Estimation with incomplete detection at distance zero
“g(0)<1”

Laake, J.L. and Borchers, D.L. Methods for incomplete detection at distance zero. **Chapter 6 in Advanced Distance Sampling**. Oxford University Press

Borchers, D., Laake, J., Southwell, C. and Paxton, C. 2006. Accommodating unmodeled heterogeneity in double-observer distance sampling surveys. *Biometrics* **62**: 372-378

Buckland, S.T., Laake, J.L. and Borchers, D.L. 2009. Double-observer line transect methods: levels of independence. *Biometrics* **66**: 169-177

Laake, J.L., Collier, B.A., Morrison, M.L. and Wilkins, R.N. 2011. Point-based mark-recapture distance sampling. JABES **16**: 389-408

Burt, M.L., Borchers, D.L., Jenkins, K.J. and Marques, T.A.M. 2014. Using mark-recapture distance sampling methods on line transect surveys. *Methods in Ecology and Evolution* **5**: 1180-1191.

Conventional Distance sampling estimates are biased if $g(0)<1$:

$$D^* = D \times g(0)$$

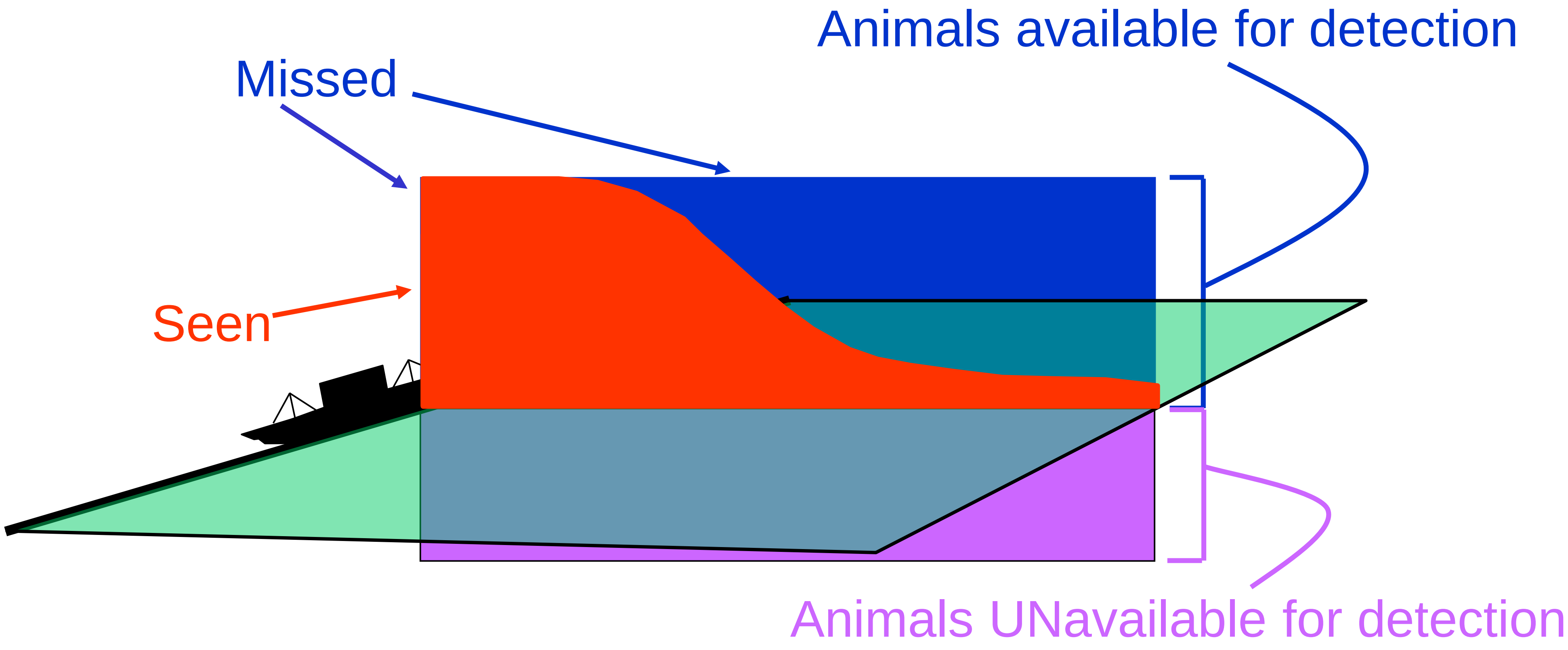
where D is the true density and D^* is the density obtained if you assume $g(0)=1$.

