Estimating Abundance of Juvenile Steelhead in Presence of Coastal Cutthroat and Steelhead-Cutthroat Hybrids:

A Two-Phase Bayes Approach

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BASIC IDEA

- Collect large *first-phase* sample from population and make visual assessments of species IDs (ST, CT, HY) – *large sample, but not unbiased*
- Take a *second phase* subsample of the first phase sample (= second-phase) and use genetic methods to generate definitive species IDs –
  Small sample, but unbiased and "exact".

BASIC IDEA (continued)

- Use "correlation" between visual and genetic species IDs in second phase sample to adjust the first phase observations – *gives approximately unbiased estimate of proportion of ST.*
- ST Abundance = Abundance of "Trout" (from Hankin-Reeves type survey) x proportion of ST

Accuracy of Visual IDs (Baumsteiger, Voight)

- Collect juvenile "trout" samples (3 streams – Baumsteiger; 2 streams, many tribs - Voight) and make visual IDs.
- Use 7 nuclear markers + 1 mtDNA marker to determine true species (ST, CT, HY) IDs of samples and to quantify visual classification accuracy.

Collections of Juvenile "Trout"

- Baumsteiger: Haphazard Collection of Trout (100-200 fin clips per stream, 2 size categories) from 3 Streams:
  - Little River (drains directly to ocean);
  - Maple Creek (tributary of Big Lagoon);
  - Ah Pah Creek (tributary to lower Klamath R.)

Collections of Juvenile “Trout”

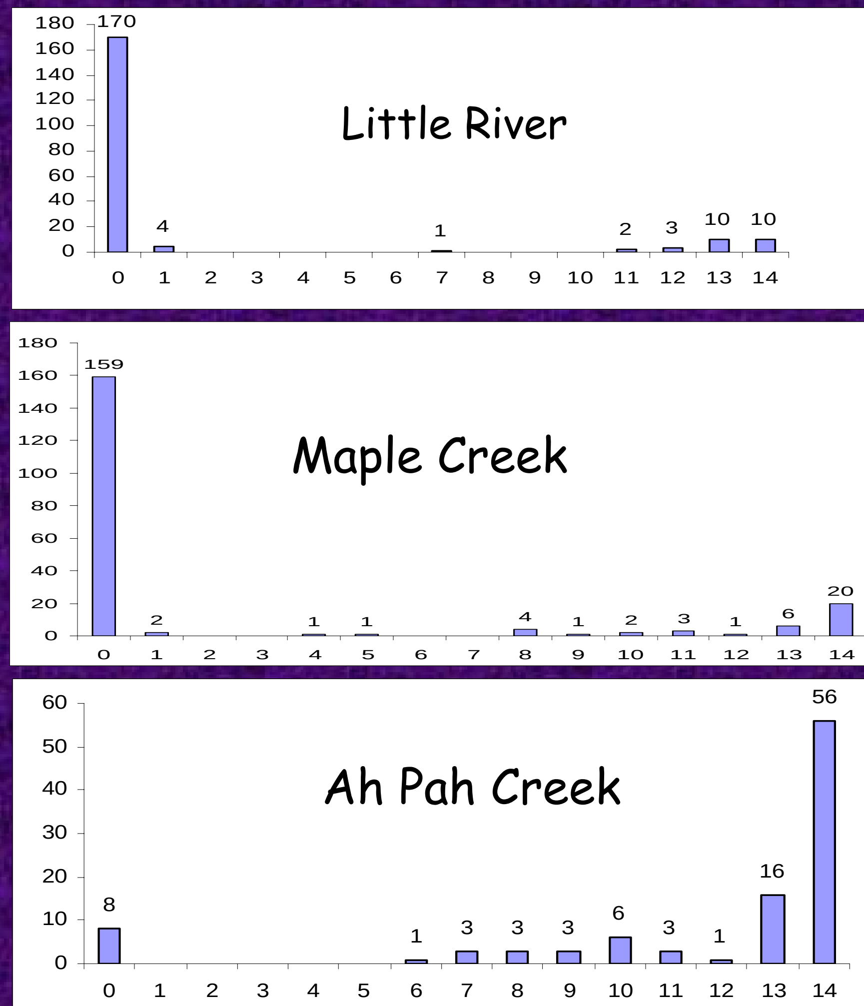
- Voight: Randomized Collection of Trout during full-stream abundance surveys (188-362 fin clips per stream, 2 size categories) from 2 Streams:
  - Freshwater Creek & tributaries (enters Humboldt Bay);
  - McGarvey Creek (tributary to lower Klamath R.)

