early results were not compelling



Logistics GSI vs. SPA:

GSI more costly & slower

Item	GSI (Microsatellite DNA)	SPA (Scales)
Cost	$30/fish for 6 markers	$0.60/fish for 4 scale variables
Processing time	M 24hrs/200fish	3.5hrs/200fish
Rebaseline	Infrequently	Annually

3. Change for SPA (scale patterns) to GSI: More power!!

Three factors eventually turned the tide in favor of GSI

1. **More markers (for 6 to15)**
2. **More complete baseline**

} Greatly improved accuracy

3. **Automated sequencer**

Increased throughput for in-season work

Addiction was inevitable!!!

4. GSI applications

Summary of Fraser sockeye genetic baseline

see Beacham et al. 2004 (TAFS 1117-1137); Beacham et al. 2004 (Cons.Gen. 411-416)

Markers

- **14 microsatellite loci and 1 MHC locus yielding 385 total alleles (8-47 per locus).**

Baseline samples

- **Approximately 17,000 sockeye from > 60 populations (7+ regions), from 14-16 stock groups, in four managed run-time groups.**

Variation statistics

- **F_{ST} = 0.064 (range 0.030 - 0.215), 0.3% of total variance among years within populations, 3.8% among populations within regions, 3.3% among regions.**

Individual stock ID from Baseline

- **Individual identification (via Geneclass): 60% to correct population, 79% to correct lake, 92% to correct region, and 90% to correct run-time.**

Summary of Fraser sockeye genetic baseline

see Beacham et al. 2004 (TAFS 1117-1137); Beacham et al. 2004 (Cons.Gen. 411-416)

Pure mixture results

- **SPAM pure simulations indicate ~ 90% accuracy to population and ~ 97% accuracy to stock group (high variance among populations).**

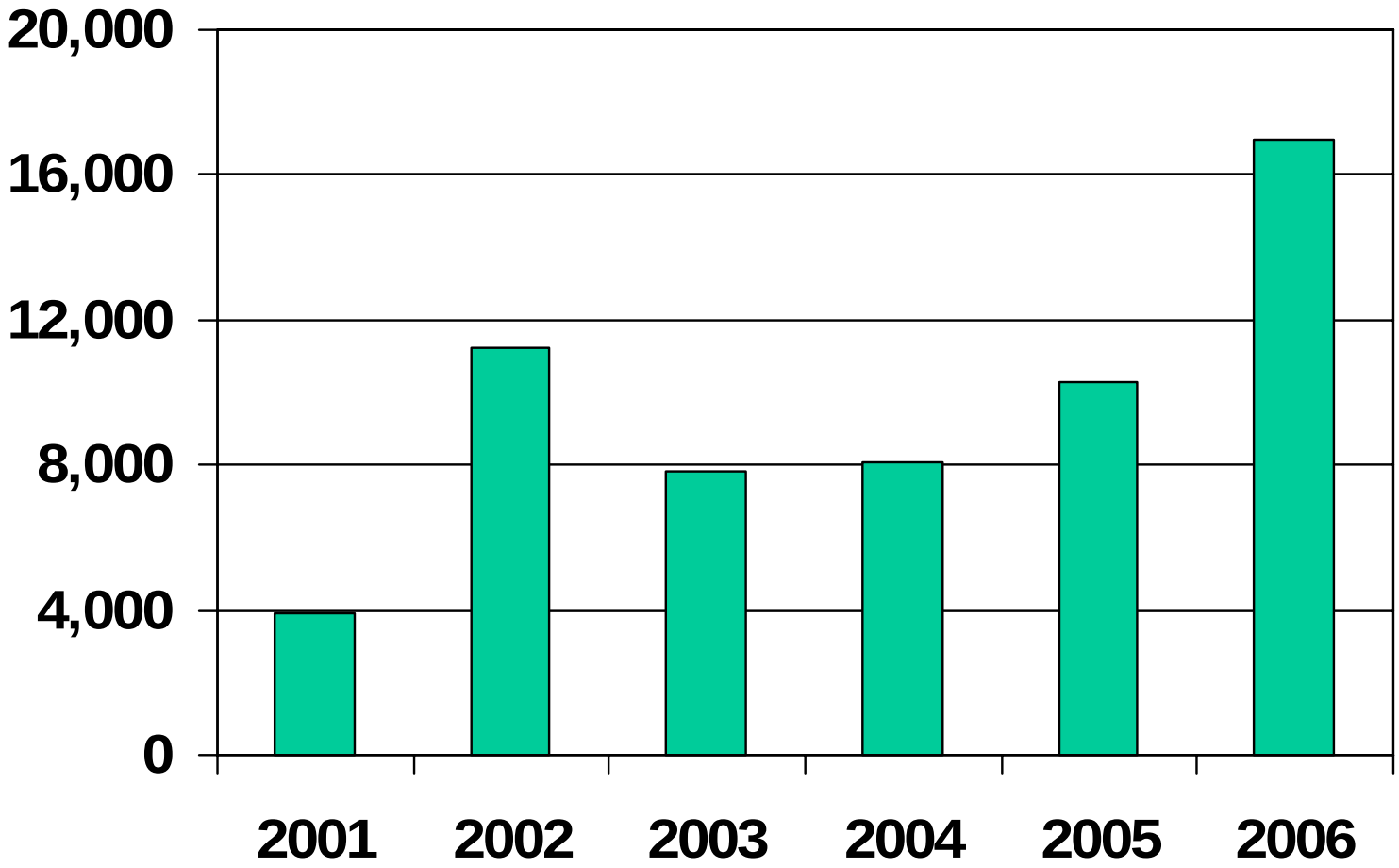
Processing time

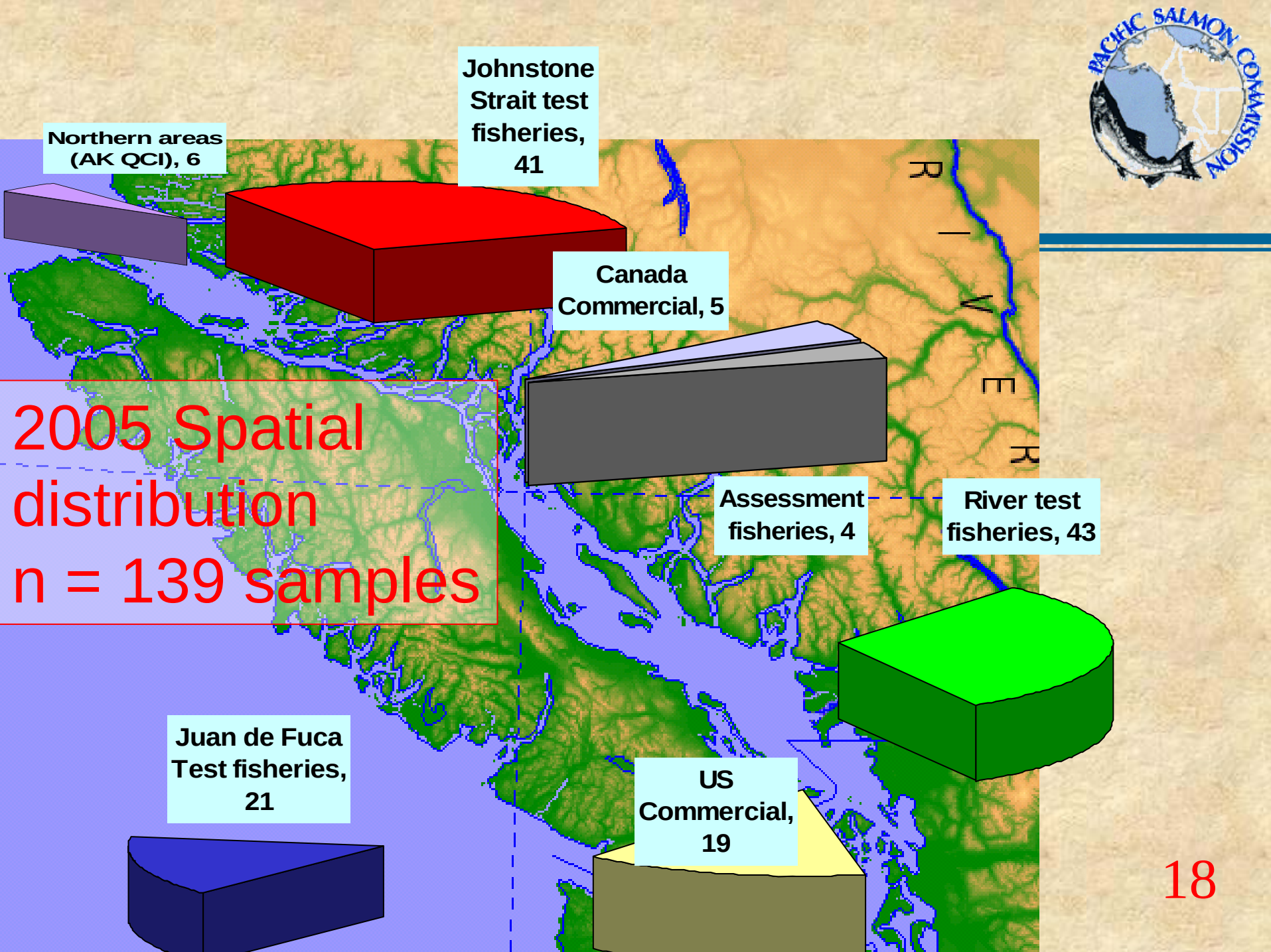
- **Most estimates ready within 24 – 72 hours of catch (MHC often requires > 1 day). Express service 12 hrs!!!**