***g*(0)<1** when there is

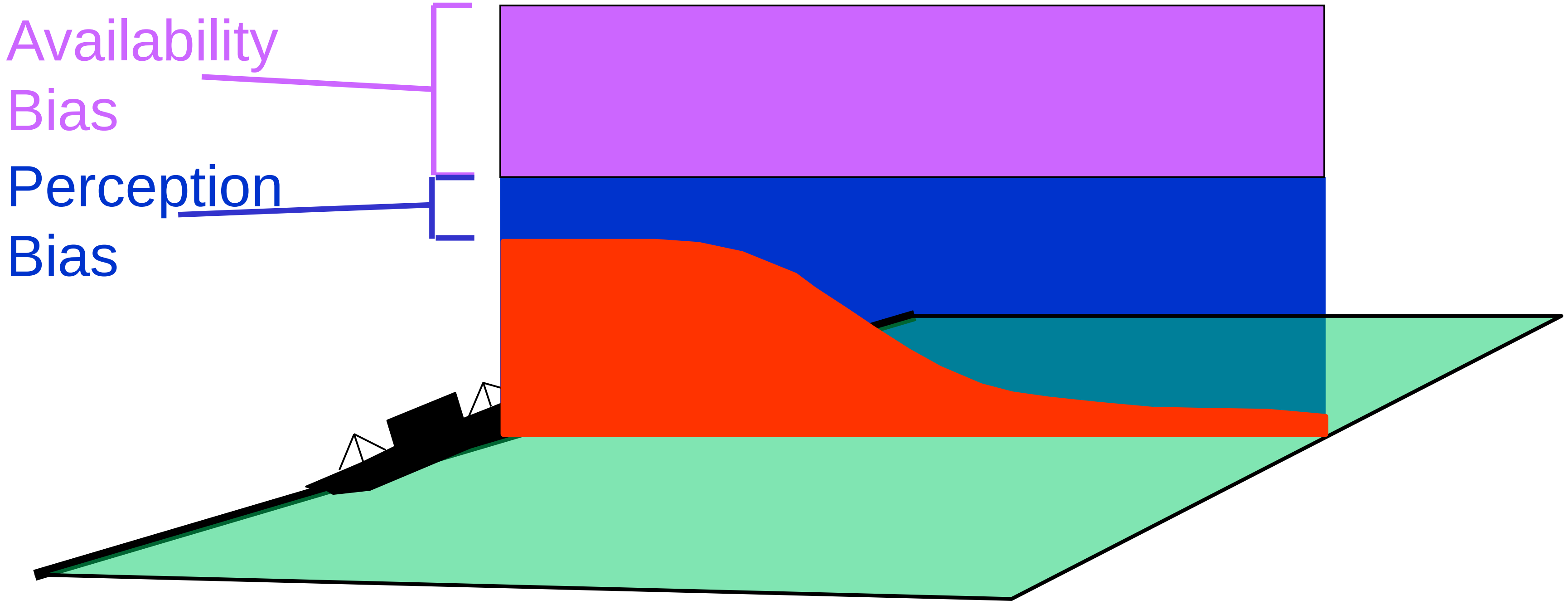
Availability Bias

Perception Bias at distance 0

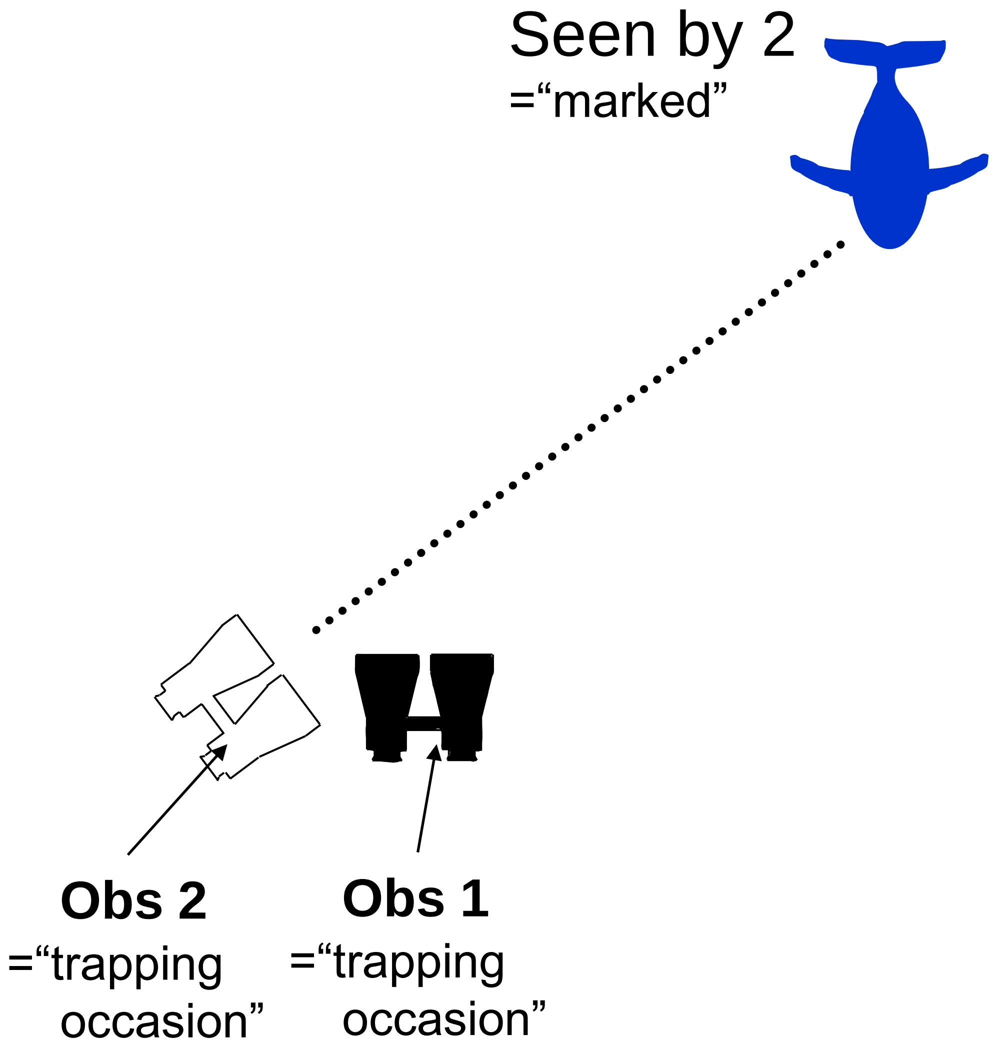
- "**Availability Bias**": When animals are unavailable for detection.
- "**Perception Bias**": When observers fail to detect animals at distance 0 although they are available



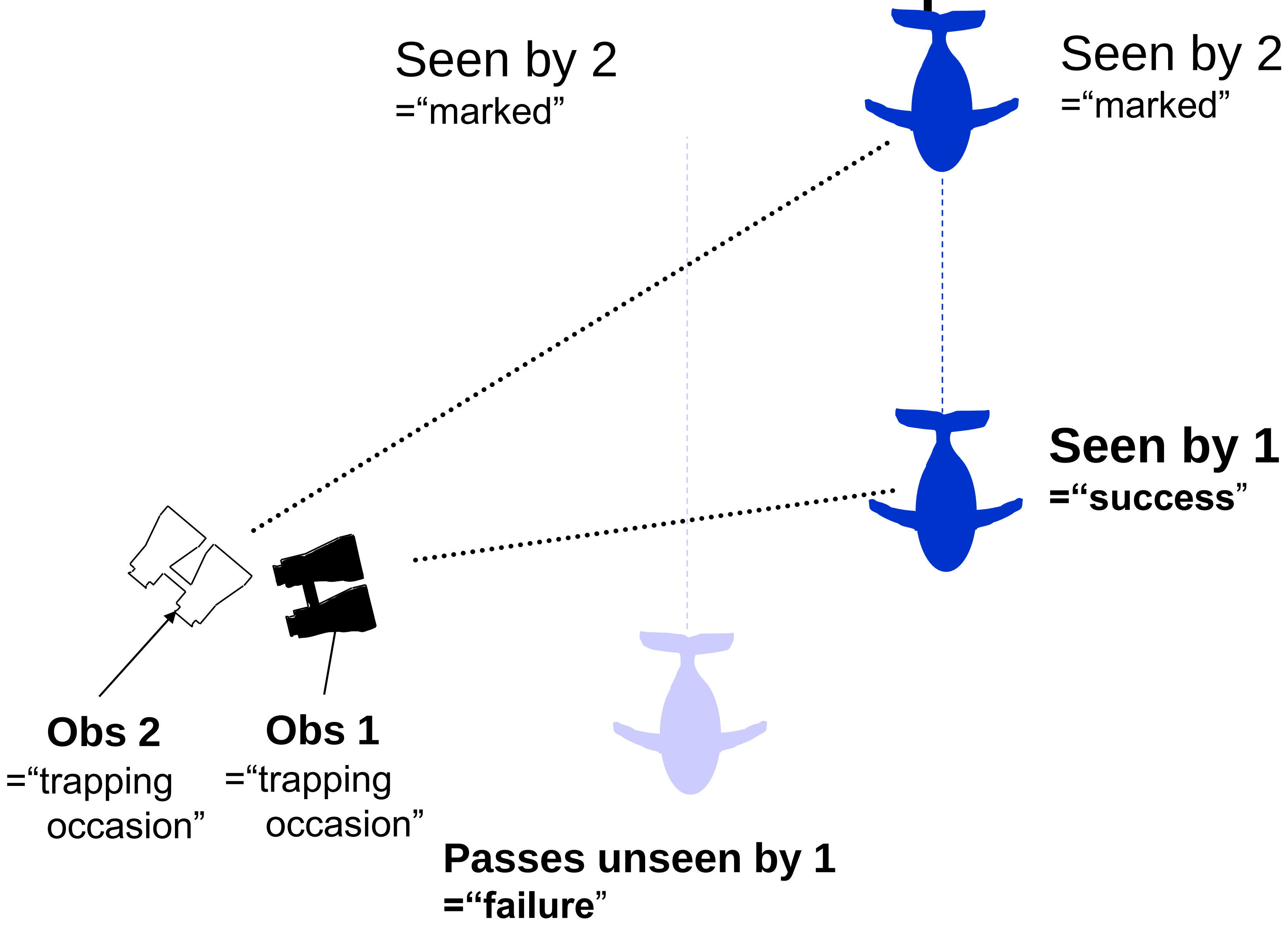
- “**Availability Bias**”: When animals are unavailable for detection.
- “**Perception Bias**”: When observers fail to detect animals on the transect although they are available