Genetic Analysis Results (Baumsteiger & Voight)

- F1 Hybrids Rare, but apparently viable
- Substantial Evidence of Preferential Backcrossing of Hybrids with Cutthroat or Hybrids
- Steelhead-Like Fish Mostly "Pure"

Frequencies of "Trout" with "x" Counts of Cutthroat Trout Alleles

Numbers of Individuals



Counts of cutthroat trout alleles

Example Cross-Classification Tables: Baumsteiger

Collapsed Categories (3 x 3):

VISUAL CATEGORIES

2000 Maple Creek : >= 85 mm

	GENETIC CATEGORIES		
	I Pure Steelhead	II-IV "Hybrid"	V Pure Cutthroat
1 or 2 (Def. & Prob. Steelhead)	54	1	0
3 Hybrid/ Unknown	13	3	0
4 or 5 (Def. & Prob. Cutthroat)	0	14	14

Example Cross-Classification Tables: Baumsteiger

Collapsed Categories (3 x 3):

VISUAL CATEGORIES

2000 Maple Creek : < 85 mm

	GENETIC CATEGORIES		
	I Pure Steelhead	II-IV "Hybrid"	V Pure Cutthroat
1 or 2 (Def. & Prob. Steelhead)	80	1	0
3 Hybrid/ Unknown	10	0	0
4 or 5 (Def. & Prob. Cutthroat)	2	2	6

Example Cross-Classification Table: Voight

VISUAL CATEGORIES

	GENETIC CATEGORIES		
	Pure Steelhead	"Hybrid"	Pure Cutthroat
Steelhead	35	4	1
Hybrid/ Unknown	1	4	4
Cutthroat	0	31	78

2003 Freshwater Tribs : >= 80 mm

Example Cross-Classification Table: Voight

		GENETIC CATEGORIES		
		Pure Steelhead	"Hybrid"	Pure Cutthroat
VISUAL CATEGORIES	Steelhead	9	17	26
	Hybrid/ Unknown	0	0	8
2003 Freshwater Tribs : < 80 mm	Cutthroat	0	14	31

Key Data From Second Phase: Classification Probabilities

	Genetic	
Visual	ST	NOT ST
ST	C1	C2
NOT ST	C3	C4

SENSITIVITY =
P(Visually Classify as ST | True = ST) =
(C1)/(C1+C3)

SPECIFICITY =
P(Visually Classify as NS|True = NS) =
(C4)/(C2+C4)

Empirical Estimates of Sensitivity and Specificity: Baumsteiger 2000

		SENSITIVITY		SPECIFICITY	
LOCATION	Fish Size	Observer A	Observer B	Observer A	Observer B
Little River	< 85 mm FL	0.97 (99)	0.92 (99)	0.67 (3)	0.67 (3)
	>=85 mm FL	0.55 (71)	0.55 (71)	0.96 (27)	0.93 (27)
Maple Creek	< 85 mm FL	0.87 (92)	0.84 (92)	0.89 (9)	0.89 (9)
	>=85 mm FL	0.81 (67)	0.69 (67)	0.97 (32)	0.97 (32)
Ah Pah Creek	< 85 mm FL	NA (0)	NA (0)	1.00 (38)	1.00 (38)
	>=85 mm FL	0.63 (8)	0.25 (8)	1.00 (54)	1.00 (54)

Empirical Estimates of Sensitivity and Specificity: Voight 2002-3

LOCATION	FISH SIZE	SENSITIVITY	SPECIFICITY
McGarvey Creek 2002	< 80 mm FL	0.67 (18)	1.00 (107)
	>= 80 mm FL	1.00 (4)	1.00 (59)
McGarvey Creek 2003	< 80 mm FL	0.94 (36)	0.93 (163)
	>= 80 mm FL	1.00 (3)	0.92 (105)
Freshwater Creek Tribs 2003	< 80 mm FL	1.00 (9)	0.60 (88)
	>= 80 mm FL	0.97 (36)	0.96 (122)