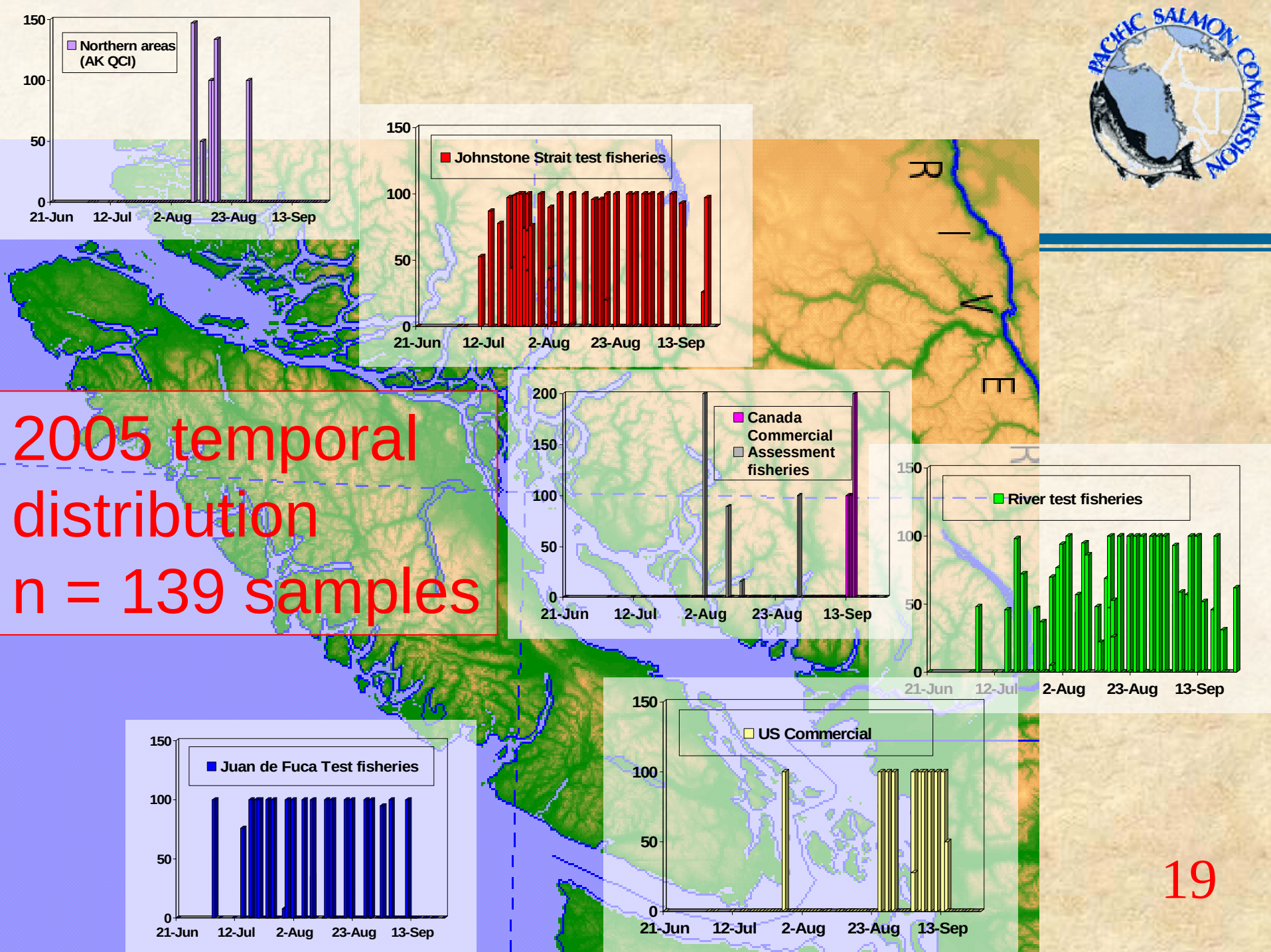
Analysis approach

- **Unbinned allelic genotypes are processed in SPAM with Rannala-Mountain assumptions.**

Total numbers of sockeye analyzed for mixtures since 2001:

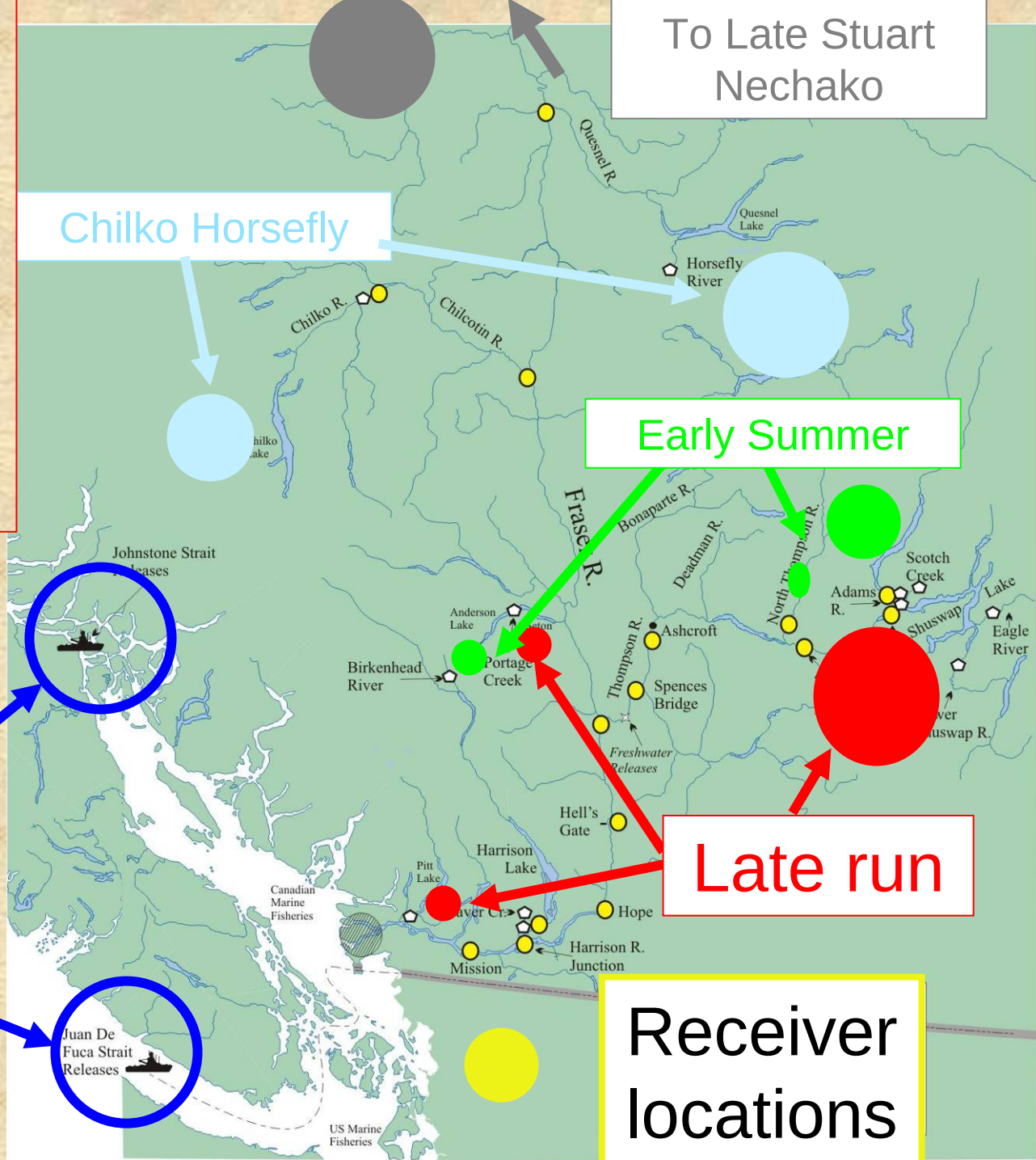



Johnstone Strait test fisheries, 41
Northern areas (AK QCI), 6
Canada Commercial, 5
2005 Spatial distribution
n = 139 samples
Assessment fisheries, 4
River test fisheries, 43
Juan de Fuca Test fisheries, 21
US Commercial, 19
RIVER

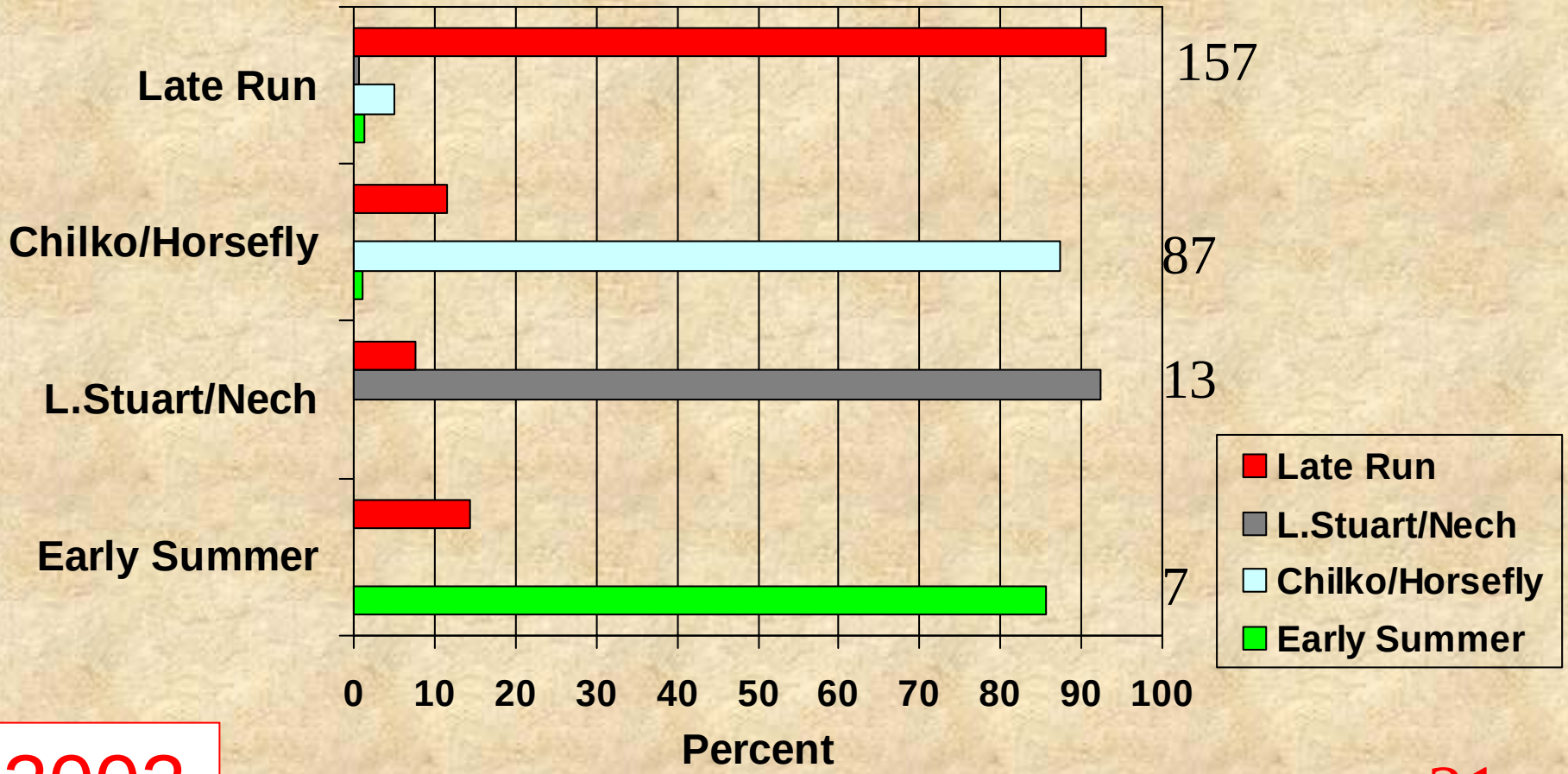

Northern areas (AK QCI)
150
100
50
0
21-Jun
12-Jul
2-Aug
23-Aug
13-Sep
Johnstone Strait test fisheries
Canada Commercial Assessment fisheries
200
River test fisheries
US Commercial
Juan de Fuca Test fisheries
2005 temporal distribution
n = 139 samples
PACIFIC SALMON COMMISSION