Visual Mark-Recapture



Visual Mark-Recapture

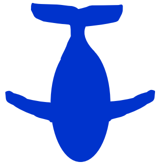


Visual Mark-Recapture

Seen by 2
="marked"

Passes unseen by 1
="failure"

Seen by 2
="marked"

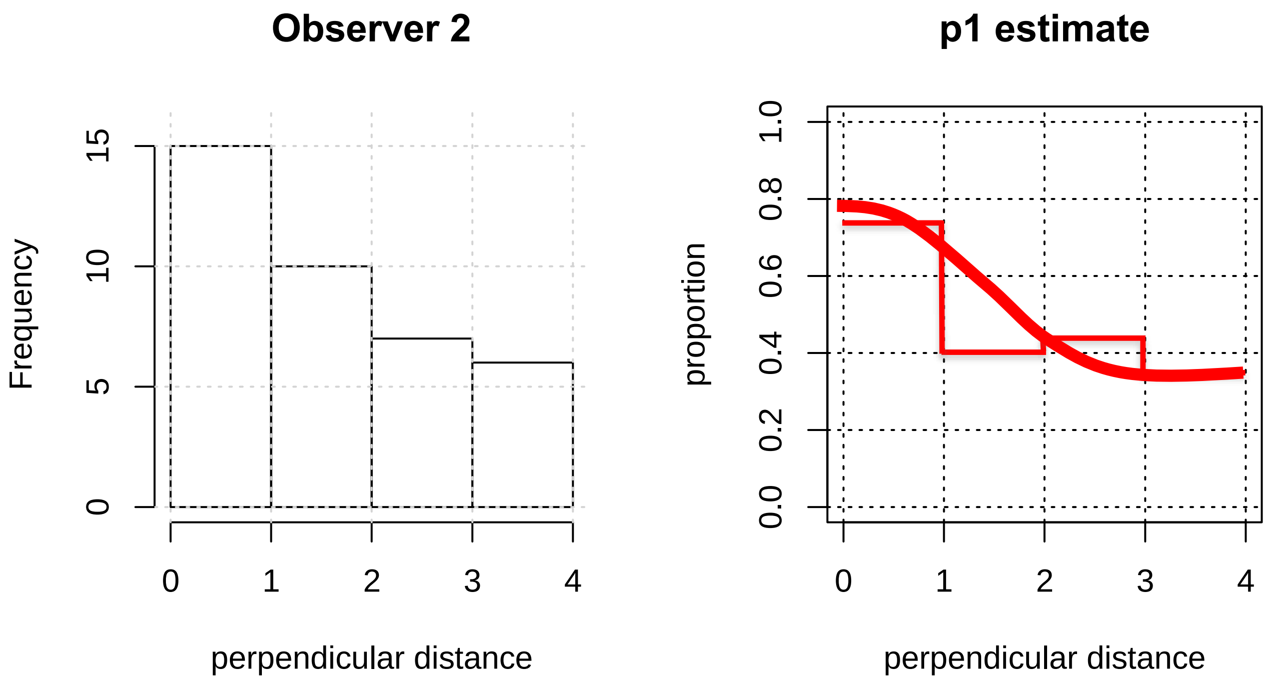


Seen by 1
="success"

- We know 2 animals passed (because Obs 2 saw them)
- Of these, Obs 1 saw 1
- So **estimate:**
  Pr(Obs 1 sees) = $\hat{p}_1 = \frac{1}{2} = \frac{n_{12}}{n_2}$ = $\frac{\text{number "duplicates"}}{\text{number seen by 2}}$

Note: In this section, we use *p*, not *g* for the detection function

Class Exercise

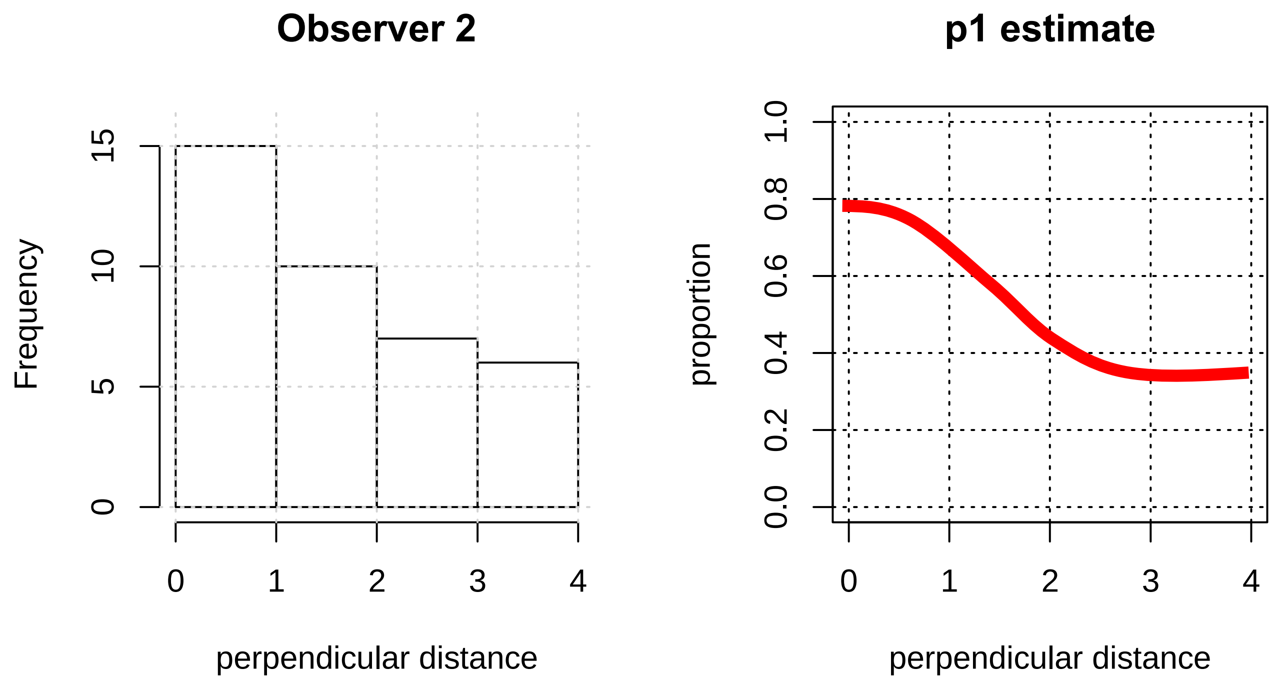


Obs 2 detections:

		n_2	$\hat{p}$	n_1	$\hat{N}_x$
100s:	101,102,103,104,105,106,107,108,111,112,114,115,116,118,134	15			
200s:	201,202,204,205,206,207,211,214,215,218	10			
300s:	301,303,304,305,307,313,314	7			
400s:	402,404,407,416,417,418	6			
	$n_{dups} = 20$	38		25	

$$\hat{N}_{Petersen} = \frac{n_1}{\hat{p}_1} = \frac{25}{20/38} = 47.5$$

$$\hat{N}_{TOTAL} =$$



Fit smooth curve using Logistic Regression
(instead of grouping into distance intervals)