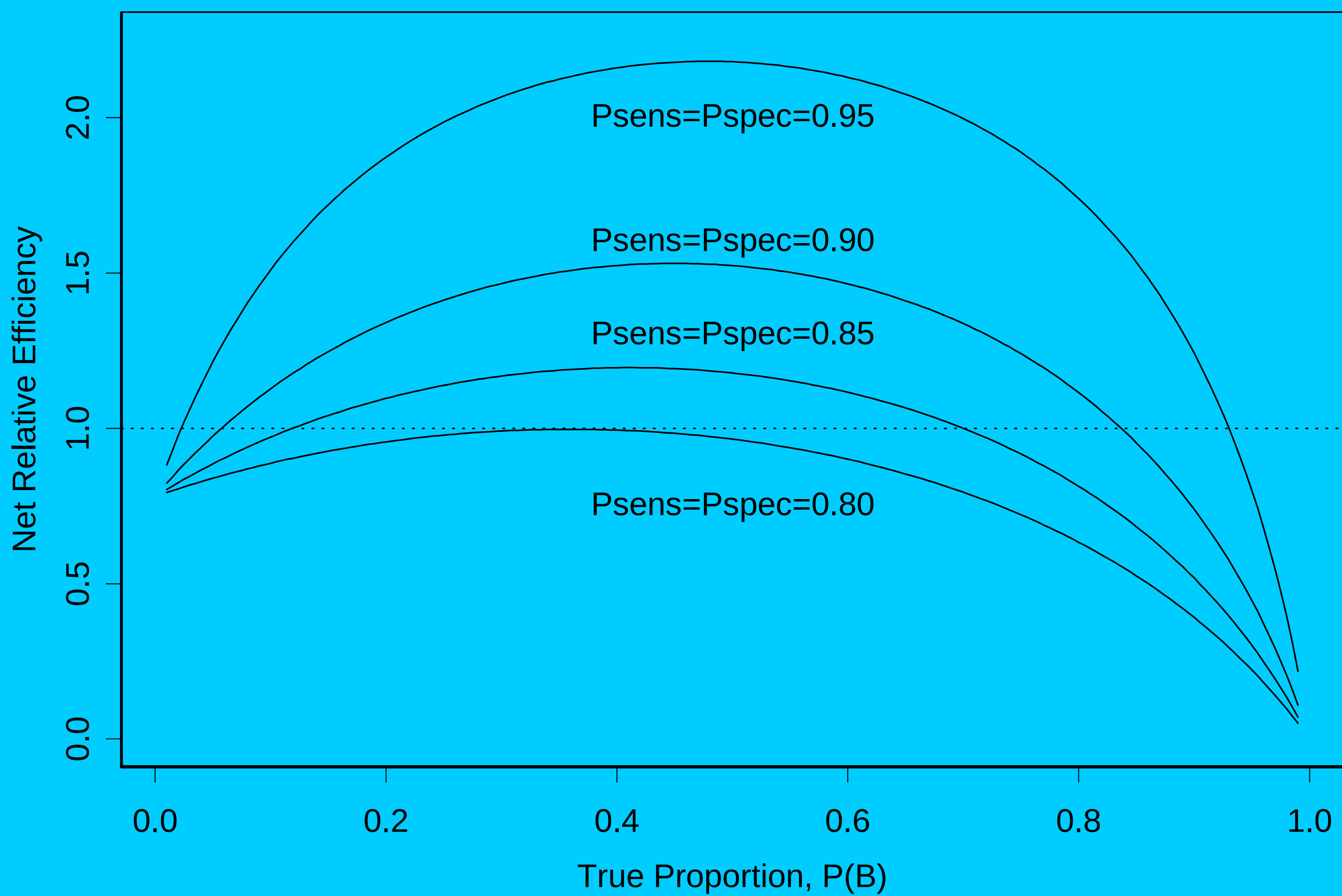
CONCLUSION

- Visual Data, By Themselves, are NOT Adequate to Estimate Proportion of ST
- Separation of “Pure” Cutthroat from Hybrids will be even more difficult!

