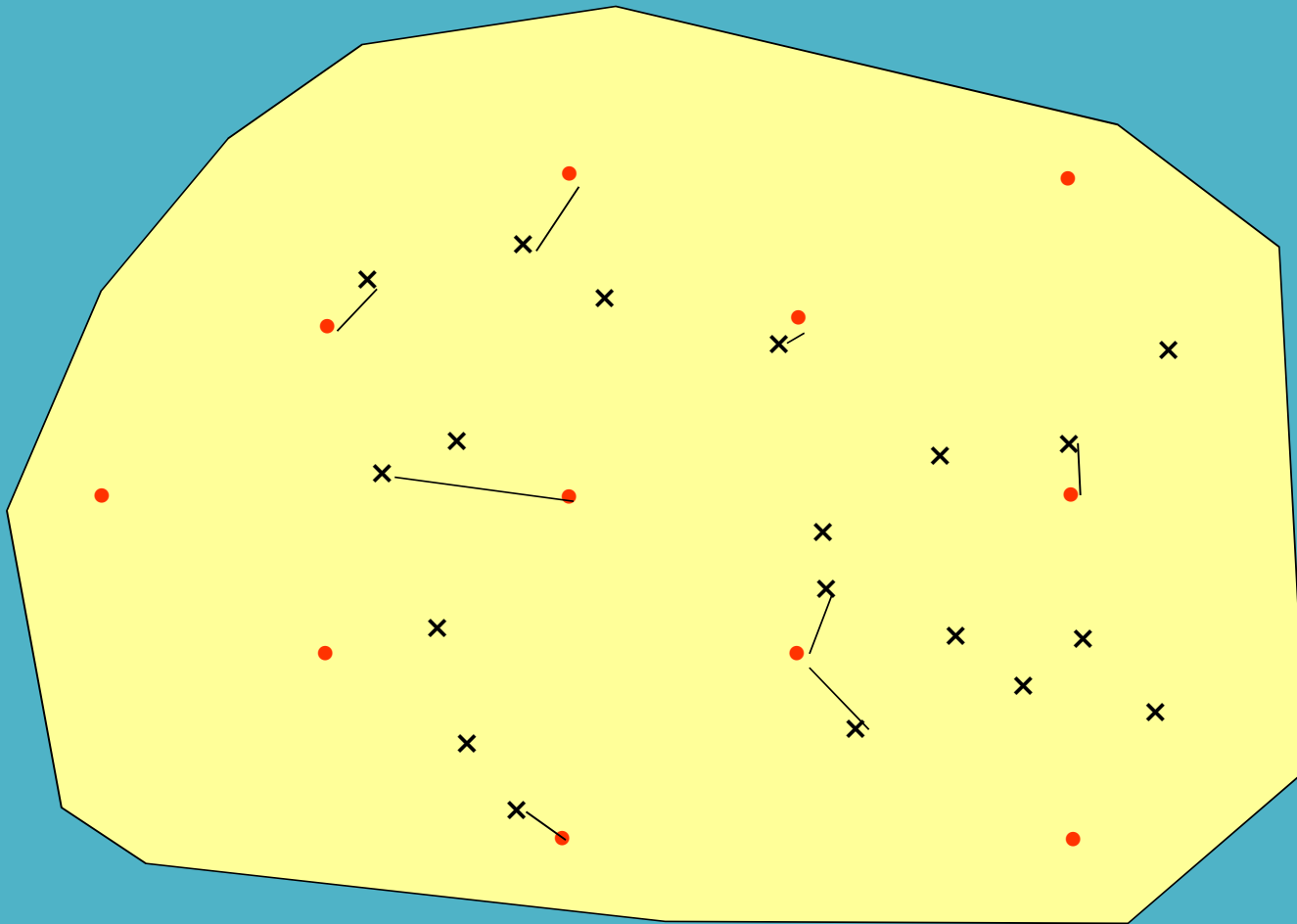


Point transect sampling



Random points or systematic grid of points randomly placed; observer records distance to any detected animals