Duplicate Identification

Field methods

- Use a dedicated “duplicate identifier”
- Record measure of confidence in duplicate identification.
- Record positions and times as precisely as possible
- Record ancillary data
- Have at least one observer “track” animals

Duplicate Identification

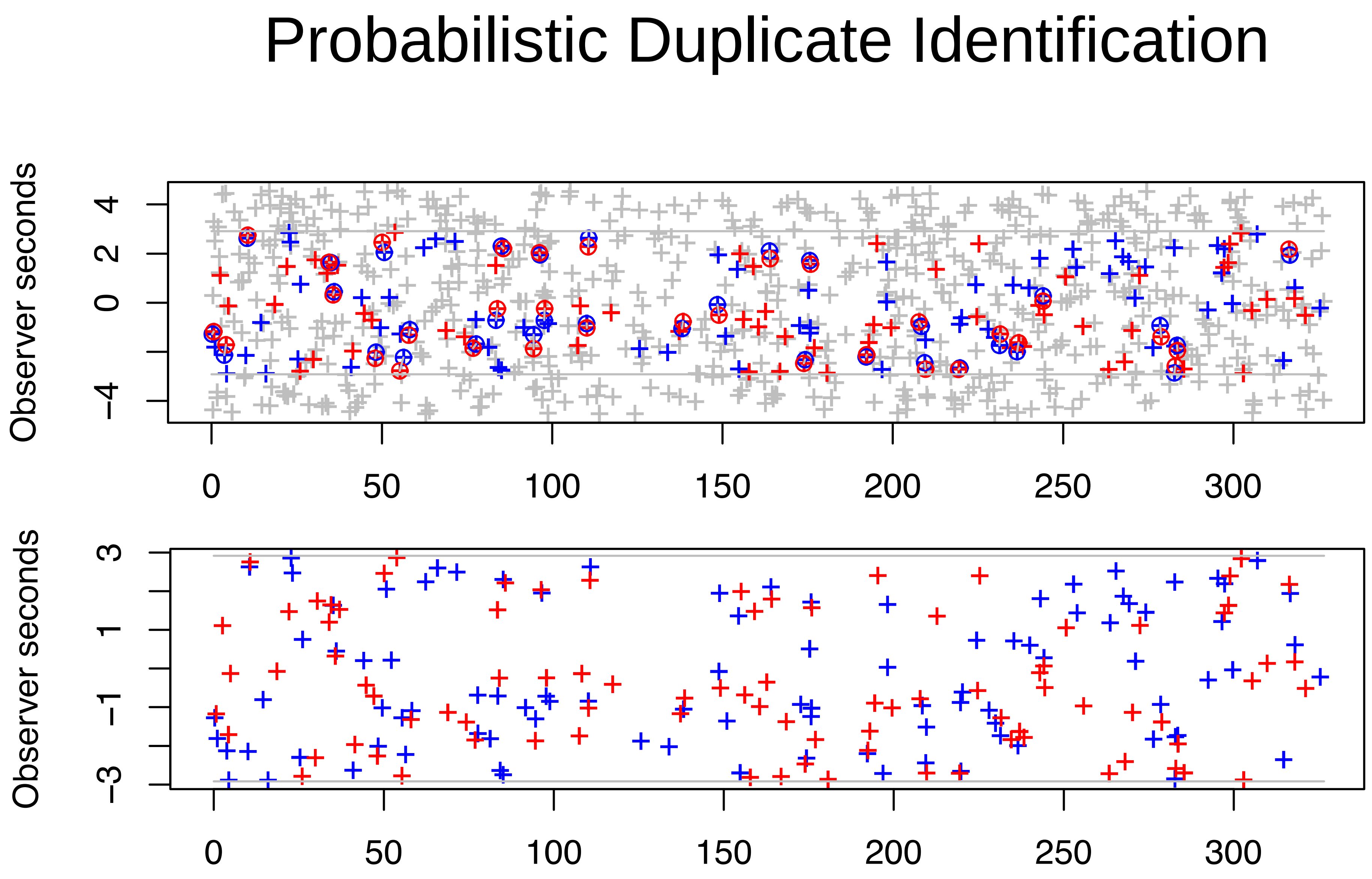
Analysis methods

- Bracket "best" estimate by two extremes

- Rule-based duplicate identification after the survey. (e.g. Schweder et al., 1996)

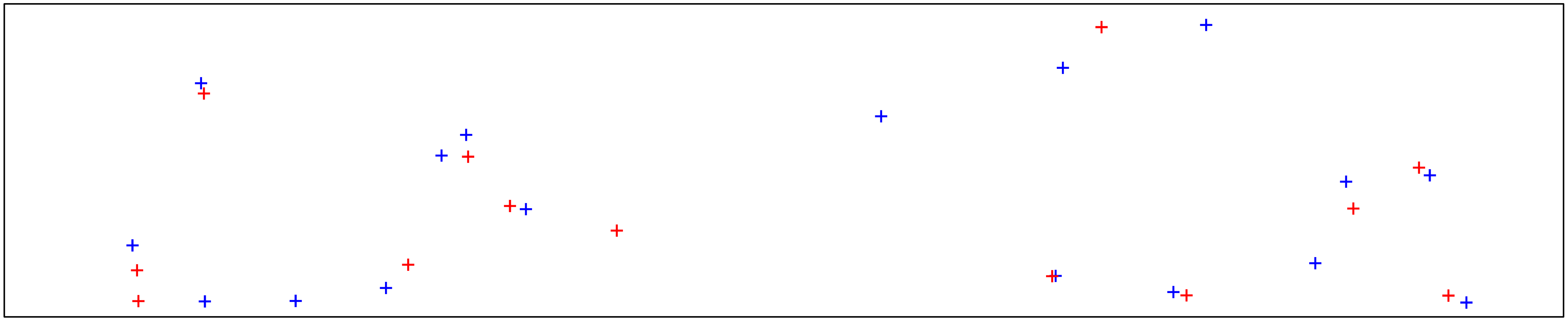
- Probabilitistic duplicate identification after the survey. (e.g. Hiby and Lovell, 1998, Stevenson *et al*. *submitted*)

Stevenson, B.C., Borchers, D.L. and Fewster, R.M. Cluster capture-recapture to account for identification uncertainty on aerial surveys of animal populations. (under revision for Biometrics).
Schweder, T., Hagen, G., Helgeland, J. and Koppervik, I. 1996. Abundance estimation of northeastern Atlantic minke whales. *Rep. Int. Whal. Commn.* **46**: 391-405.
Hiby, A. and Lovell, P.1998. Using aircraft in tandem formation to estimate abundance of harbour porpoise. *Biometrics* **54**: 1280-1289.