“Two-Phase Bayes Estimator”

- Preliminary Simulation Work – Promising –Does Generate Unbiased Estimates of Proportion of ST
- AND Analytic Variance Expression has been recently developed by Xue!!!!
- Key Issues: When will this kind of survey be cost-effective?? *Compare 2-Phase Bayes w Single Phase Genetic.*

N=1000, f1=0.1, f2=0.2, c1=1, c2=20



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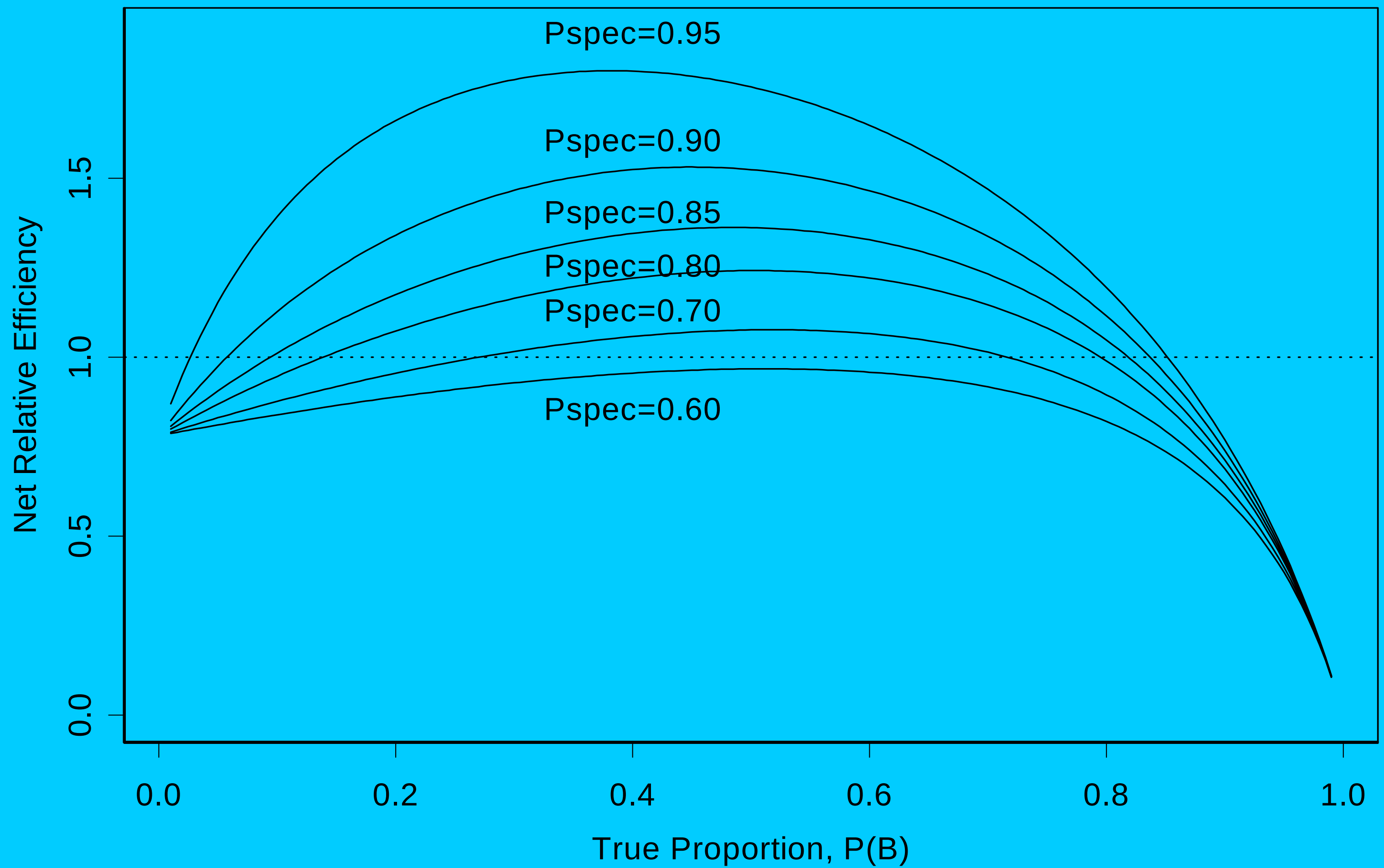
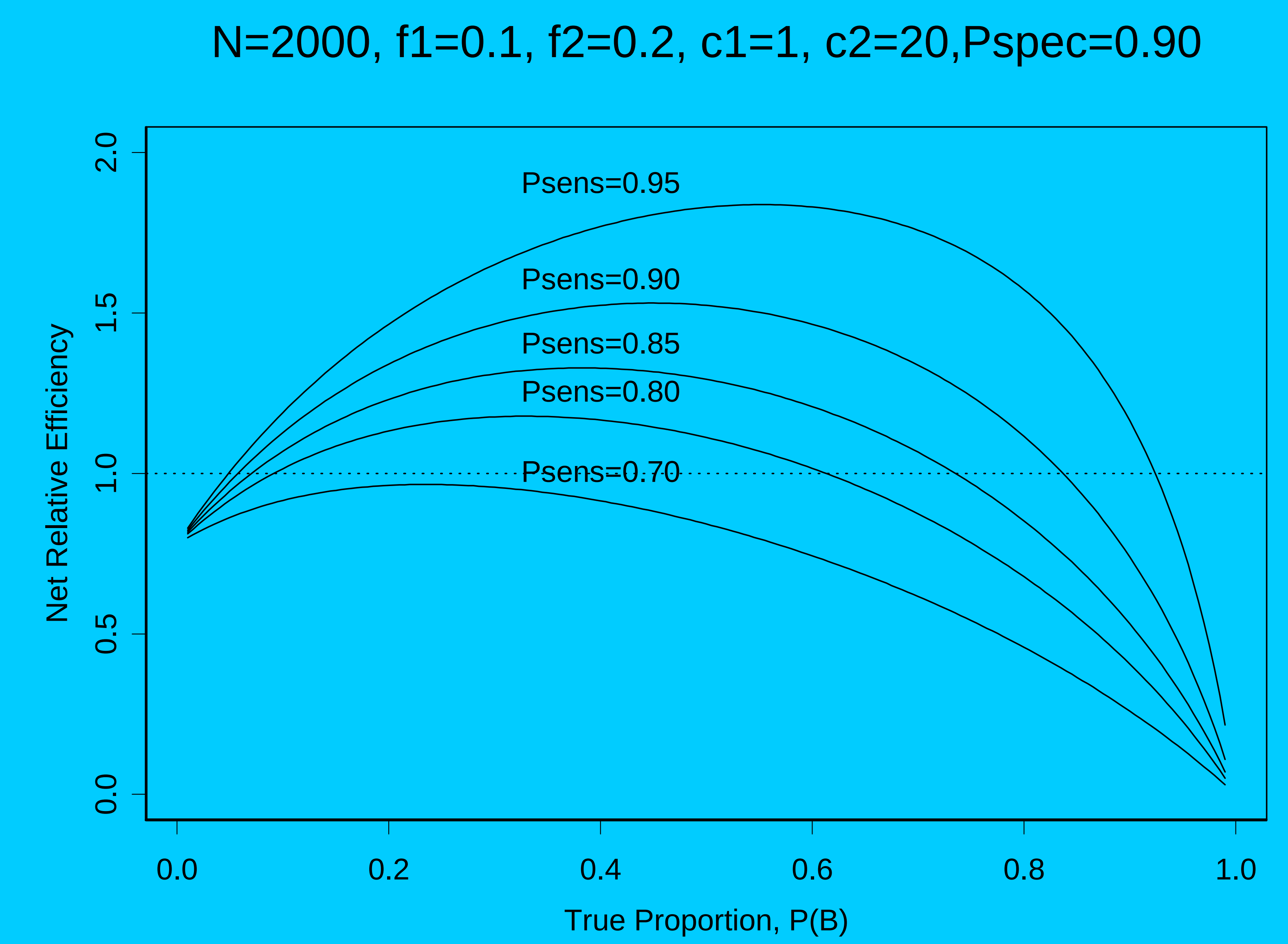
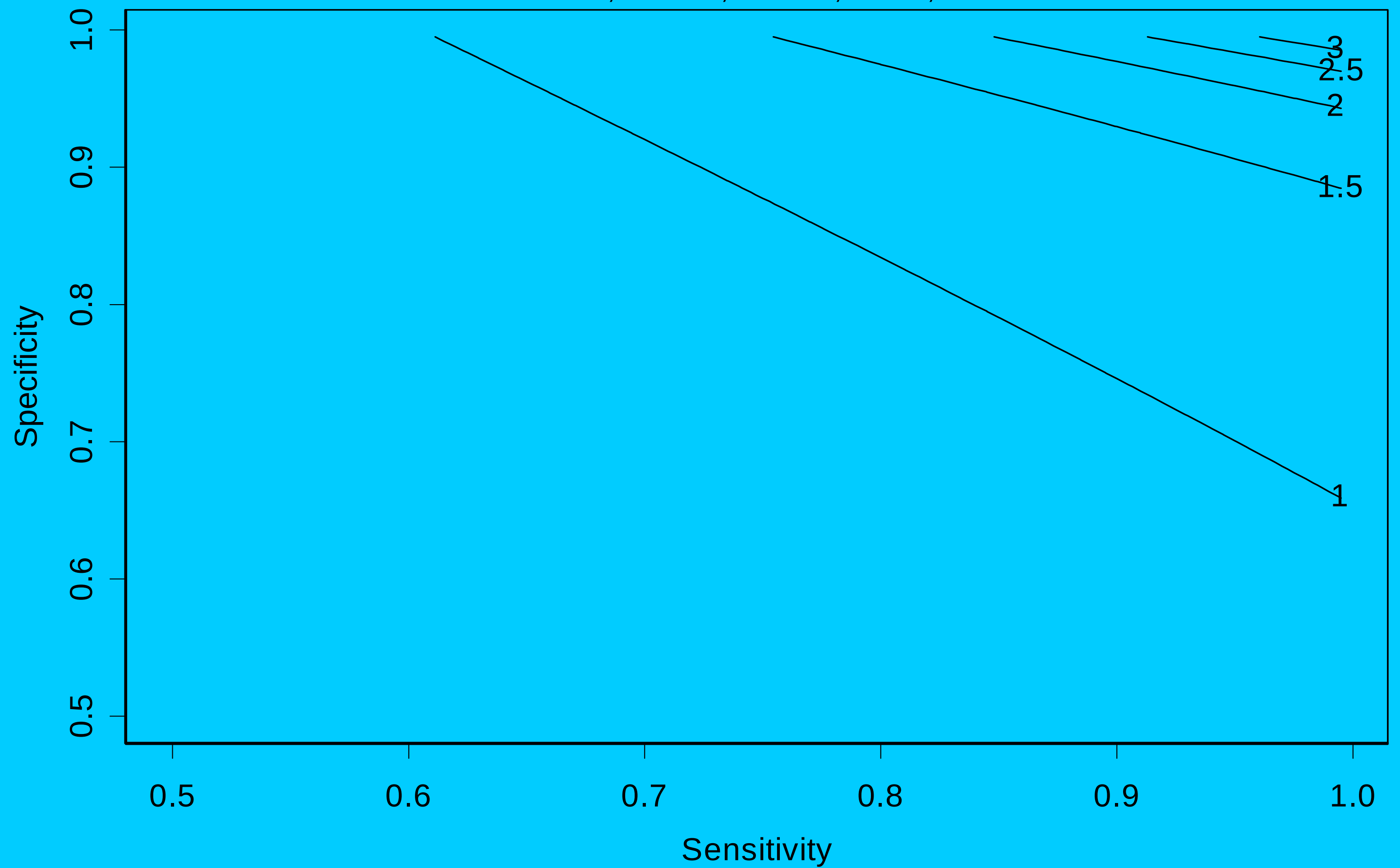