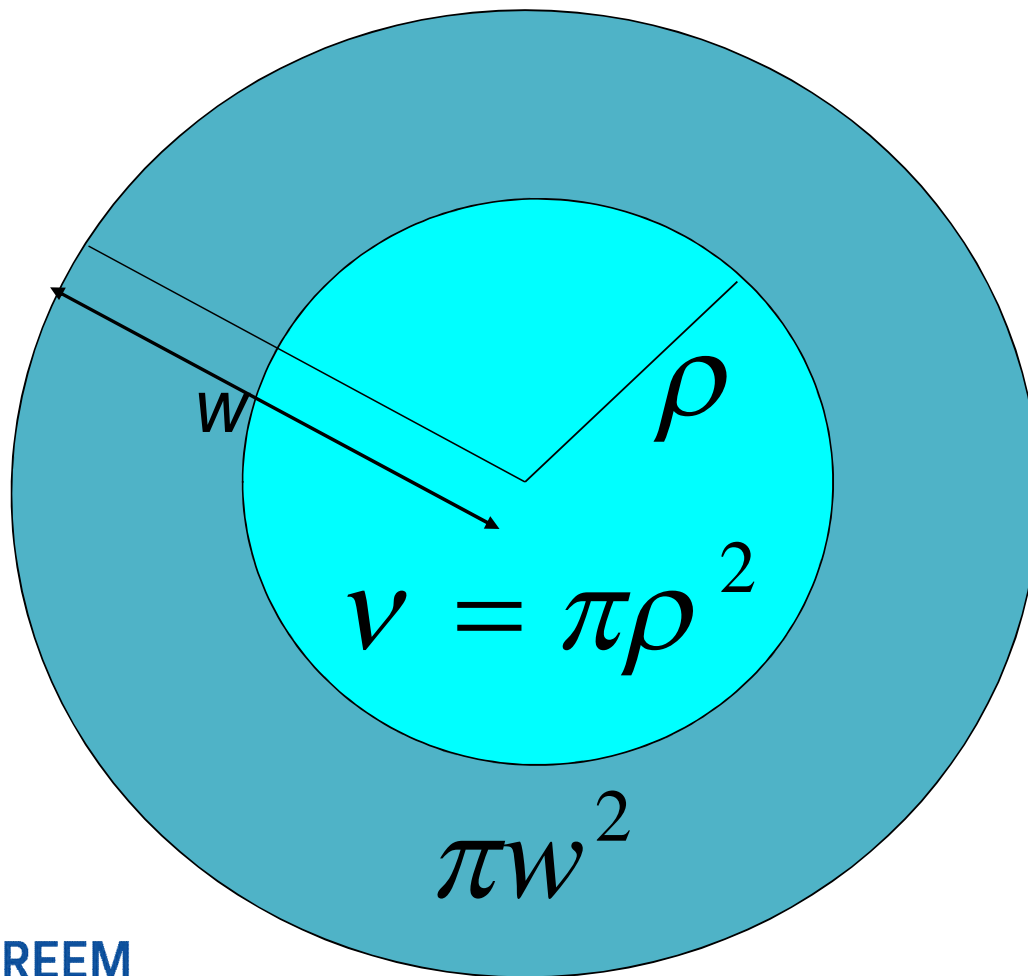
Point transect sampling

For k point counts with certain detection to distance w :

$$\hat{D} = \frac{n}{k\pi w^2}$$

How does this change if detection is uncertain?

Effective radius and effective area



ρ = effective radius

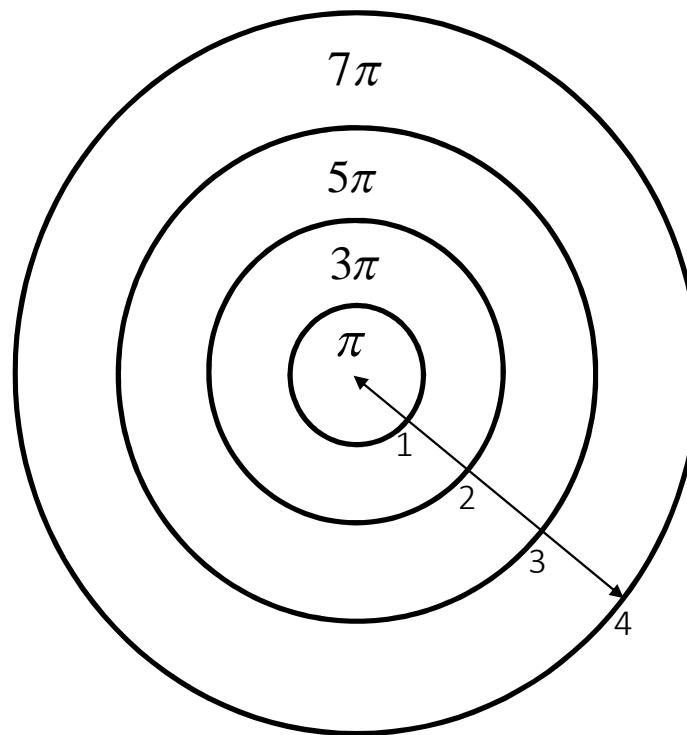
v = effective area

Covered area: $a = k\pi w^2$

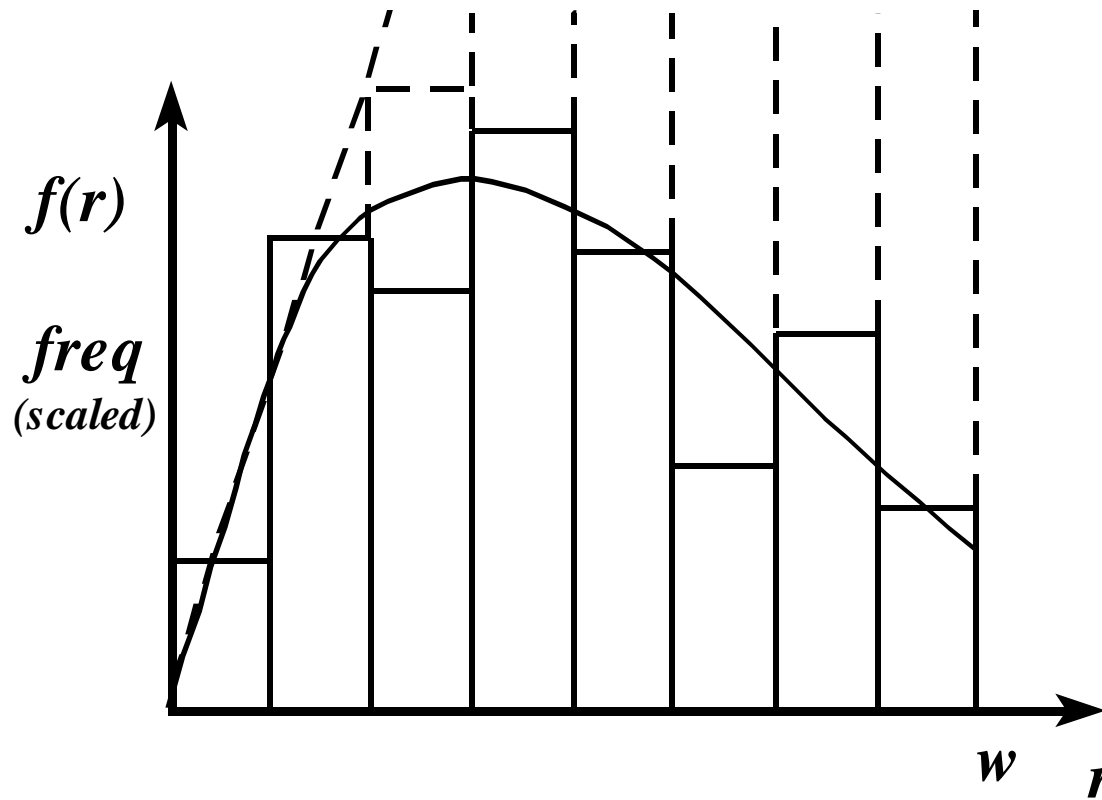
Proportion detected: $P_a = \frac{k\pi\rho^2}{k\pi w^2} = \frac{\rho^2}{w^2}$