4. GSI applications

Individual ID with radio telemetry



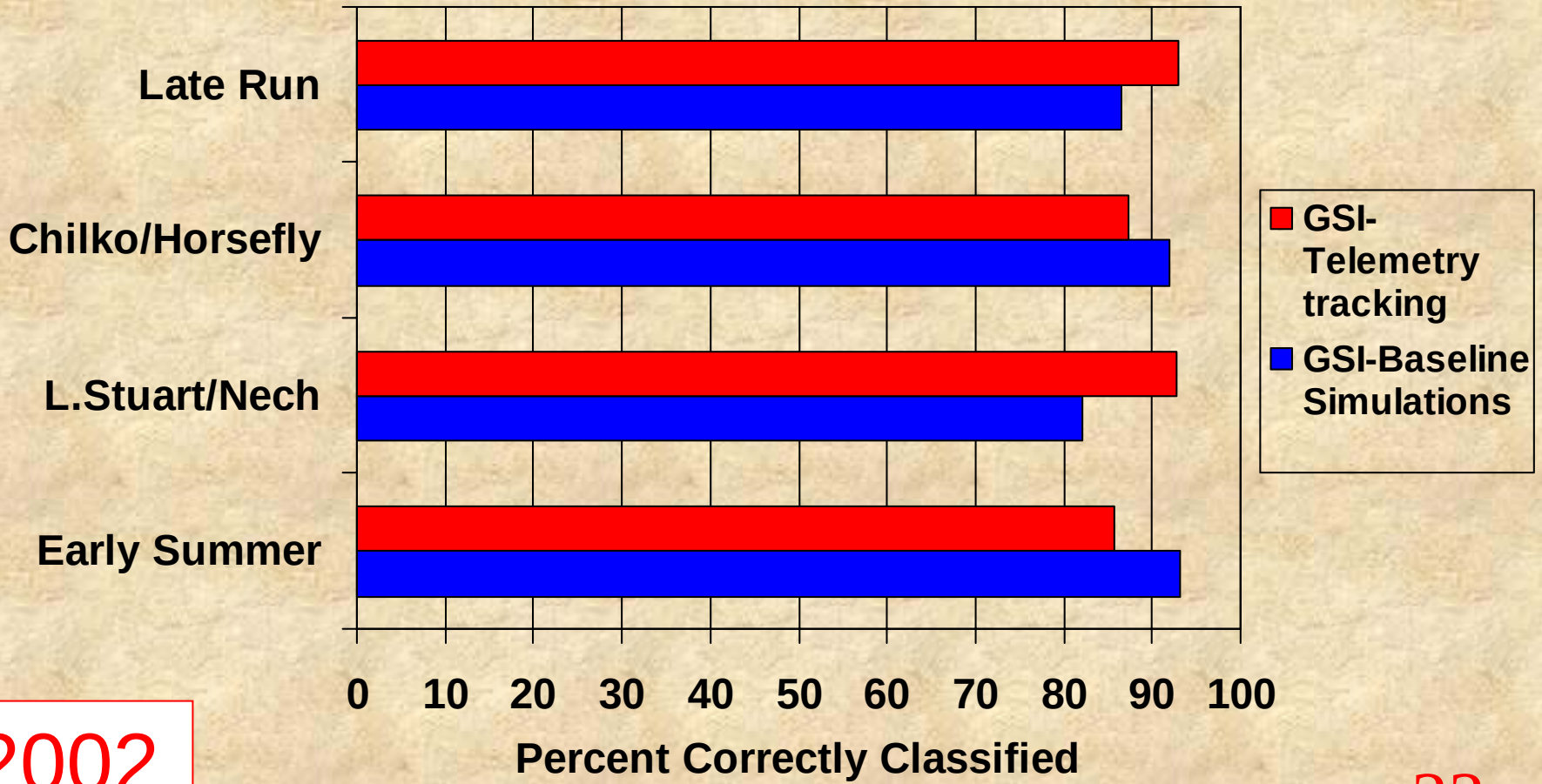
GSI Classification Accuracy
(by stock group)
- using radio-telemetry data (n=264)



2002

English et al. 2005

DNA Classification Accuracy - Telemetry and Baseline Results



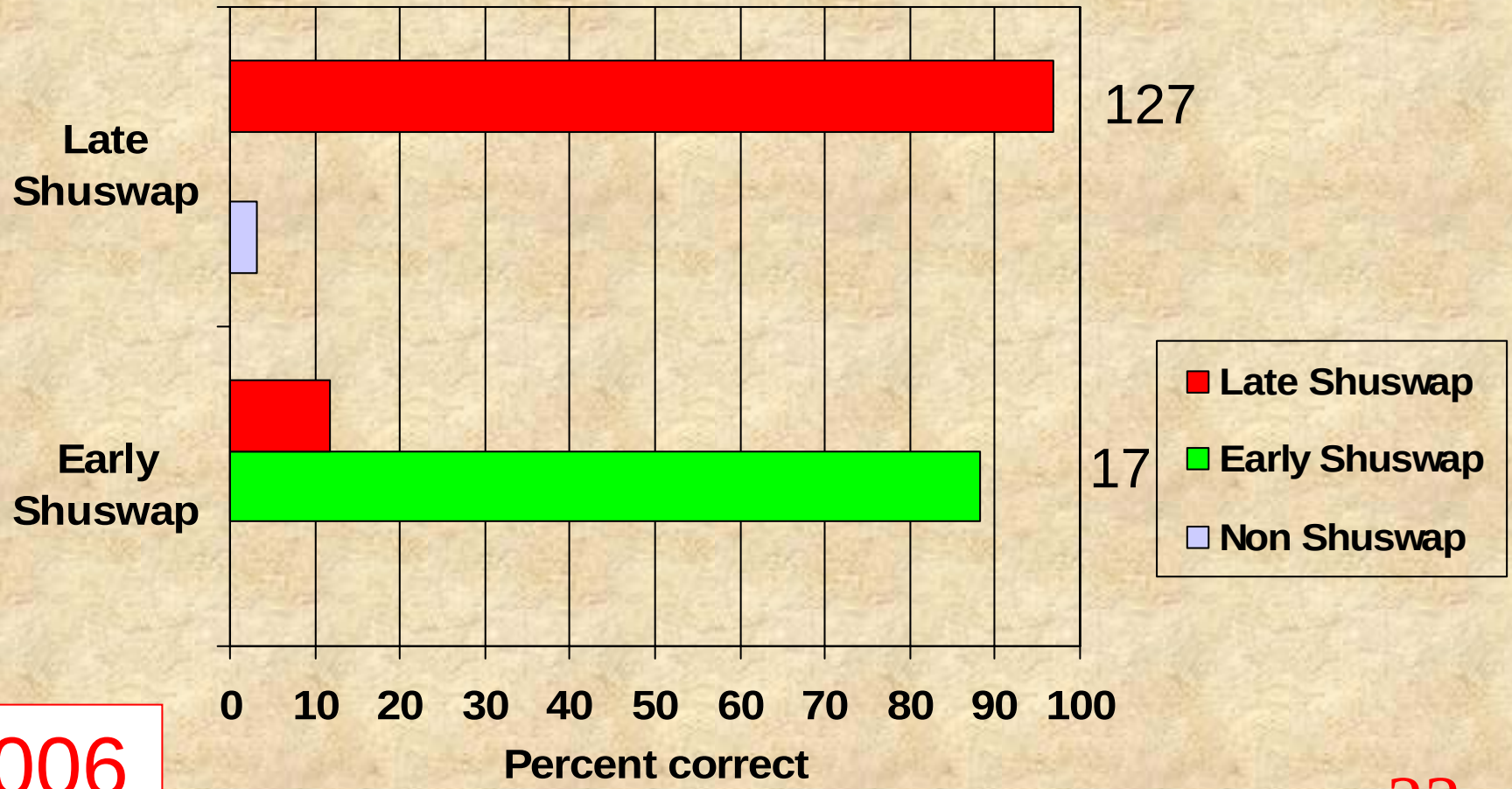
2002

English et al. 2005

GSI Classification Accuracy

timing groups in Shuswap Lake

- using radio-telemetry data (n=144)



2006

4. GSI applications:

"Known-Unknown"

mixture analysis with n = 275

2002

Stock group	Telemetry location	GSI mixture proportions	Absolute difference
Early Summer	2.2 %	3.0 %	0.8 %
Late Stuart / Stellako	5.1 %	5.0 %	0.1 %
Chilko / Horsefly	30.2 %	31.7 %	1.5 %
Late Shuswap / Portage	55.6 %	52.9 %	2.7 %
Other Lates	4.4 %	5.5 %	1.1 %
Birkenhead	2.5 %	1.9 %	0.6 %

4. GSI applications: Weak stock management

Cultus Lake sockeye

- Cultus sockeye were assessed and recommended for listing under Canada's Species at Risk acting in fall 2002.
- Government chose not to legally list, but instead committed to actions to help stock recover.
- Since 2004 total exploitation rate limits as low as 11% have been imposed.
- Mixed stock constraints have resulted in large foregone catches

4. GSI applications: Weak stock management

Cultus Lake sockeye

- **Cultus sockeye are part of small number of lower Fraser populations which are very distinct genetically from populations elsewhere in drainage.**
- **Individual classification accuracy was estimated at 96% (Beacham et al. 2004)**

GSI to the rescue!!!

4. GSI applications: Weak stock management

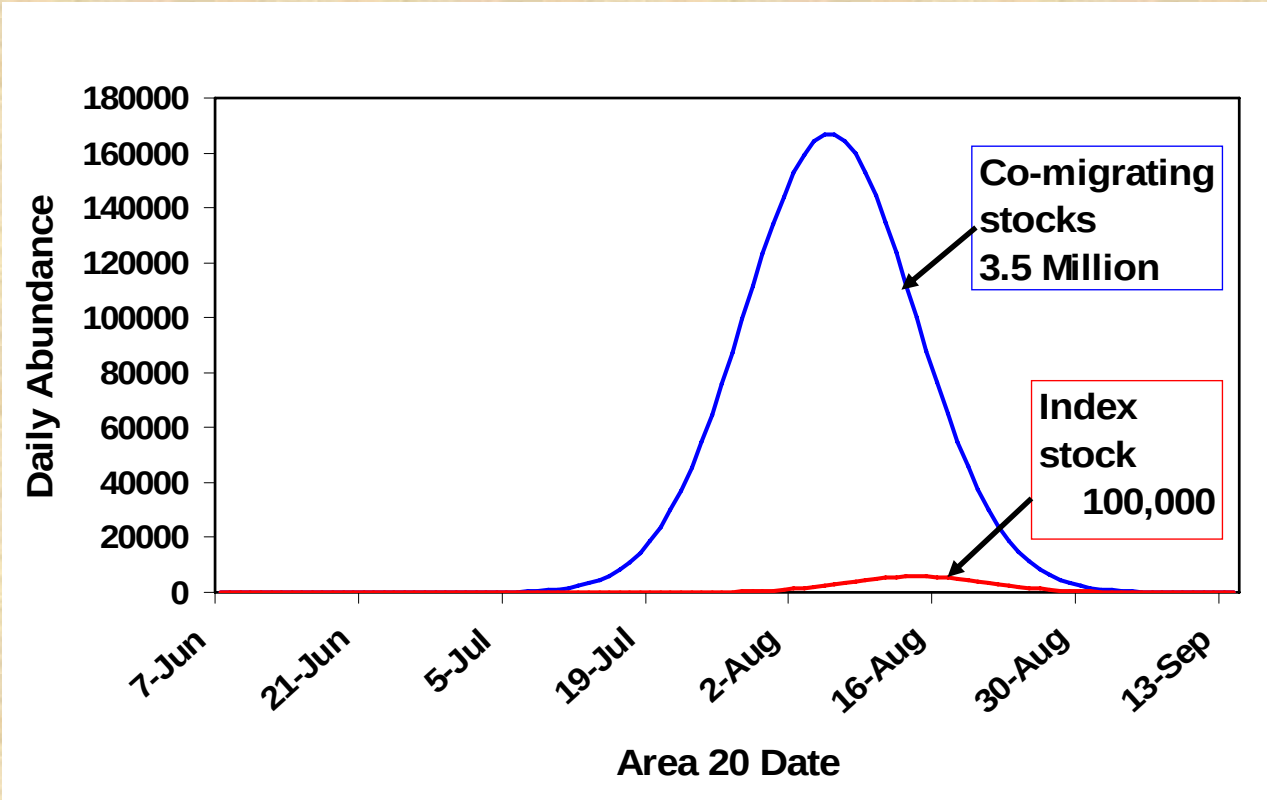
Cultus Lake sockeye

GSI to the rescue? … Whoa!!!