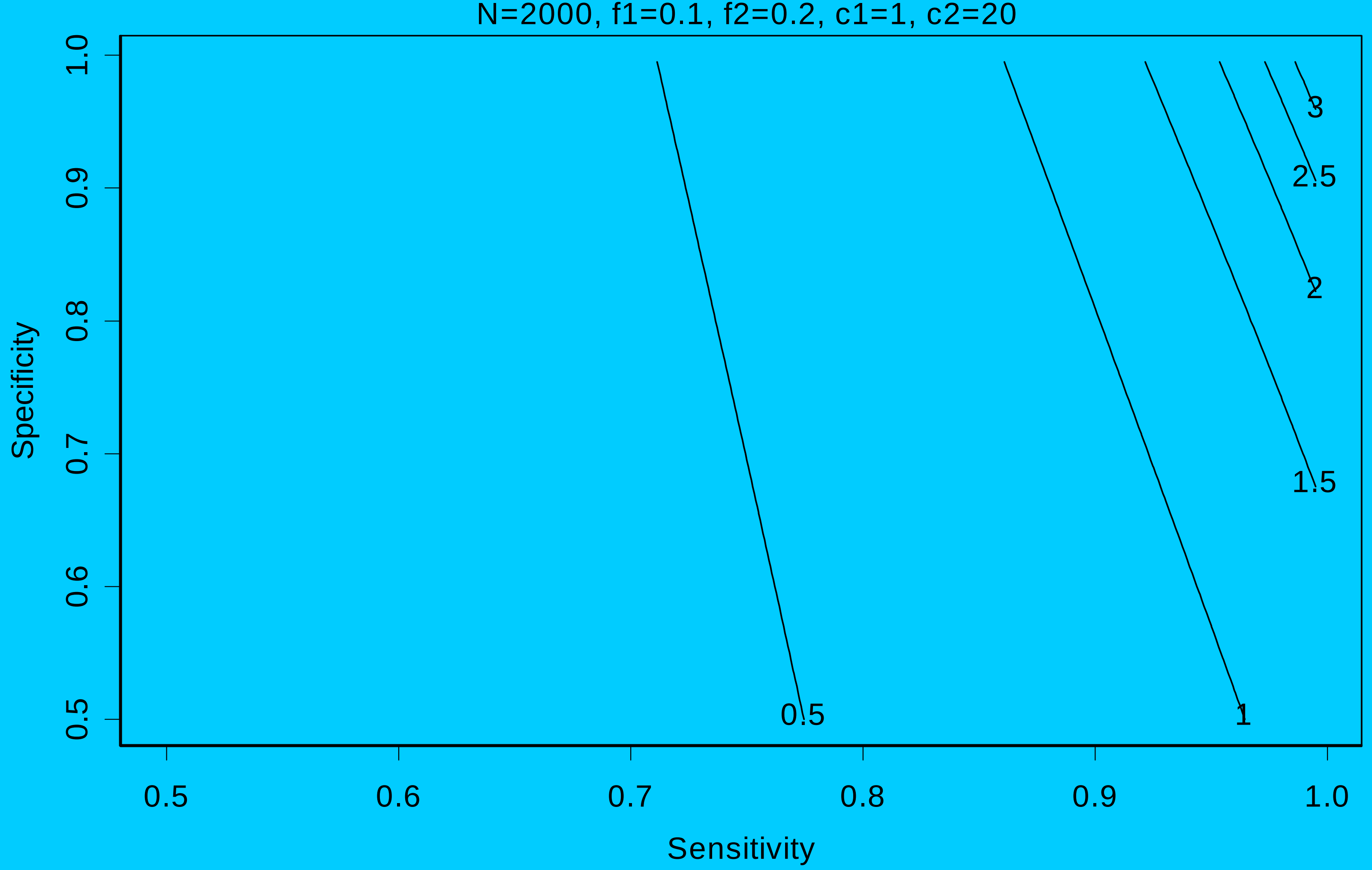

N=2000, f1=0.1, f2=0.2, c1=1, c2=20,Pspec=0.90
Psens=0.95
Psens=0.90
Psens=0.85
Psens=0.80
Psens=0.70
Net Relative Efficiency
0.0
0.5
1.0
1.5
2.0
0.0
0.2
0.4
0.6
0.8
1.0
True Proportion, P(B)