Estimated density: $\hat{D} = \frac{n}{a\hat{P}_a} = \frac{n}{k\pi w^2 \times \hat{\rho}^2 / w^2} = \frac{n}{k\pi\hat{\rho}^2}$

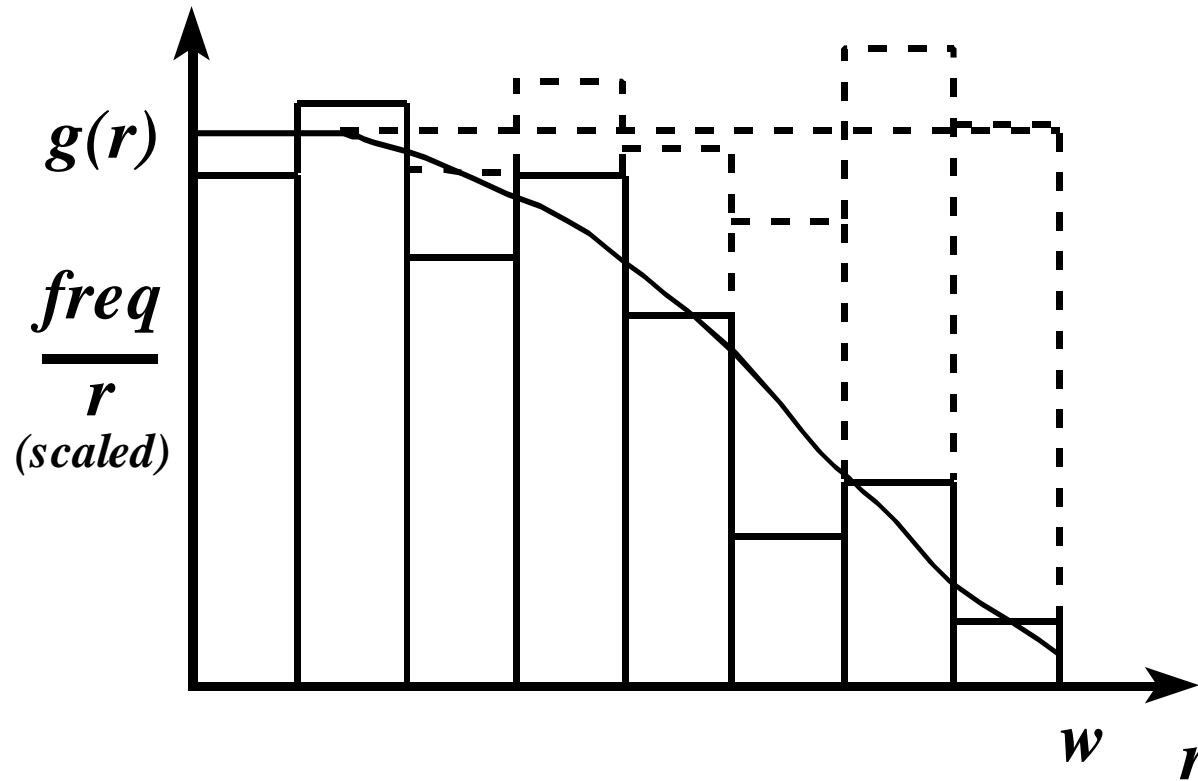
Area and hence number of birds increase linearly with distance:



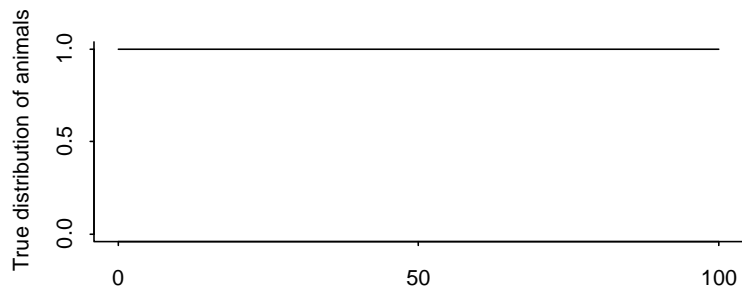
Probability density function



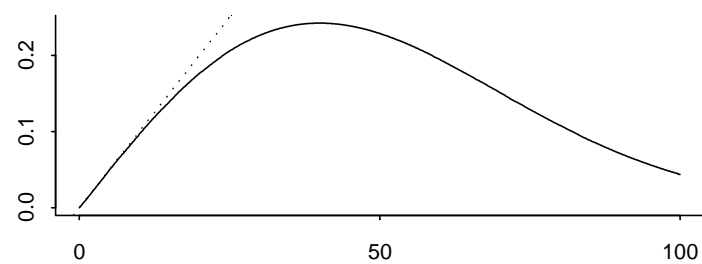
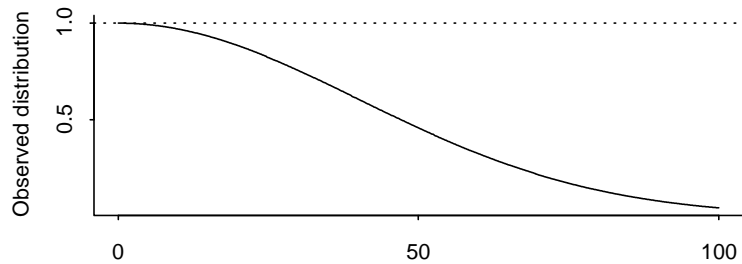
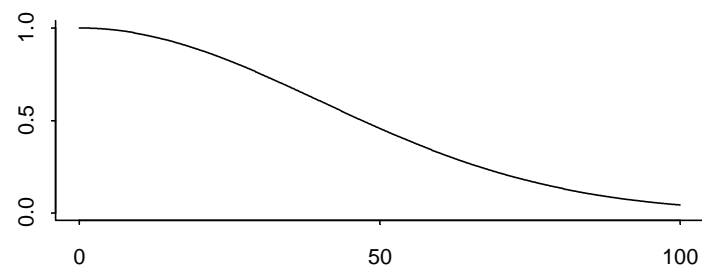
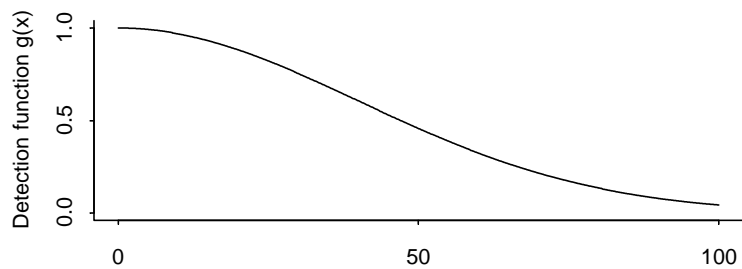
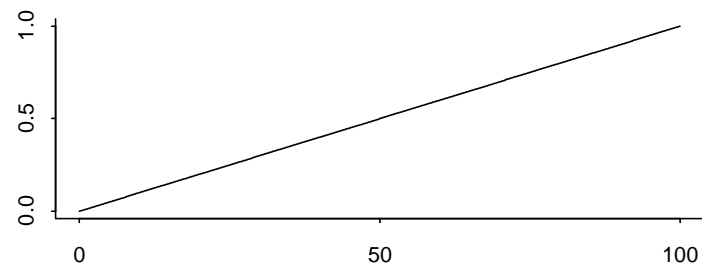
Detection function



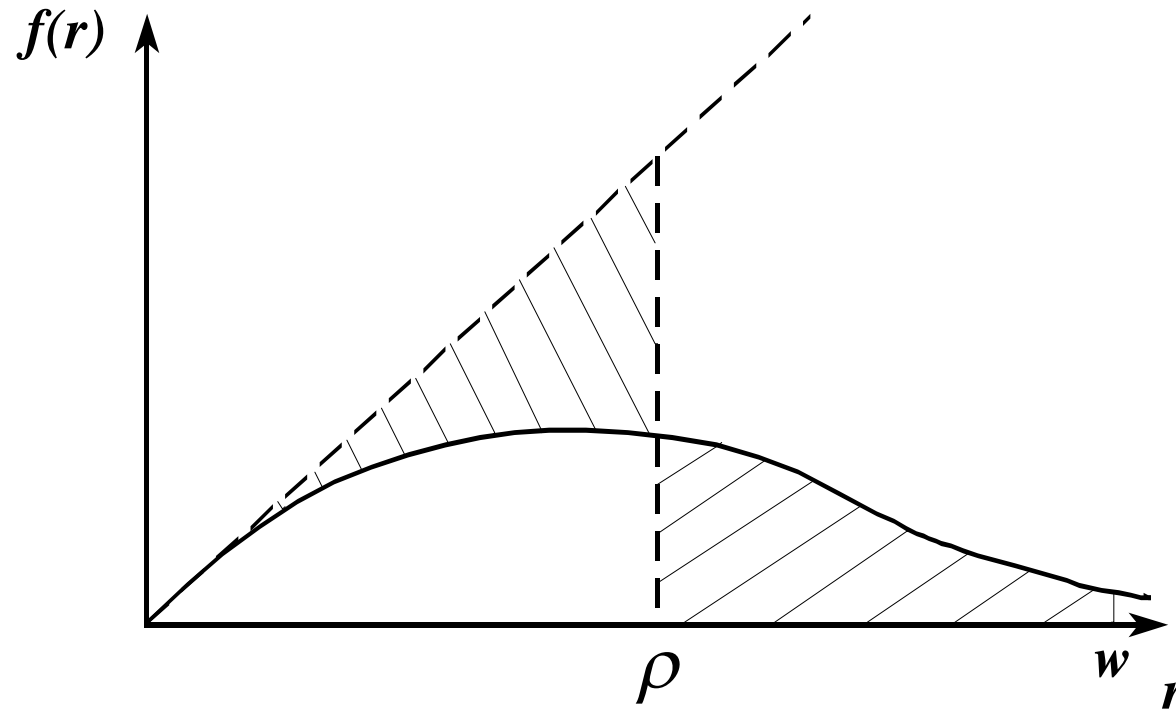
Line transect



Point transect



The effective radius ρ ...



... is the distance such that as many birds beyond ρ are detected as are missed within ρ of the point.