Year	Cultus forecast	Co-migrating stocks
2004	<500	3,500,000
2005	<500	11,000,000

2004 Management plan

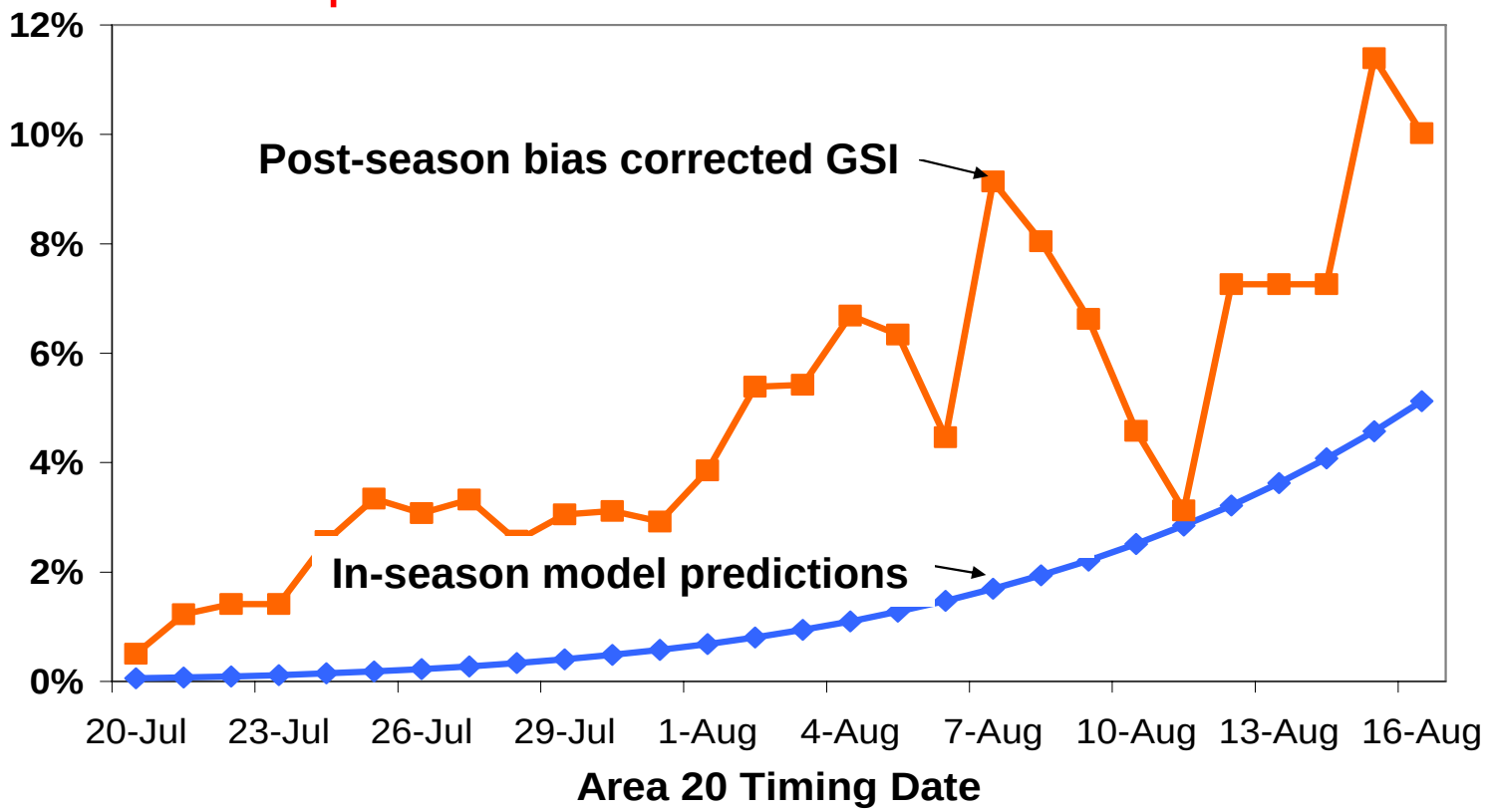
Considered an index stock, but eventually Abandoned GSI and Used the model expectations with updated in-season abundance and timing



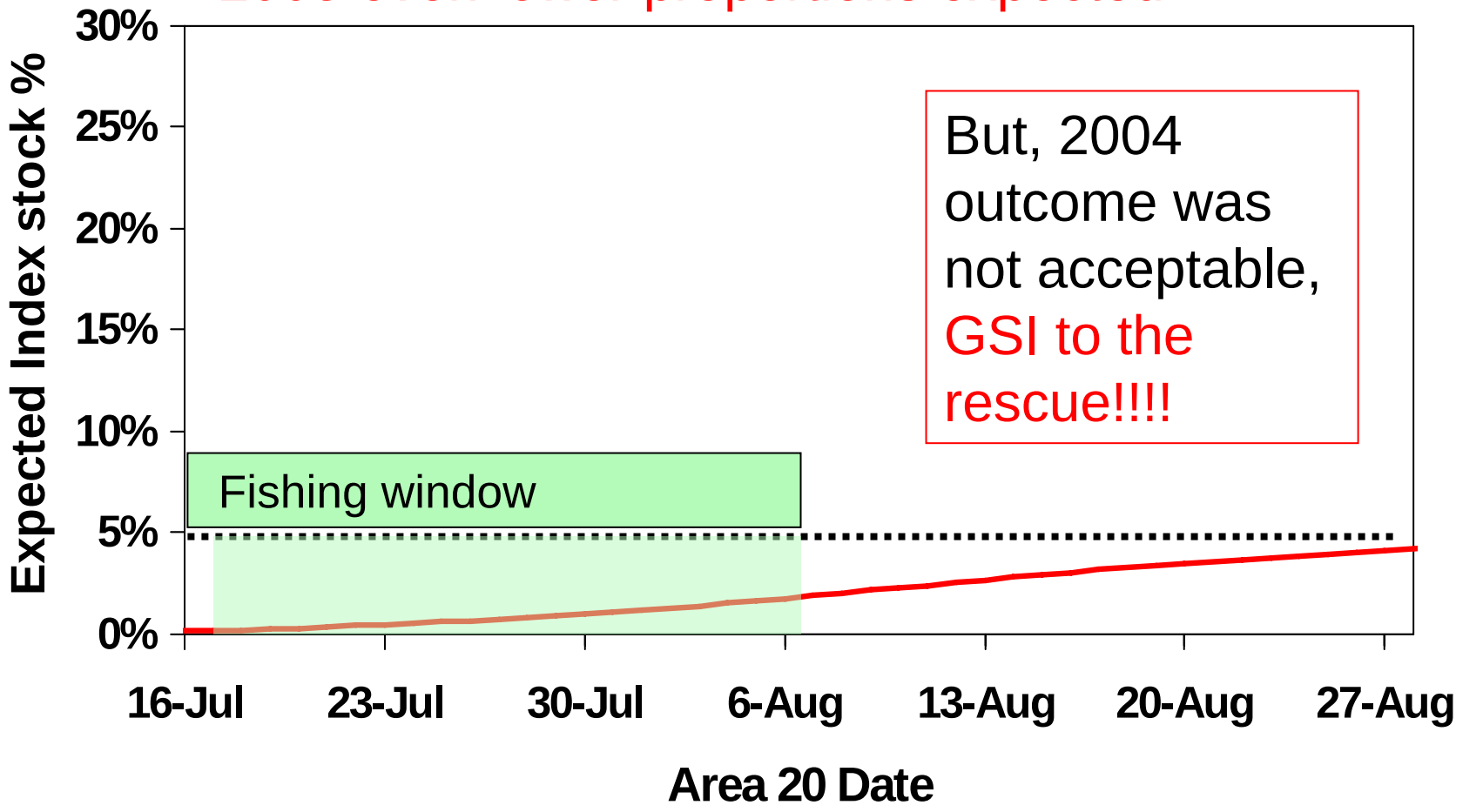
2004 Outcome

Exploitation rate limit = 11%

Exploitation rate estimate = 30%!