Probabilistic Duplicate Identification
Observer seconds
4
2
0
−4
0
50
100
150
200
250
300
Observer seconds
3
1
−1
−3
0
50
100
150
200
250
300

Probabilistic Duplicate Identification



Design to deal with availability bias

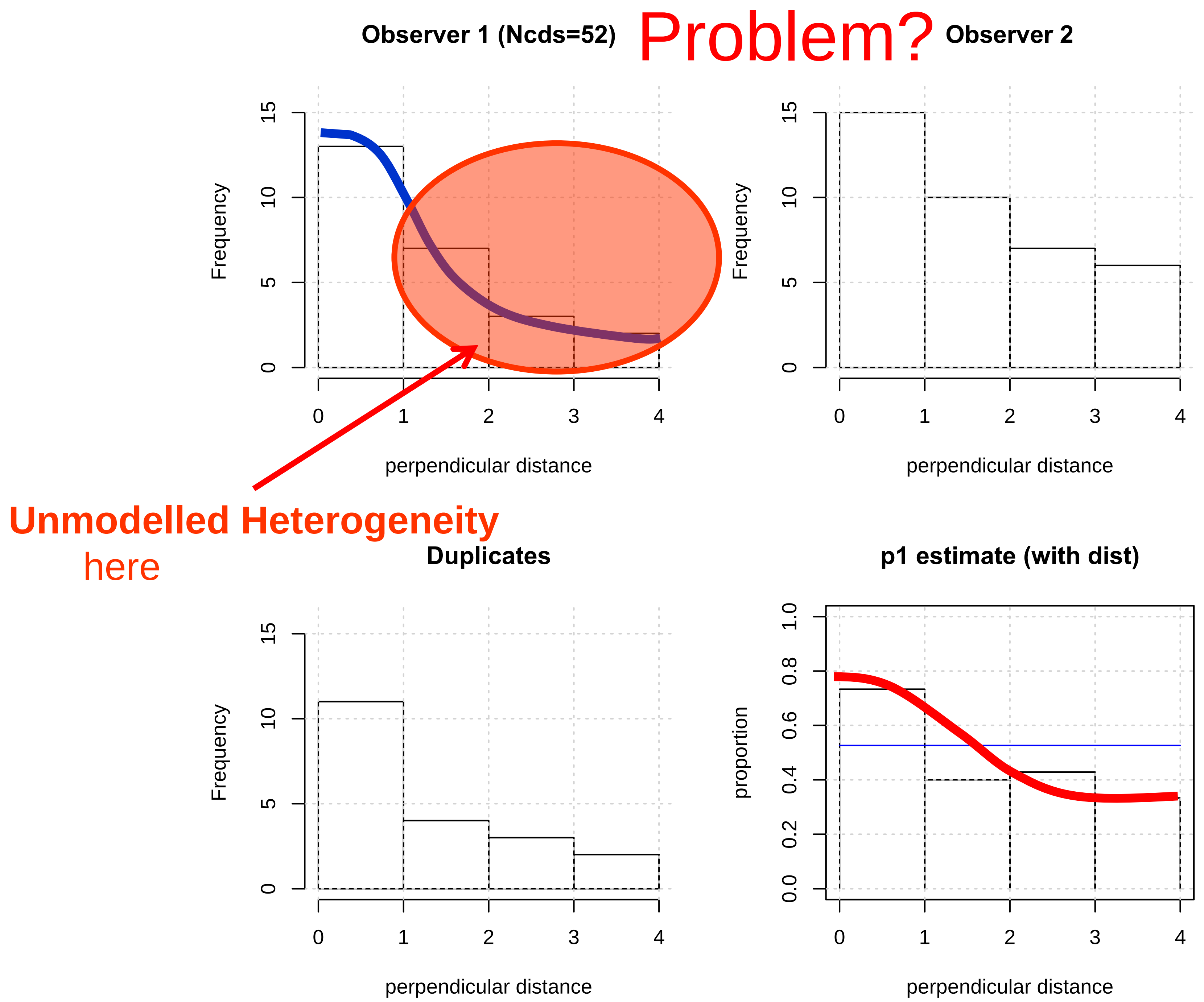
Use enough effort for certain detection at *x*=0: May not be possible

Use cue-based methods : Need to estimate availability process

Separate search areas of the observers (see pp 176-177 Adv. book)

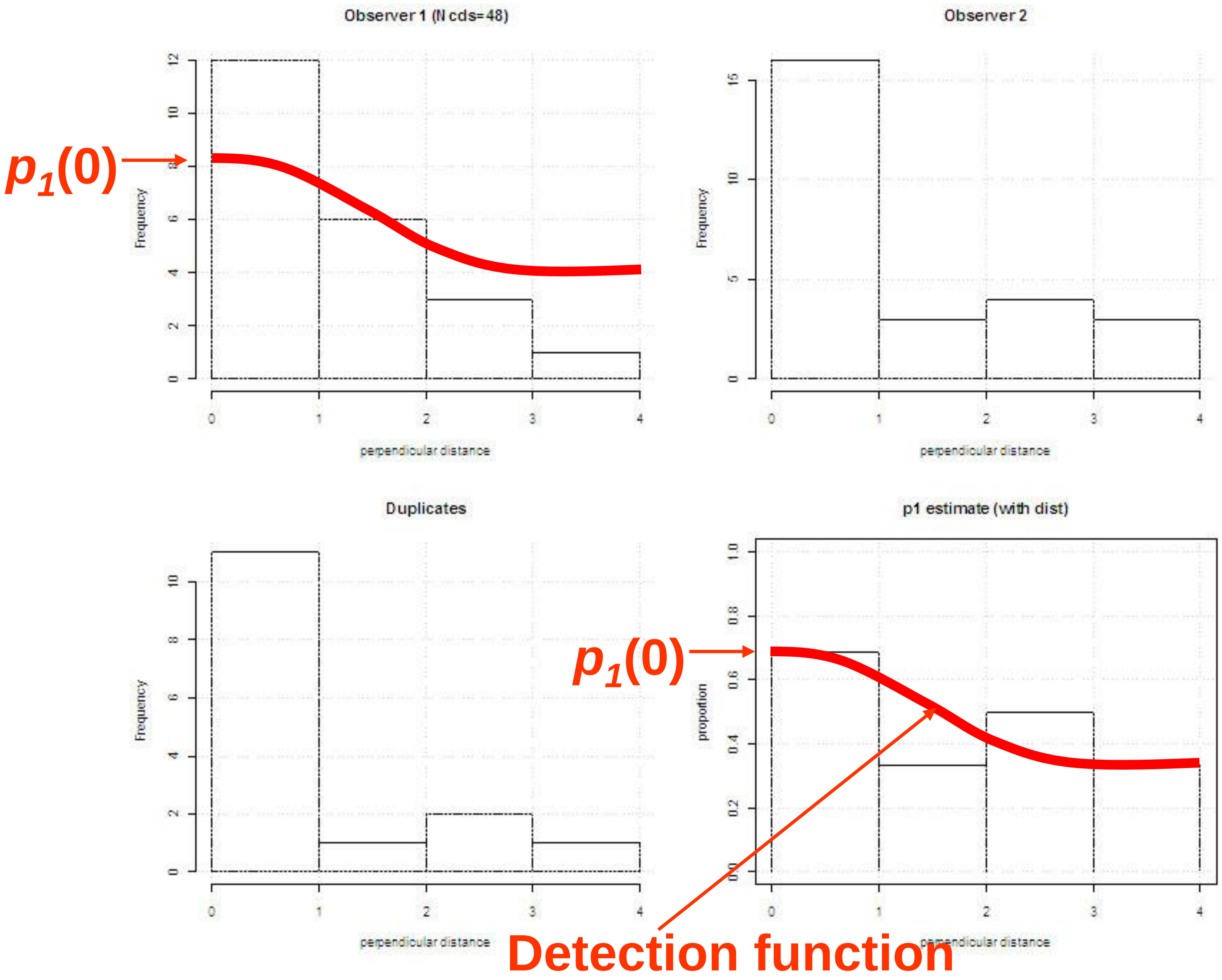
Use different types of observers (e.g. visual and acoustic; visual and radio-tag)

Availability bias correction factor: Need to be careful if animals in view for more than very small fraction of their availability cycle time.