Area under curve:

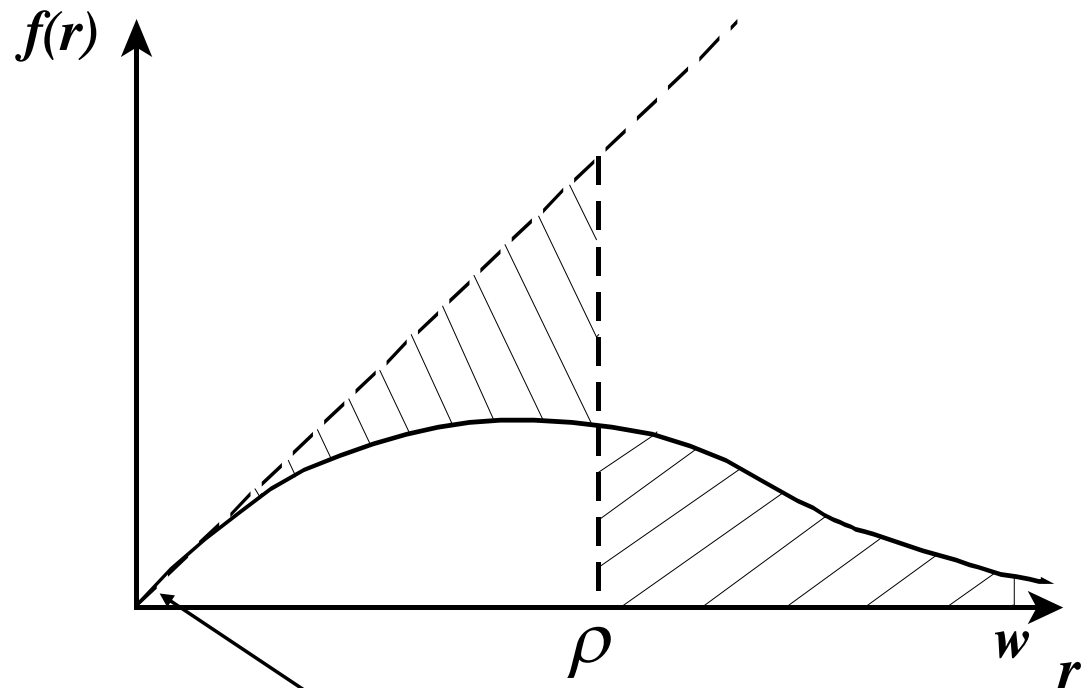
$$\int_0^w f(r) dr = 1$$

Area of triangle:

$$\frac{\rho \times \rho f'(0)}{2} = \frac{\rho^2 h(0)}{2}$$

Hence $\hat{\rho}^2 = \frac{2}{\hat{h}(0)}$ and $\hat{v} = \frac{2\pi}{\hat{h}(0)}$

so that $\hat{D} = \frac{n\hat{h}(0)}{2\pi k}$



Slope = $h(0)$

Notation: point transects

Known constants and data:

k = number of points

n = no. of animals or clusters detected

r_i = distance of i^{th} detected animal or cluster from the point, $i = 1, \dots, n$

w = truncation distance for r

A = size of region of interest

a = size of covered region = $k\pi w^2$

s_i = size of i^{th} detected cluster, $i = 1, \dots, n$

Point transect notation (cont)

Functions:

$g(r)$ = detection function

$f(r)$ = probability density function (pdf) of detection distances

$h(r) = f'(r)$ = slope of pdf $f(r)$

$h(0)$ = slope of pdf evaluated at $r=0$

Comparative study^a

1. Point transect, 5-minute counts (9.8 hrs)
2. Point transect, snapshot method (8.4 hrs)
3. Cue counting, 5 mins per point (10.0 hrs)
4. Line transect sampling (7.9 hrs)
5. Territory mapping

^aBuckland, S.T. 2006. Point-transect surveys for songbirds: robust methodologies. *The Auk* 123:345-357.