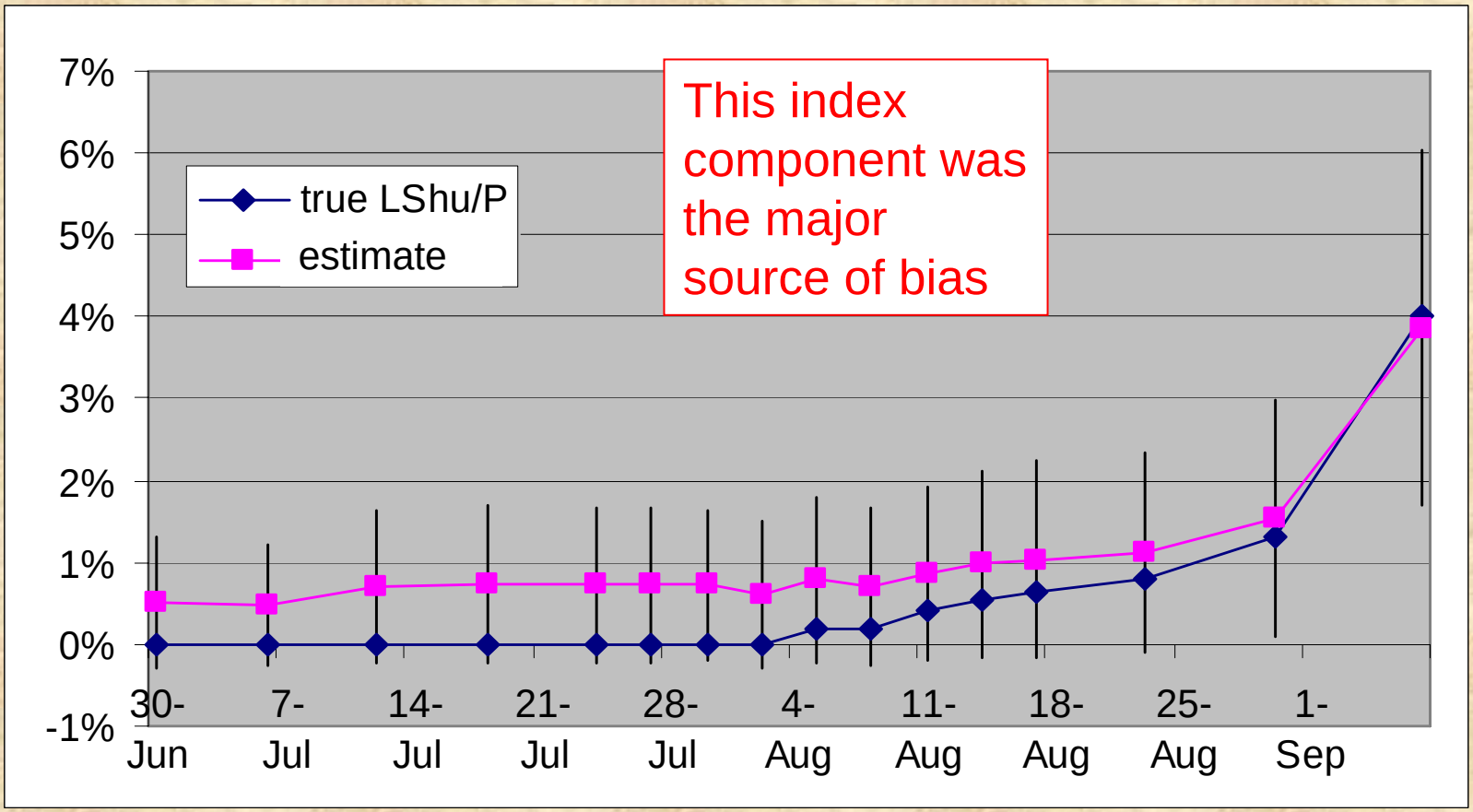


4. GSI applications: Weak stock management



4. GSI applications: Weak stock management

Bias varied among index stock components



4. GSI applications: Weak stock management

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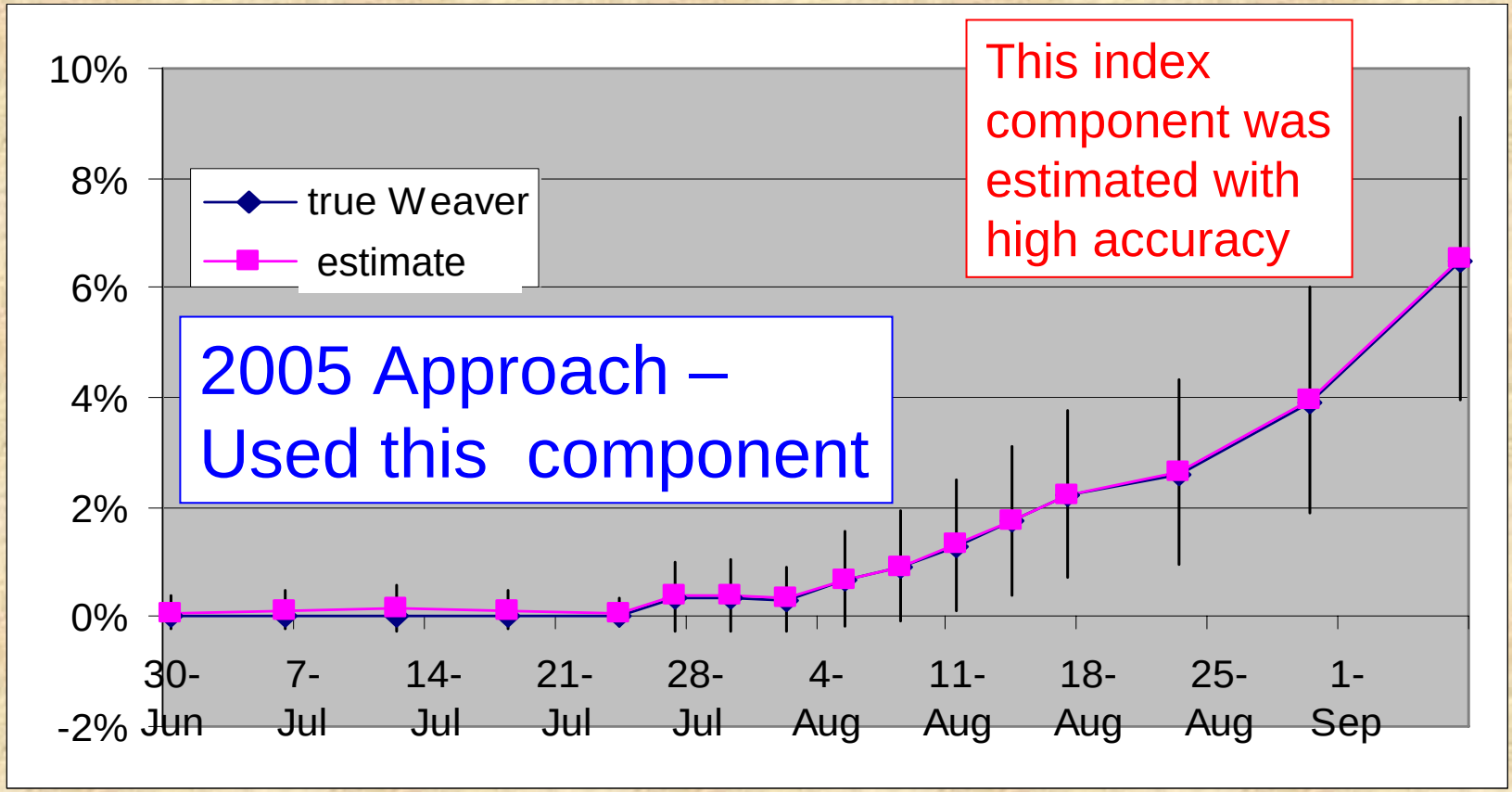
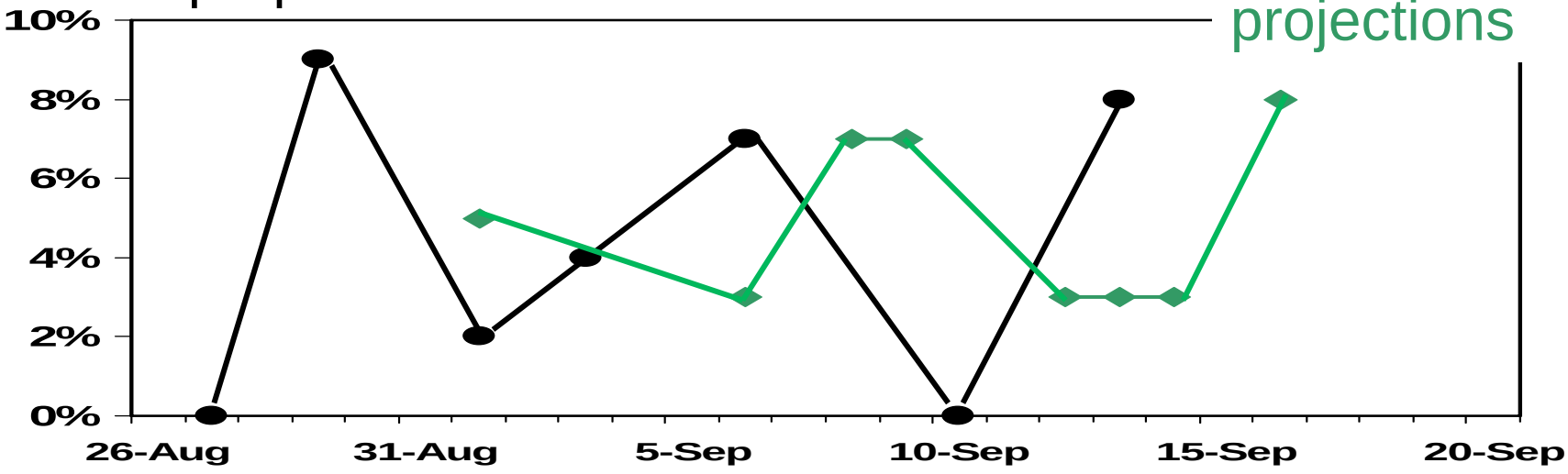
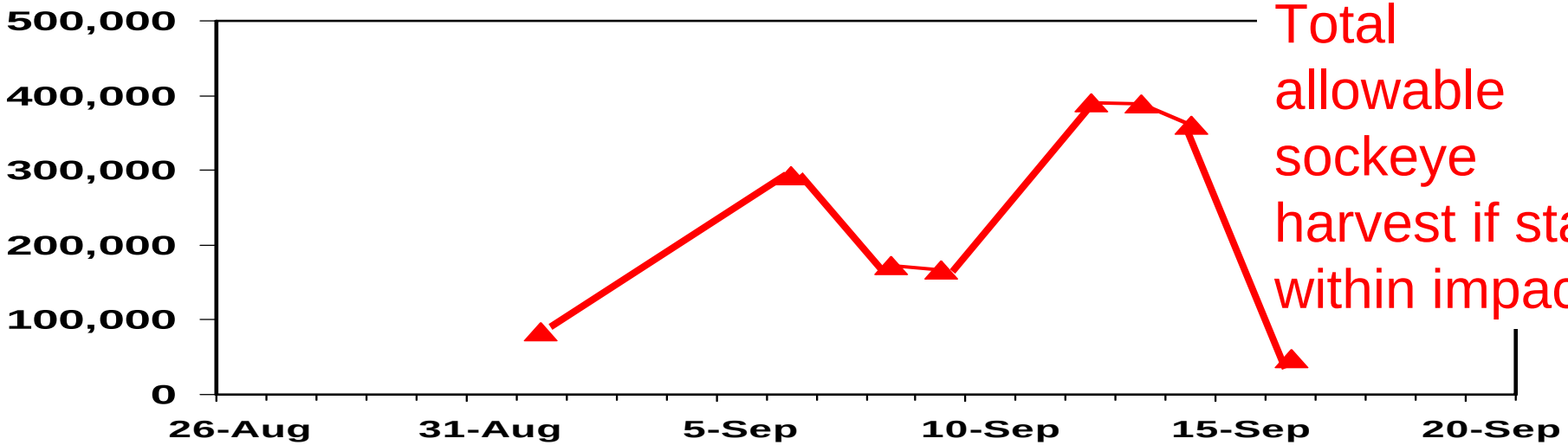


Time sequence of events 2005

Index stock proportions

Index stock projections





Total allowable sockeye harvest if stay within impacts

2005 Outcome

- **Variability in GSI results did not create conservation problem in 2005. We stayed within the exploitation rate impacts (10% vs. 11%) GSI to the rescue!!!**