Net Relative Efficiency for P(B) = 0.20

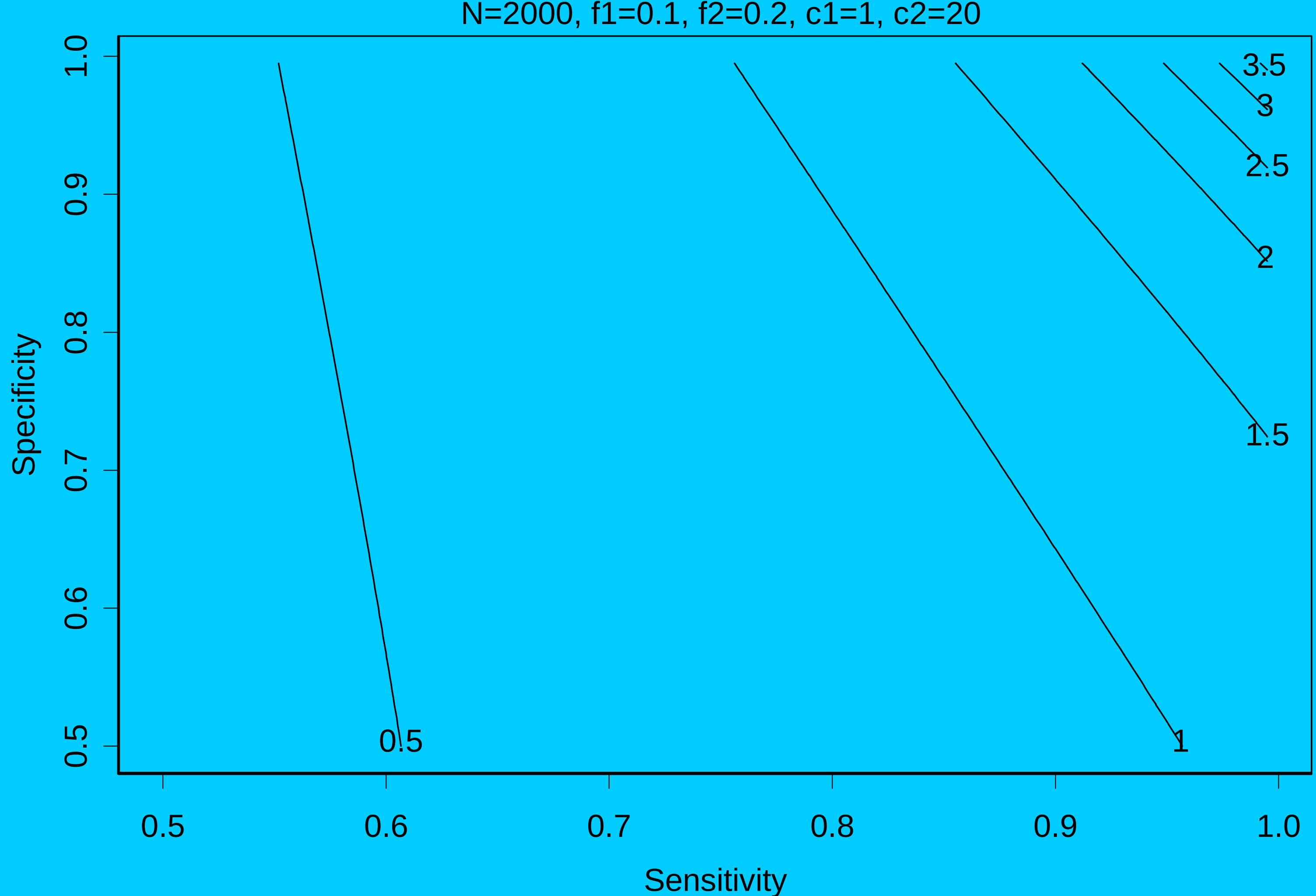
N=2000, f1=0.1, f2=0.2, c1=1, c2=20



Net Relative Efficiency for P(B) = 0.40



Net Relative Efficiency for P(B) = 0.60



Net Relative Efficiency for P(B) = 0.80