Focal species in Montrave study

Chaffinch
Fringilla coelebs



Robin
Erithacus rubecula



Great tit
Parus major



Wren
Troglodytes troglodytes



Study area, Montrave Estate

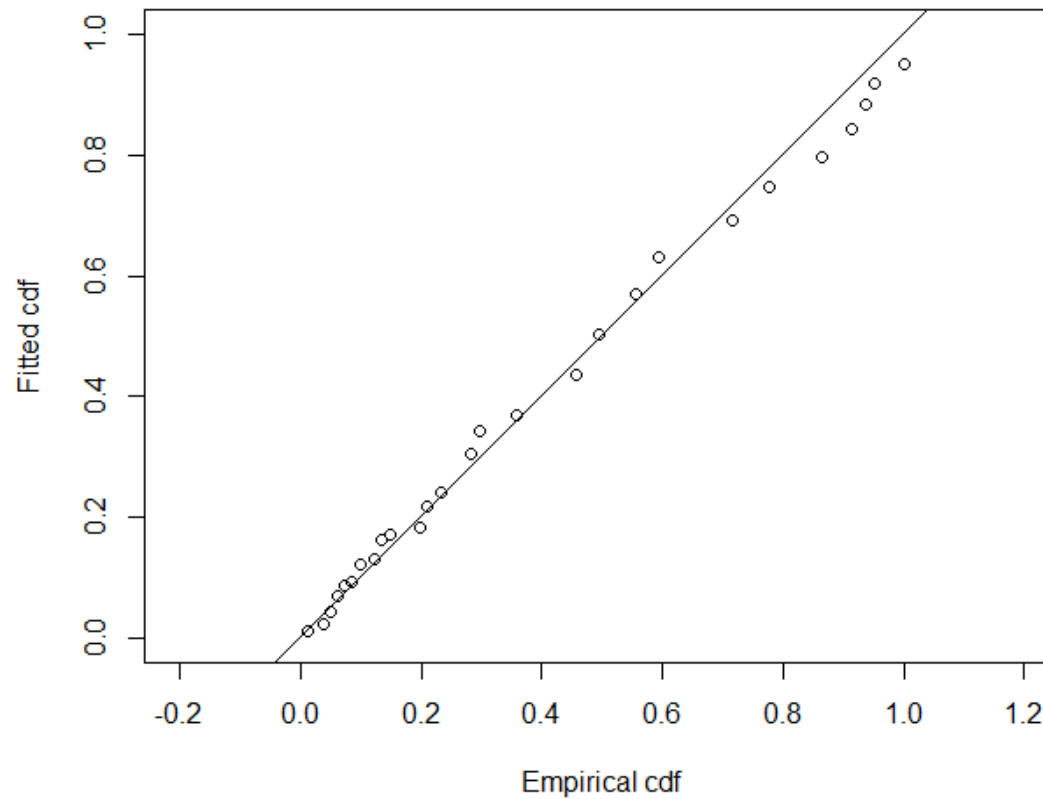


Parkland and
mixed woodland
33.2 ha
 $k = 32$ points

The data

	Chaffinch	Great tit	Robin	Wren
M1 ($w=110m$) n :	74	44	57	132
M2 ($w=110m$) n :	63	18	50	117
M3 ($w=92.5m$) n :	627	177	785	765
Cue rate:				
Sample size	33	12	26	43
Mean	7.9	8.2	17.9	7.3
M4 ($w=95m$) n :	73	32	80	155
M5 territories:	25	7	28	43