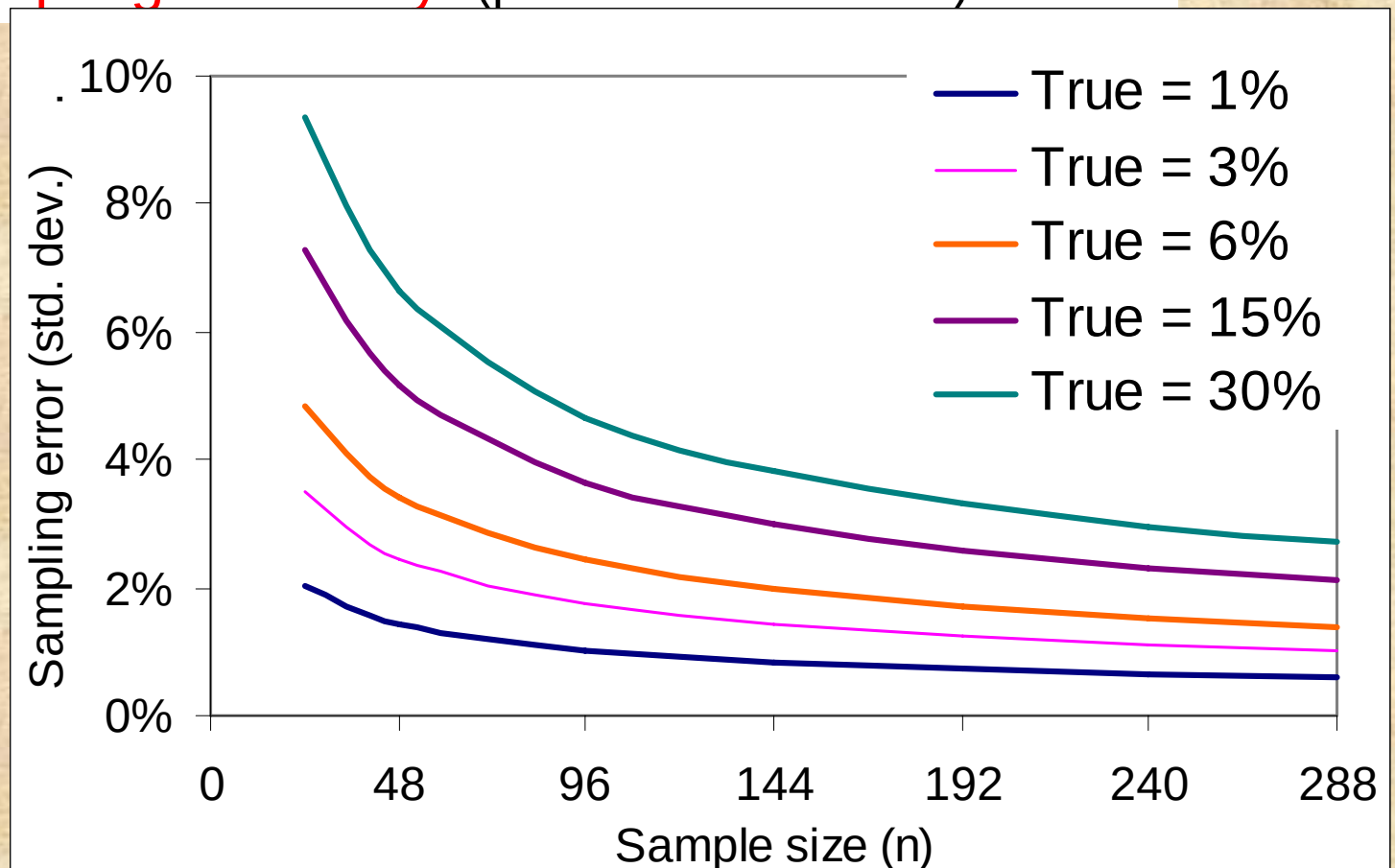
  but …

- **The very limited fishery that occurred (Sept. 14) resulted in a total Canadian Commercial catch of only 130,000 fish.**
- **Fishermen blamed variability in GSI results for missed harvest opportunities.**

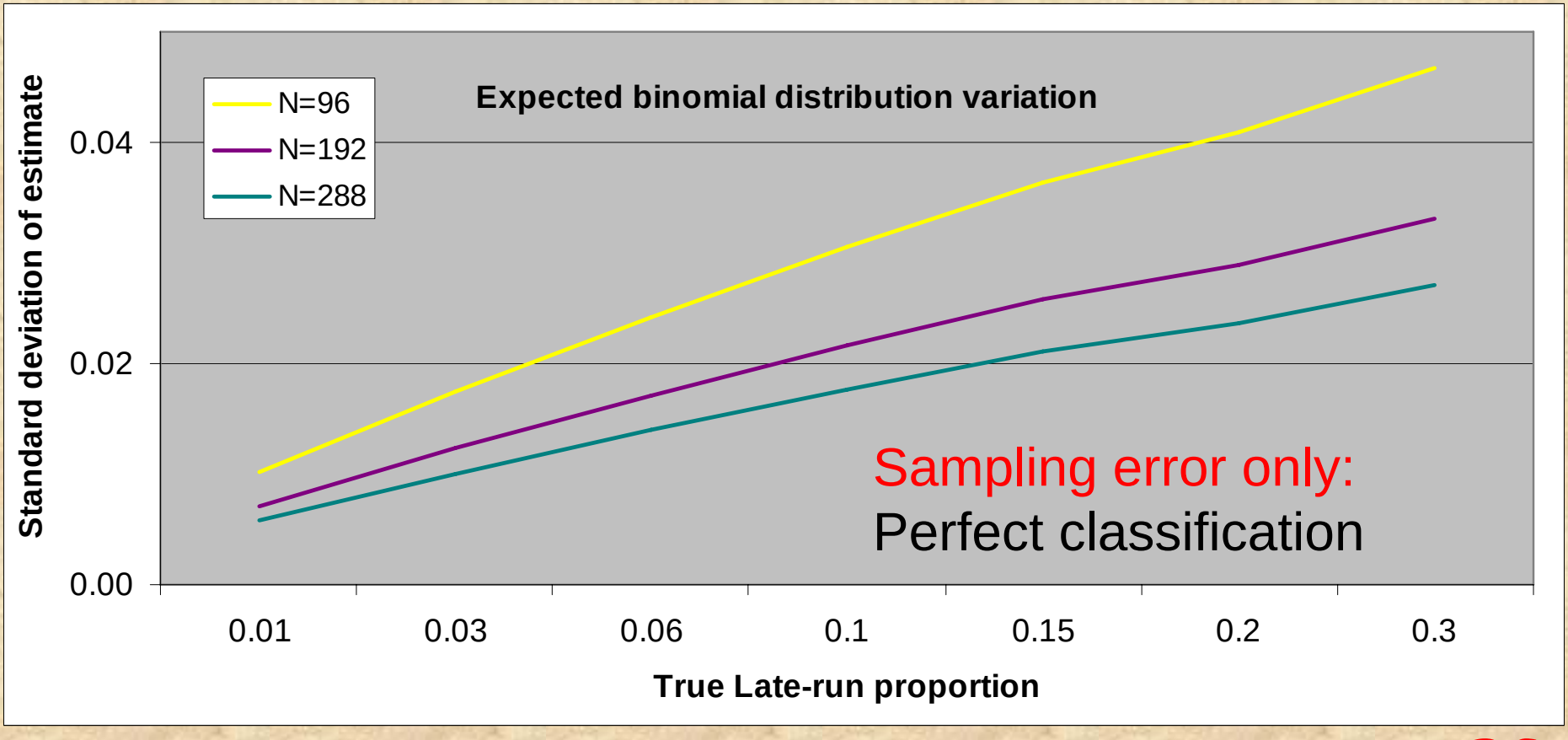
4. GSI applications:
Inter-sample variation

Components of Variation

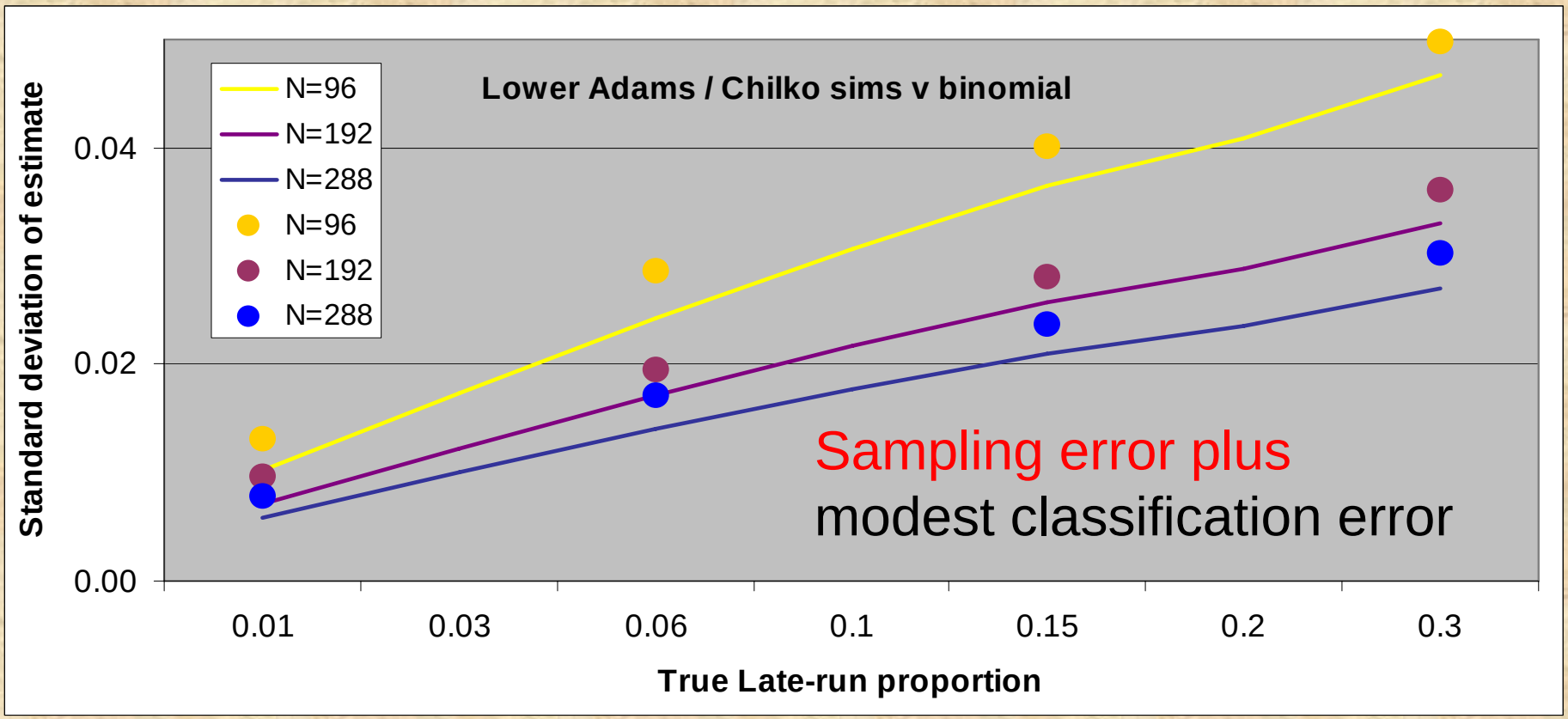
Sampling error only (perfect classification)