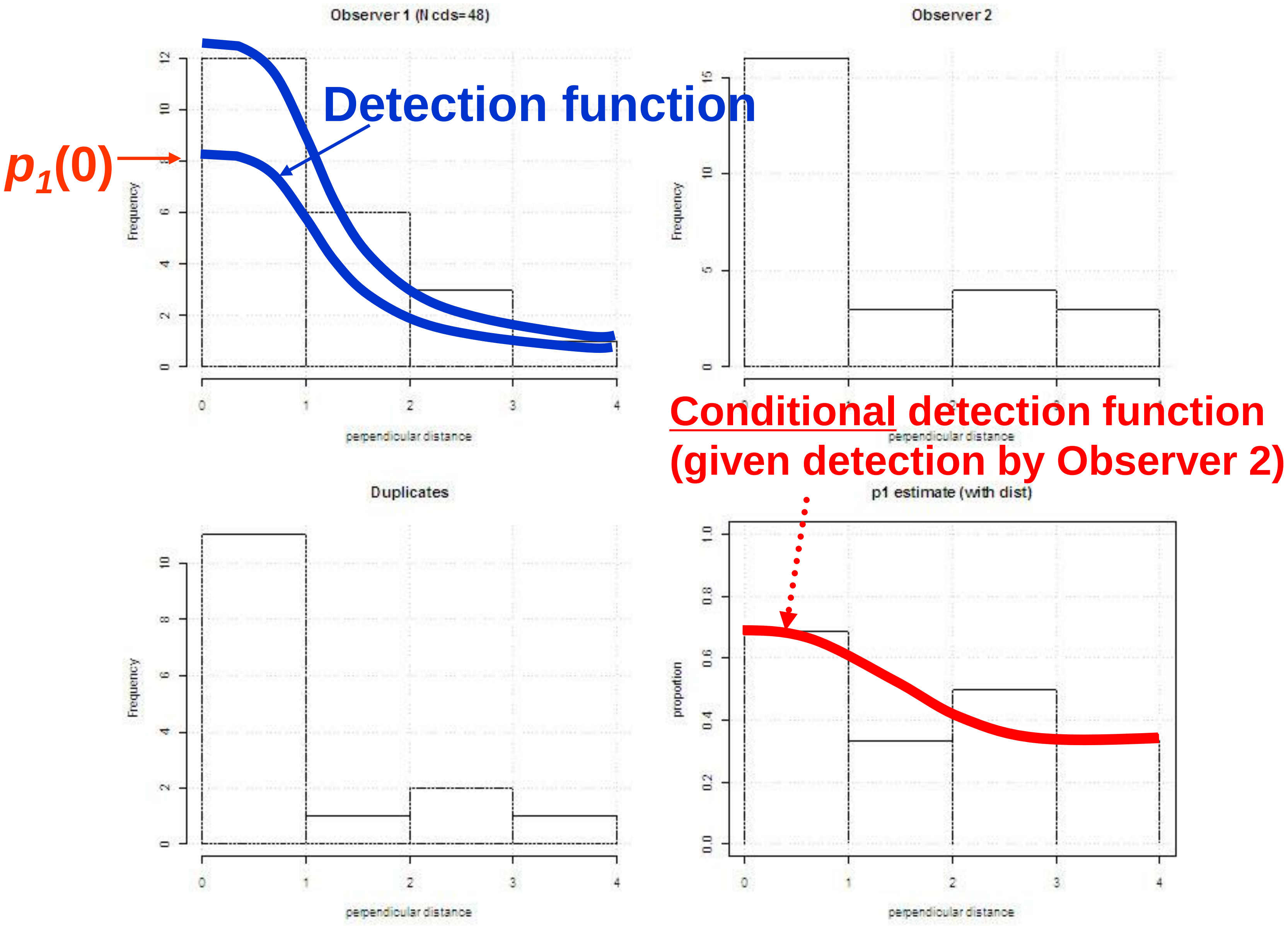


Observer 1 (Ncds=52)
Problem?
Observer 2
Unmodelled Heterogeneity
here
Duplicates
p1 estimate (with dist)
Frequency
proportion
perpendicular distance
0
5
10
15
0.0
0.2
0.4
0.6
0.8
1.0
1
2
3
4

Full Independence (FI) Model:



Point Independence (PI) Model:



Point vs Full Independence

Full Independence

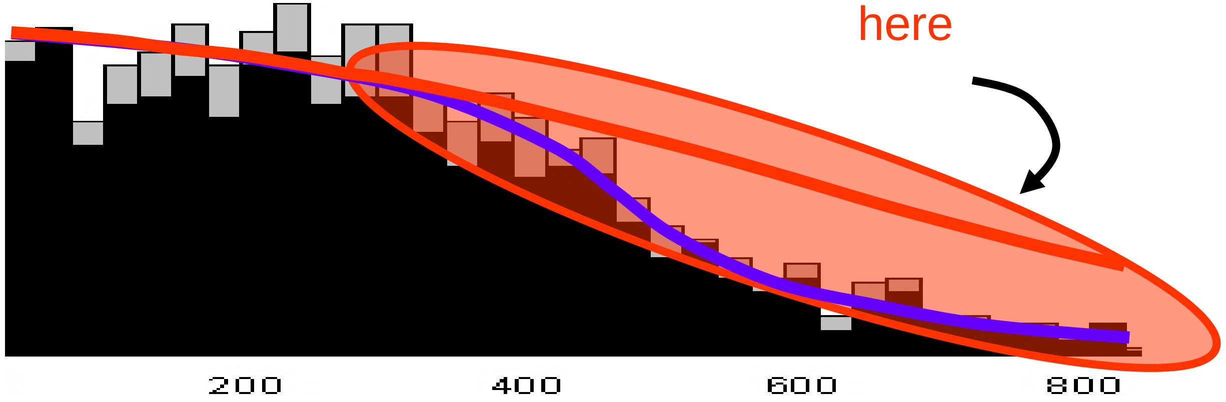
- Class e.g. Nhat= 48.
- Sensitive to unmodelled heterogeneity: negative bias.
- Assumption of uniform animal distribution not required - so useful if there is responsive movement.
- Don’t use unless you have to.

Point Independence

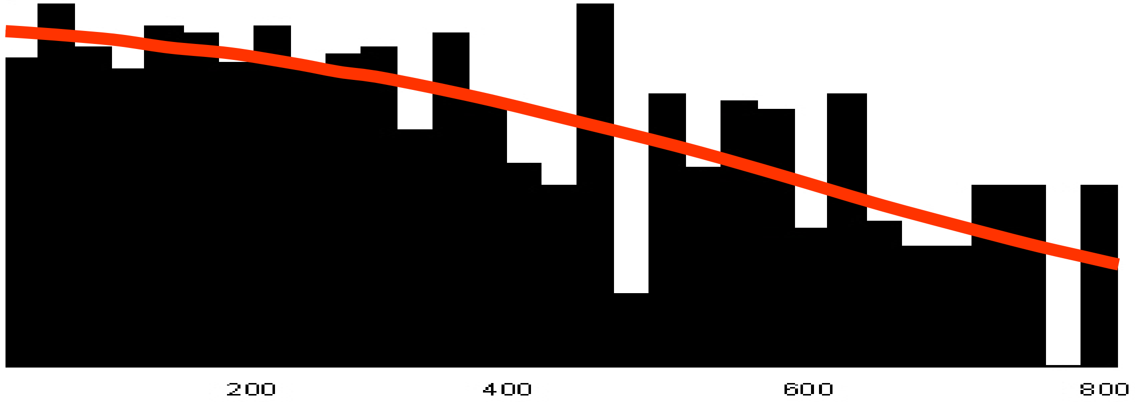
- Class e.g. Nhat= 70.
- Much less sensitive to unmodelled heterogeneity.
- Assumption of uniform animal distribution required – so no good if there is responsive movement.
- Use it unless there is responsive movement (or other non-uniform distribution).