Example analyses: chaffinch

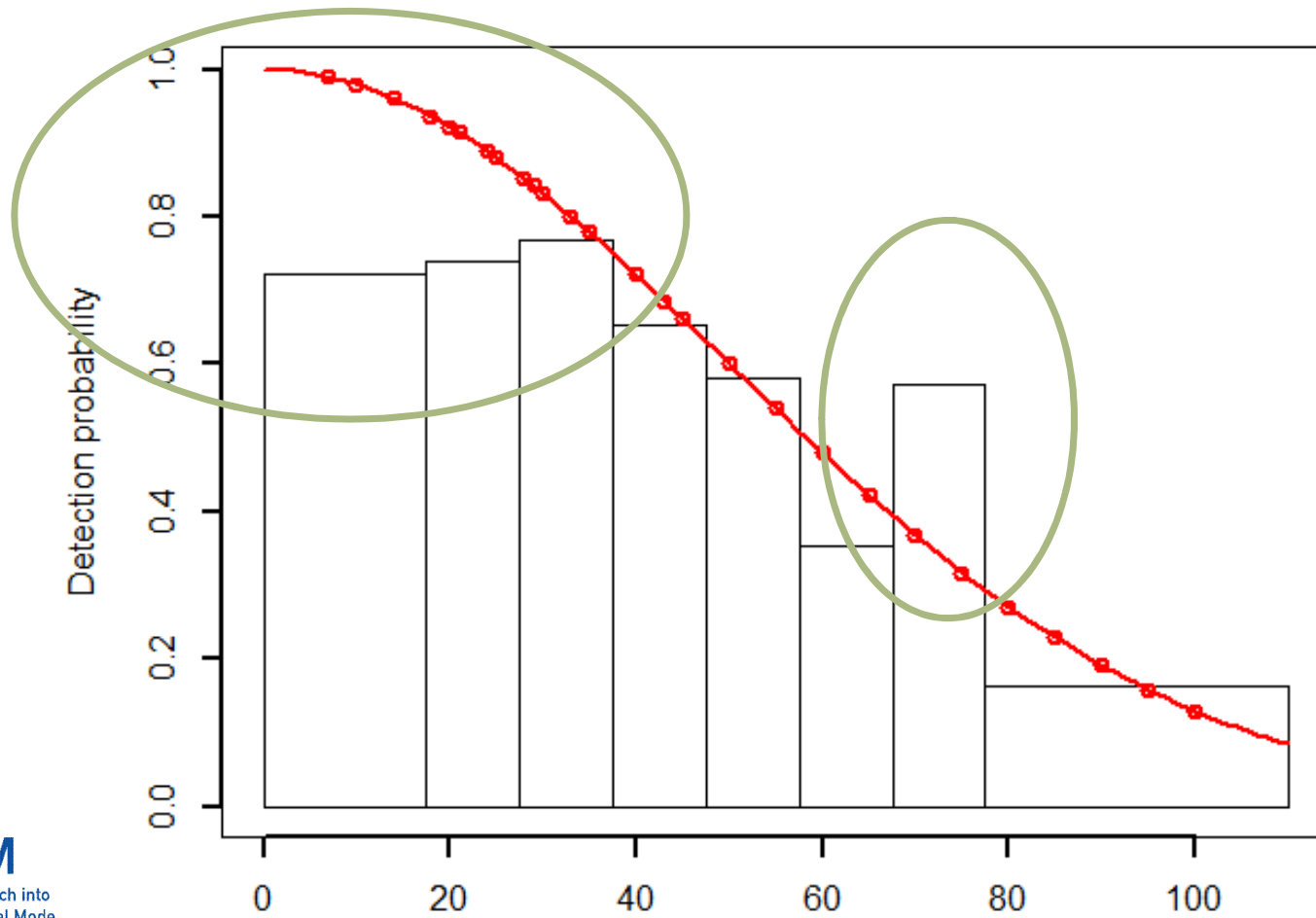


K-S and C-von M tests

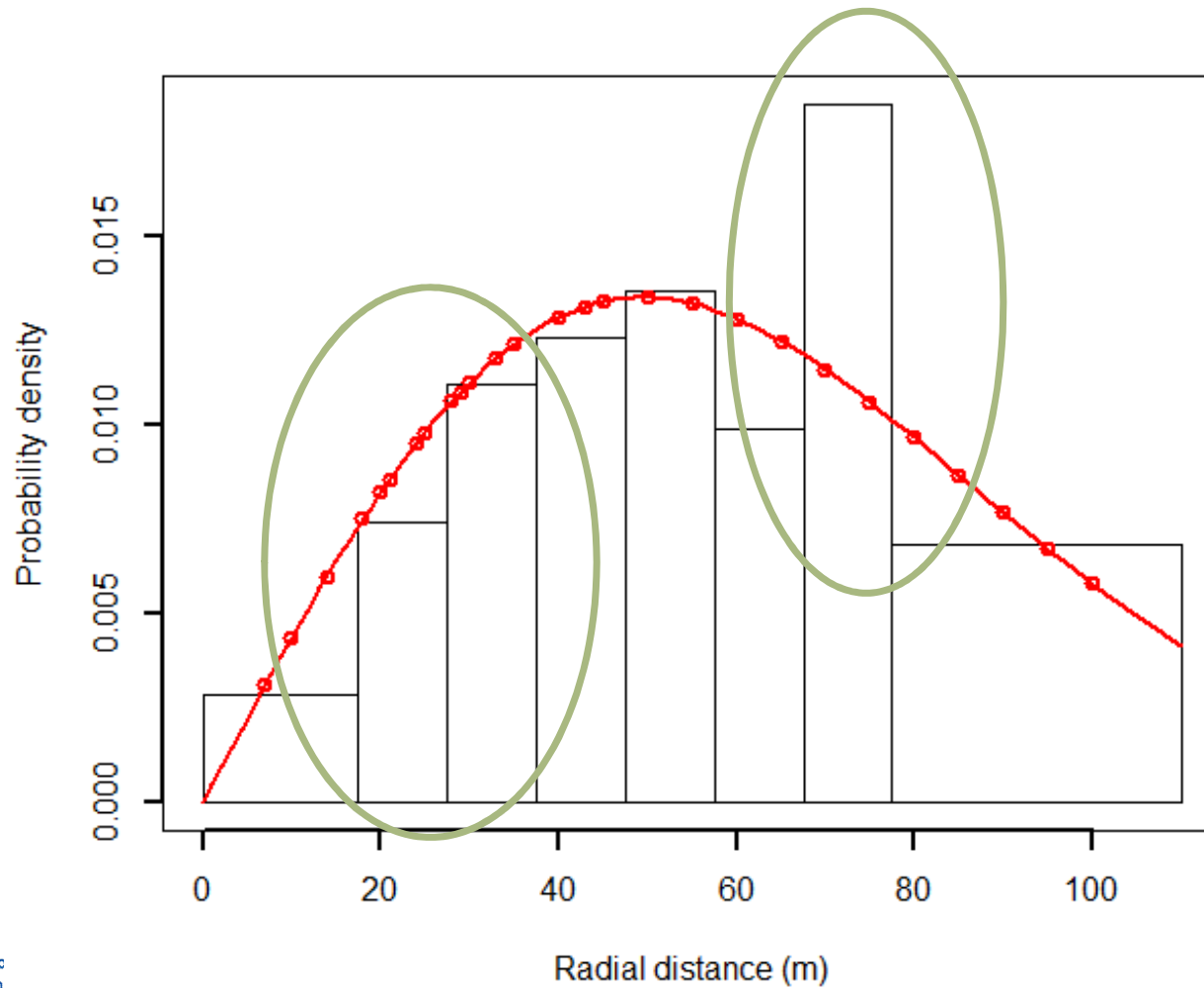
Distance sampling Kolmogorov-Smirnov test
Test statistic = 0.0978209 p-value = 1
(p-value calculated from 100/100 bootstraps)

Distance sampling Cramer-von Mises test (unweighted)
Test statistic = 0.119375 p-value = 0.497973

Detection function



Probability density function



Chi-square gof test

Goodness of fit results for ddf object

Chi-square tests

	[0,17.5]	(17.5,27.5]	(27.5,37.5]	(37.5,47.5]
Observed	4.0000000	6.0000000	9.0000000	10.0000000
Expected	5.3587946	7.2910947	9.4176515	10.57407254
Chisquare	0.3445407	0.2286248	0.0185219	0.03116673

	(47.5,57.5]	(57.5,67.5]	(67.5,77.5]	(77.5,110]
Observed	11.00000000	8.0000000	15.000000	18.00000000
Expected	10.768415022	10.1474426	8.946303	18.49622571
Chisquare	0.004980455	0.4544504	4.096356	0.01331298

	Total
Observed	81.000000
Expected	81.000000
Chisquare	5.191954

P = 0.51944 with 6 degrees of freedom

Estimation summary

Summary for distance analysis

Number of observations : 81

Distance range : 0 - 110

Model : Half-normal key function

AIC : 742.9418

	Estimate	SE	CV
Average p	0.3708652	0.05784886	0.1559835
N in covered region	218.4081865	39.12979423	0.1791590

Summary statistics:

	Region	Area Covered	Area	Effort	n	k	ER	se.ER	cv.ER
1	Montrave	33.2	243.2849	64	81	32	1.265625	0.1269691	0.1003213

Abundance:

	Label	Estimate	se	cv	lcl	ucl	df
1	Total	29.80518	5.527653	0.1854595	20.70305	42.90909	110.9021

Density:

	Label	Estimate	se	cv	lcl	ucl	df
1	Total	0.8977464	0.1664956	0.1854595	0.6235858	1.292442	110.9021

Estimation summary (cont.)