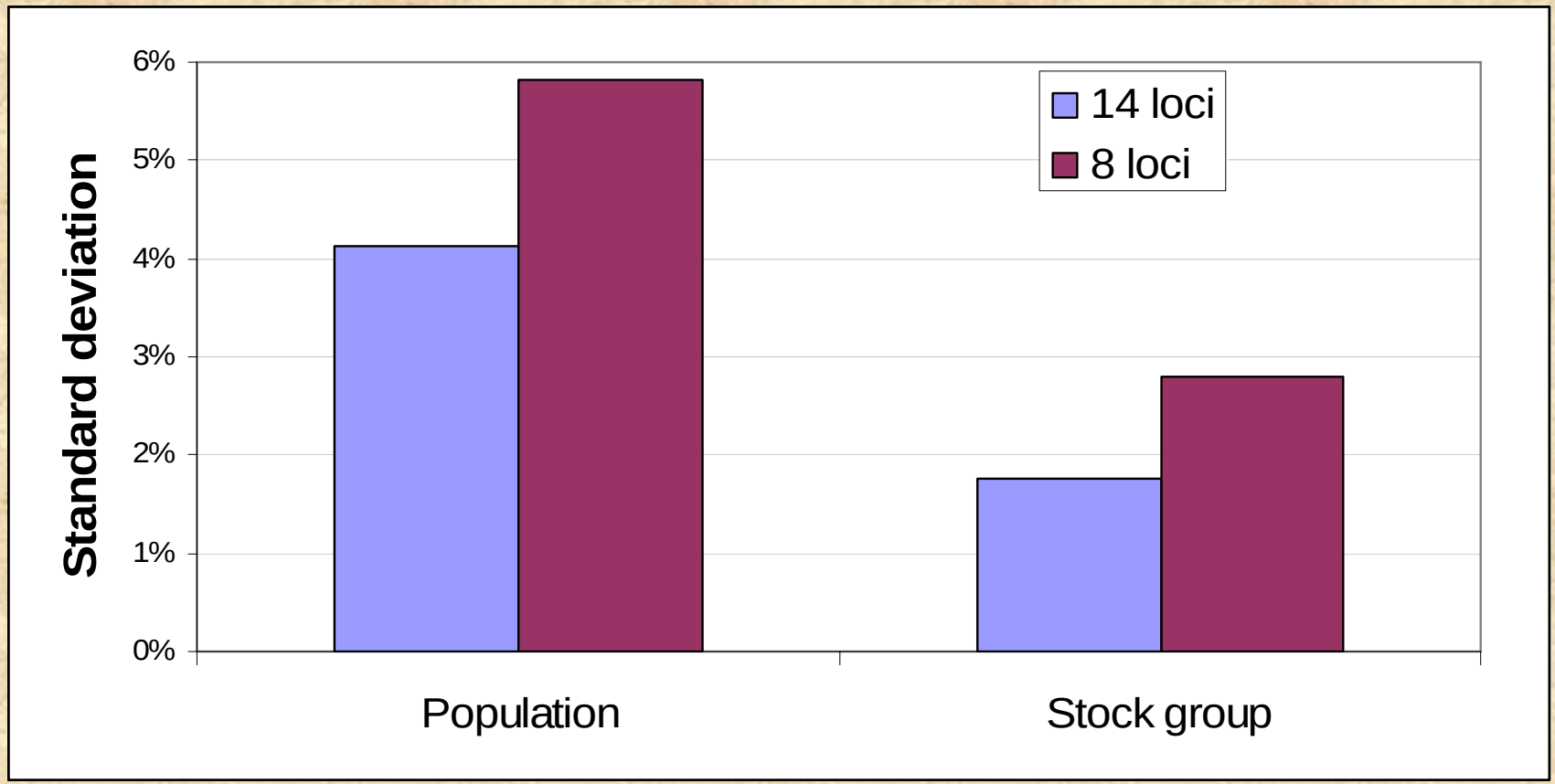
Sampling error only



Sampling error & classification error Two stocks

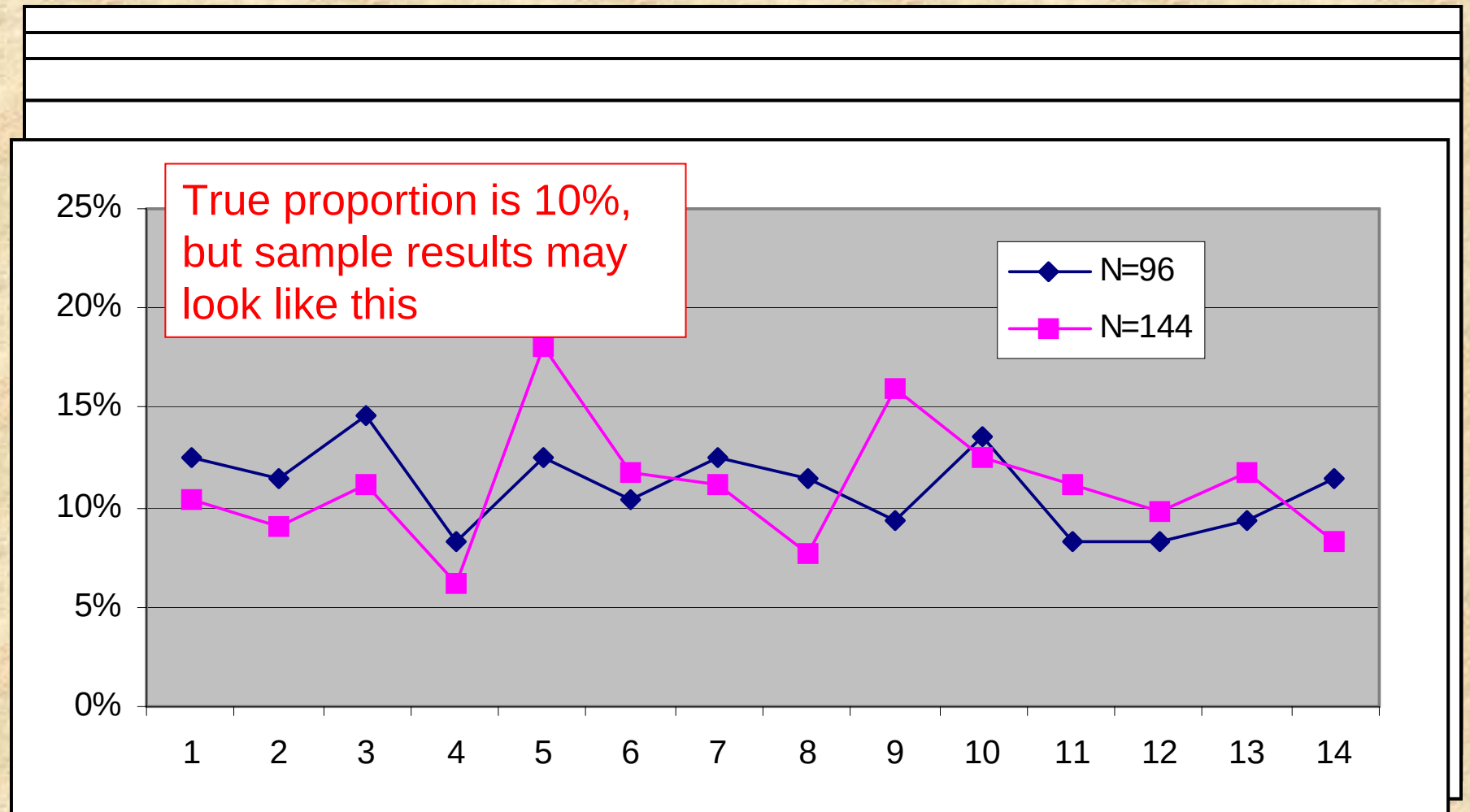


Effects of number of markers and stock aggregation on variability

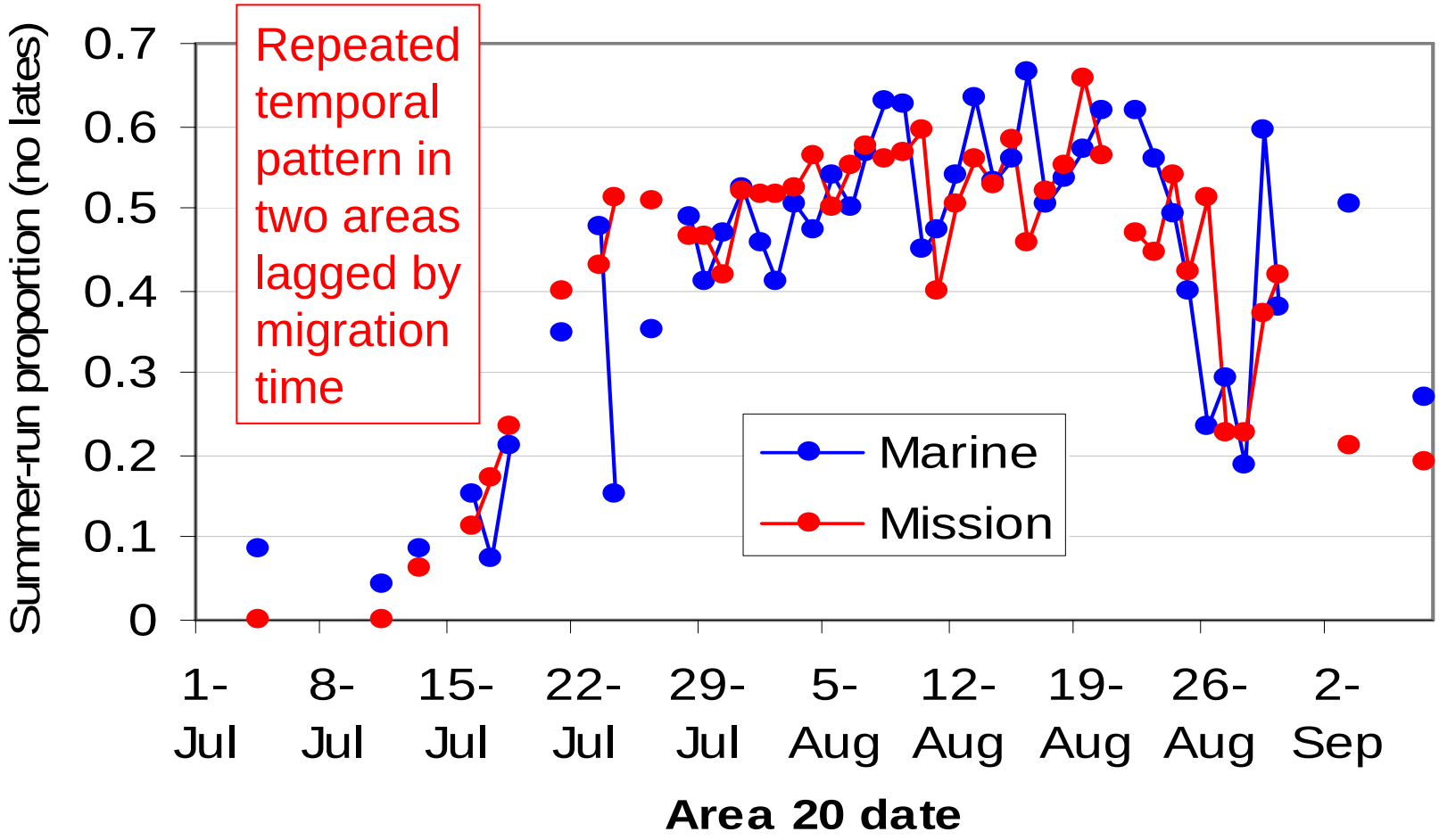


Differences are due to Classification error effects not sampling error effects

Implications of inter-sample variation (sampling error only)