Example: Pack-Ice Seals

Observer 1 detections

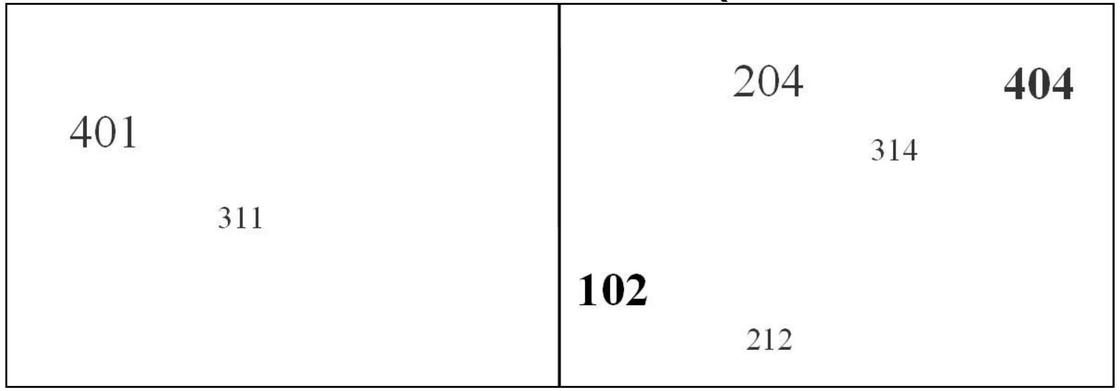


Proportion of Observer 2 detections seen by Observer 1



Sources of Heterogeneity

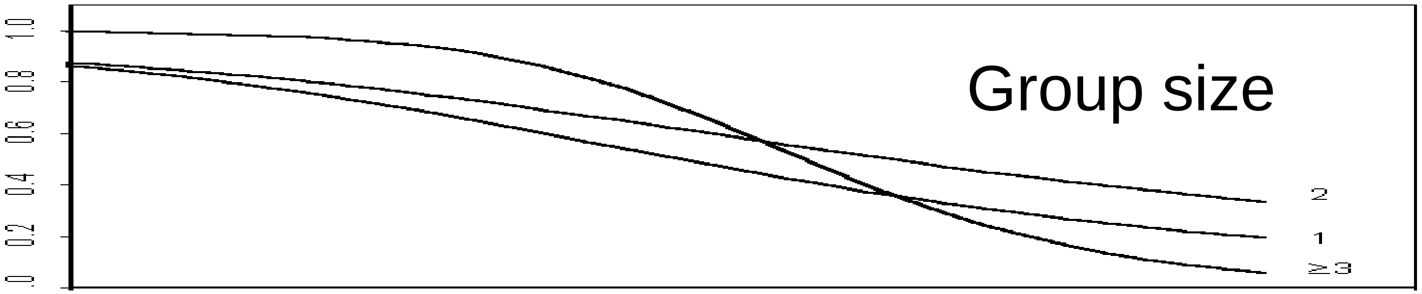
- The **animals** themselves (size, boldness)



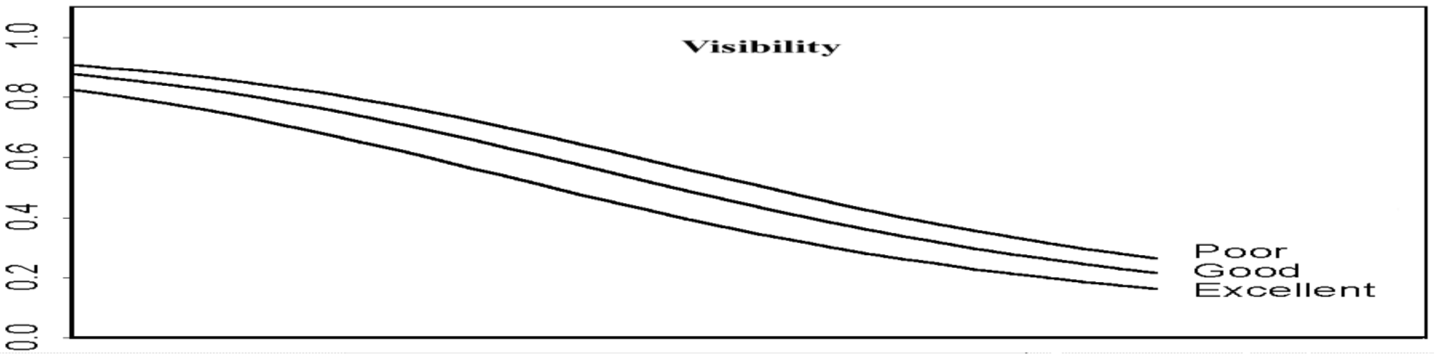
- The **environment** (clear/"misty")