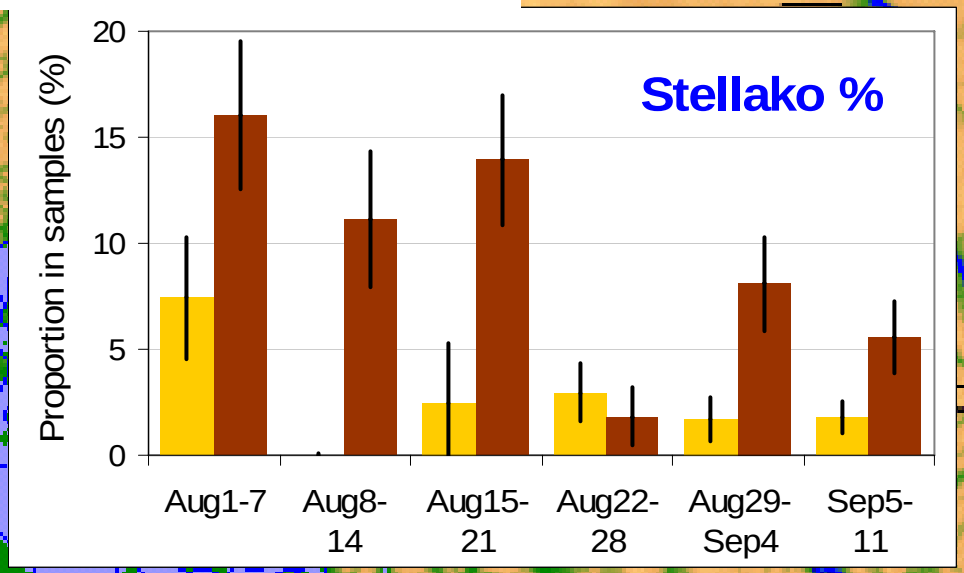


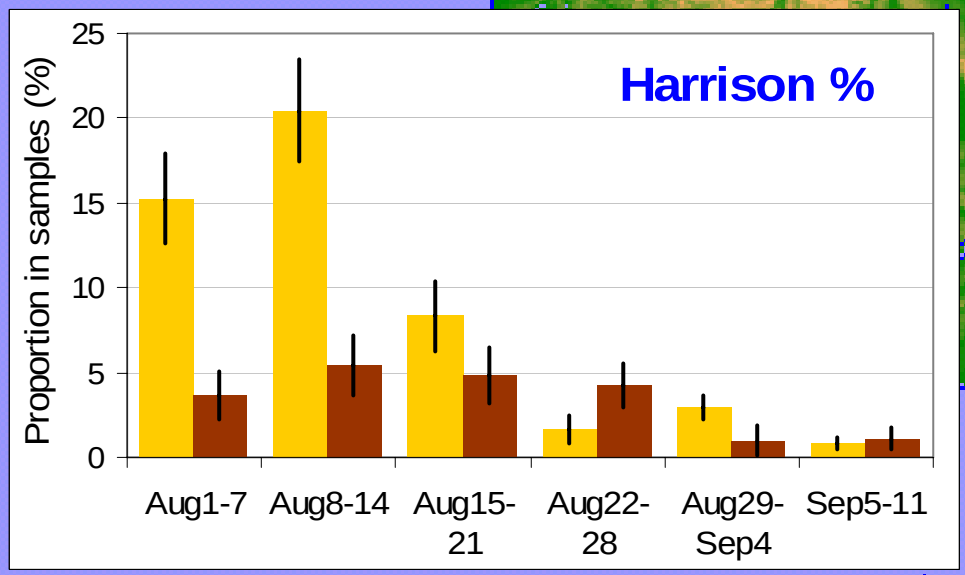
Some inter-variation is likely related to fish behavior



Other sources of Inter-sample variation – Opportunities for GSI application??

Variation in migration route among stocks and over time





5. Advice from “The Street”

1. **Application of GSI should be evaluated in the context of the assessment and management system around it.**

- **Is stock ID the weak link in the assessment?(or forecasts?, aging?)**
- **Can the management system respond to intra-seasonal changes in stock ID?**

5. Advice from “The Street”

2. The first step in implementing a new method (GSI) is comparing it to the current methods (SPA, CWT) for relevant applications.

- **Is it more accurate and cost effective in providing the same information?**
- **Can it provide other useful information?**
- **Are there other alternatives worth exploring?**

5. Advice from "The Street"

3. **Implementation of GSI for weak stock management may be sensitive to spatial and temporal variation (sampling, behavior, etc.) in addition to accuracy.**

- **How will/should the management system react/adapt to this variation?**
- **Are weak stocks estimable within sample size constraints$$? If not, does GSI provide opportunities for identifying better index stocks?**
- **What level of accuracy is required? (not just statistics and GSI but also risk tolerance for outcomes)**

5. Advice from “The Street”

4. We manage people not fish.

- **Intra-seasonal management provides opportunities to react to changes in the fish that were not expected pre-season, but from a fishermen’s perspective this makes the season is a lot less predictable than under an annual management cycle.**
- **More information isn’t always a good thing.**
- **What steps need to be taken to assure “buy-in” by people who will be affected by implementation of GSI methods?**

Acknowledgements

PSC staff

- **Steve Latham** (my personal dealer!!)
- **Bruce White** (soon to be supplying Pink GSI)

The Scale lab

Maxine Reichardt,Jullie Sellers,Holly Anozie (got me hooked on "soft" stock ID)

The Parties (for supporting my GSI habit!)

DFO/PBS staff

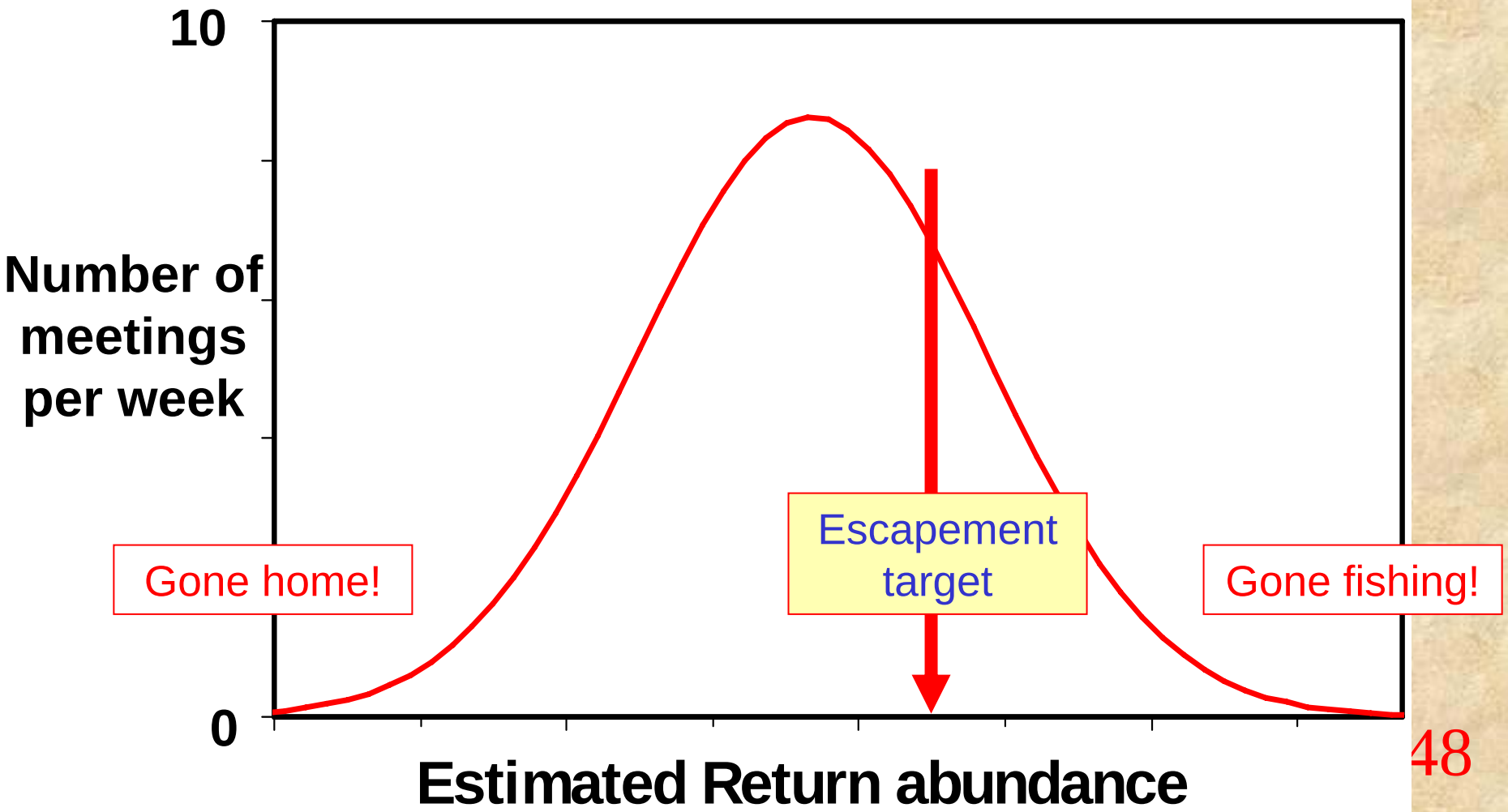
- **Terry Beacham** (personally responsible for my addiction)
- **John Candy and Colin Wallace** (in-season analysts unsympathetic to GSI induced side effects!)

PBS Genetics Lab

Brenda McIntosh, Kris Gordos, Cathy MacConnachie, and Amy Tabata ("on demand" suppliers)

The End

Fraser Panel
Meeting schedule model



4. GSI applications: Individual classification GSI Magic!!

- **Take a fish caught in the ocean**
- **Take a small snippet of tissue**
- **Use GSI to predict where it will spawn**
- **Insert radio tag at Tab A**
- **Release fish and track it to the spawning grounds**

How well did the GSI do??

2005 Approach

1. **Used most accurate index component stocks to track impacts.**

2. **Increase sample sizes to improve precision for large catch fisheries.**