Sources of Heterogeneity

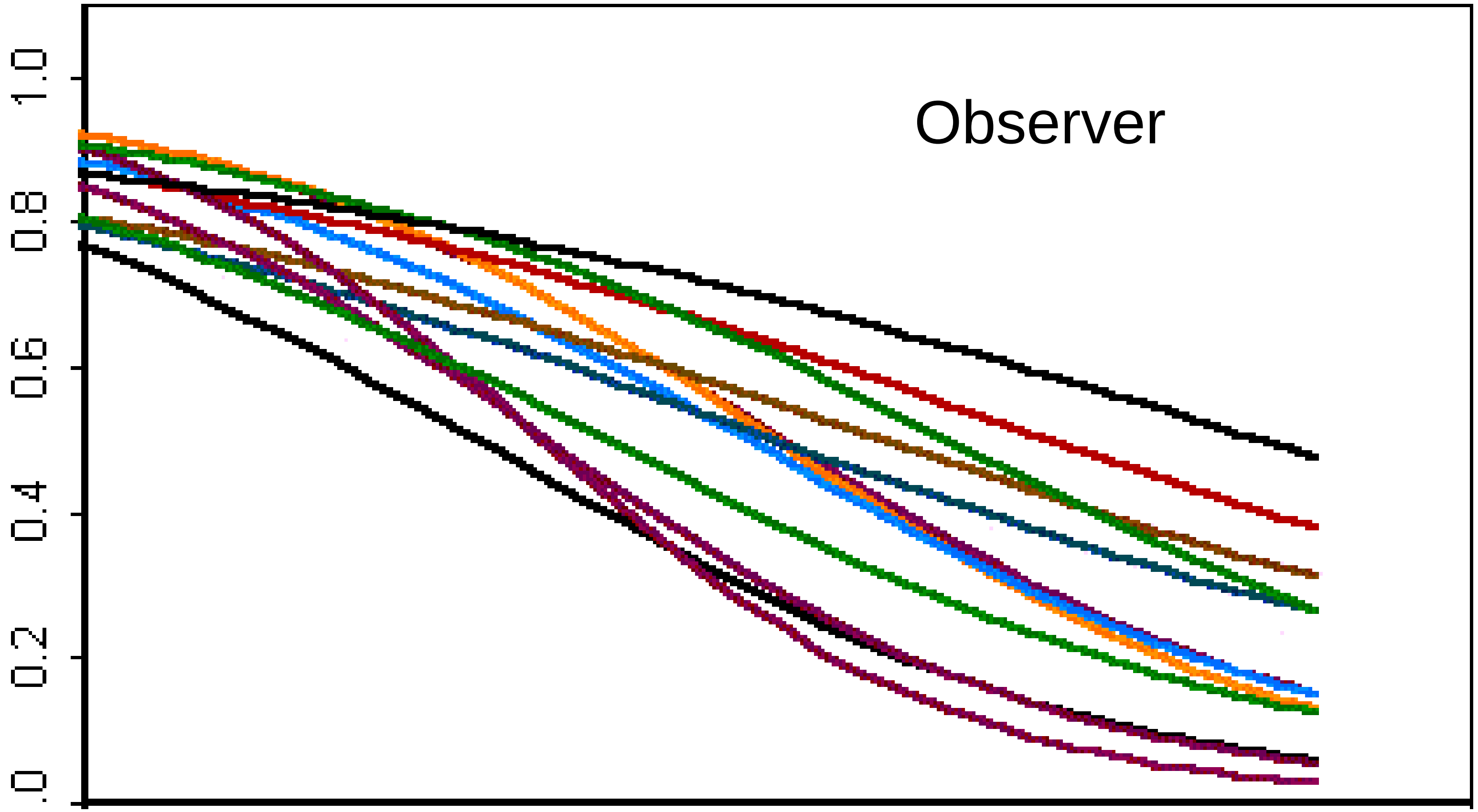
- The **animals** themselves (distance, size, availability, ...)



- The **environment** (sea state, ground cover, ...)



- The kind of **survey effort** (the observers, their platforms, ...)



Configuration:
Trial-Observer

Observer 2

↓

sets up trials for

↓

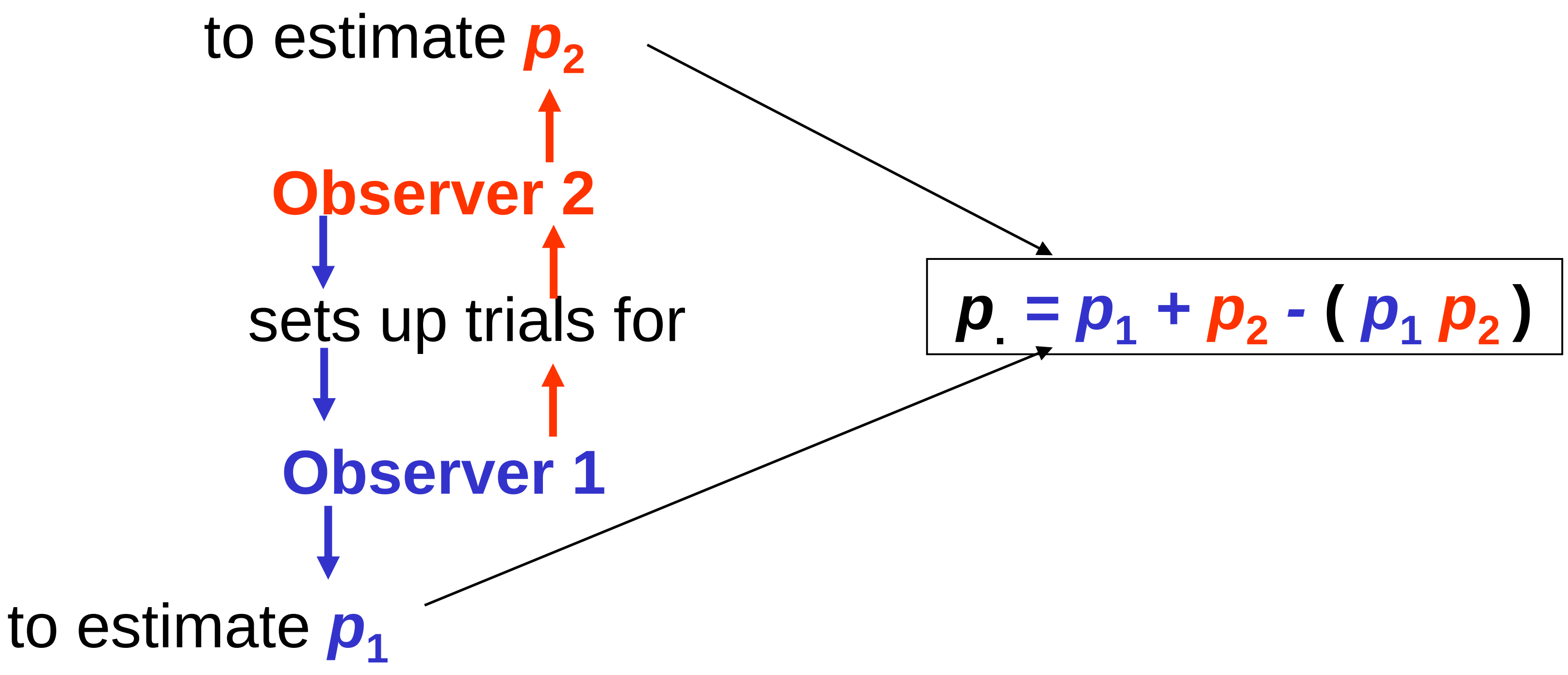
Observer 1

↓

to estimate p_1

The Observer at the end of an arrow must be independent of
the Observer at the start of the arrow

Configuration: Independent Observer



The Observer at the end of an arrow must be independent of
the Observer at the start of the arrow

Abundance Estimation

- Trial-Observer $\hat{N} = \sum_{seen\ by\ 1} \frac{1}{\hat{p}(x_i, \dots)}$

- Independent Observer $\hat{N} = \sum_{seen} \frac{1}{\hat{p}(x_i, \dots)}$

Double-Platform Analysis Types

Cue-based methods:

- Cues (not animals) are units; estimate p(see cue)
- Getting adequate estimates of cue generation process can be difficult.
- Able to incorporate heterogeneity due to availability (cue-ing) process.

- ## Animal-based methods:

We focus on these; in some applications cue-based methods perform better

- Animals are units; estimate p(see animal)
- Don’t need to estimate availability/cue-ing process.
- More difficult to incorporate heterogeneity due to availability process.

Related Models not covered:

Limiting Independence

- Assume no unmodelled heterogeneity not at any point, but only as p approaches 1.

- See Buckland, S.T., Laake, J.L. and Borchers, D.L. 2009. Double-observer line transect methods: levels of independence. *Biometrics* **66**: 169-177

Point Transects

- Can also do full, point and limiting independence with **Point Transects**.

- See Laake, J.L., Collier, B.A., Morrison, M.L. and Wilkins, R.N. 2011. Point-based mark-recapture distance sampling. JABES **16**: 389-408

Critical Assumptions of Mark Recapture Line Transect

- Have the required independence between observers
- No unmodelled heterogeneity
- Duplicates (resightings) known (else need to include uncertainty in duplicate status in estimated variance)