Measurement Units

Density: Numbers/hectares
EDR: metres

Component percentages of variance:

.Label	Detection	ER
Total	70.74	29.26

Estimated densities

Method	Chaffinch		Great Tit		European Robin		Winter Wren	
	\hat{D}	95% CL	\hat{D}	95% CL	\hat{D}	95% CL	\hat{D}	95% CL
Conventional point sampling	1.03	0.74-1.43	0.58	0.36-0.94	0.52	0.26-1.06	1.29	0.80-2.11
Snapshot	0.90	0.62-1.29	0.22	0.13-0.39	0.60	0.38-0.94	1.02	0.80-1.32
Cue-count	0.71	0.45-1.23	0.26	0.09-0.76	0.82	0.52-1.31	1.21	0.82-1.79
Line transect	0.64	0.46-0.90	0.26	0.16-0.42	0.69	0.47-1.00	1.07	0.87-1.31
Territory mapping	0.75		0.21		0.84		1.30	

Estimated effective detection radii (meters)

Method	Chaffinch		Great Tit		European Robin		Winter Wren	
	$\hat{\rho}$	95% CL	$\hat{\rho}$	95% CL	$\hat{\rho}$	95% CL	$\hat{\rho}$	95% CL
Conventional point sampling	67	58-78	62	51-74	74	52-104	71	57-90
Snapshot	67	57-78	64	54-75	65	54-77	75	69-83
Cue-count	74	70-79	65	58-71	51	47-57	66	63-69
Line transect [†]	59	48-72	63	47-84	60	44-83	75	65-86

[†]effective strip half-width shown for line transect method

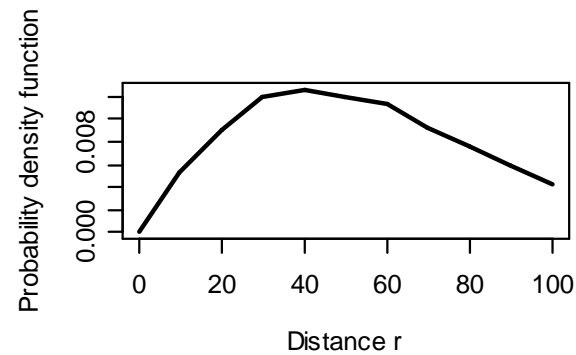
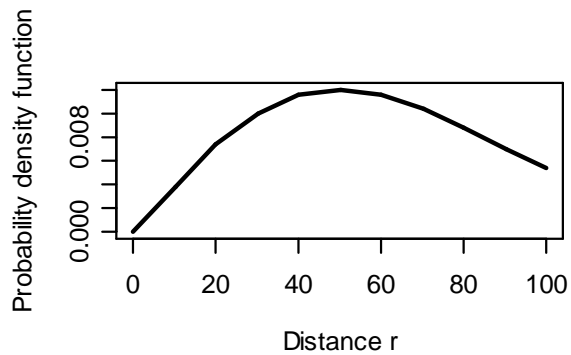
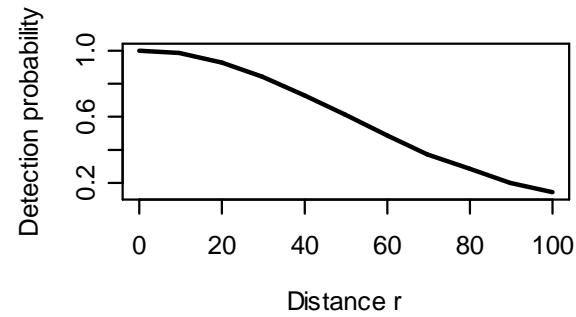
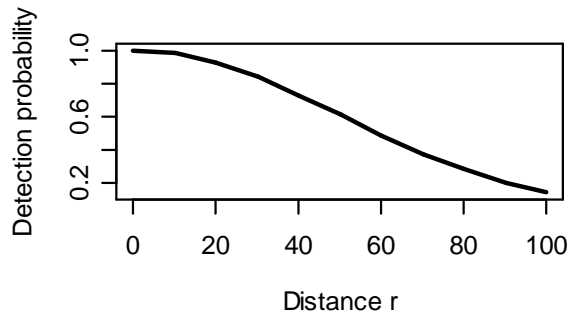
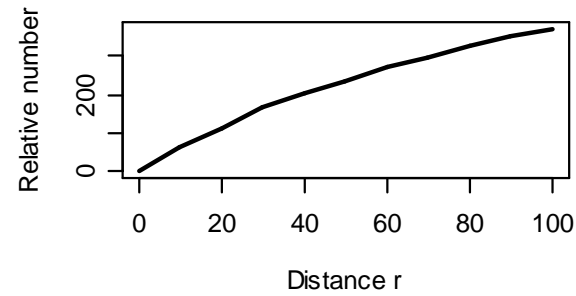
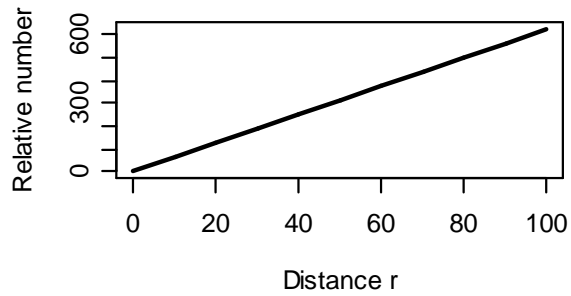
Estimated hours of fieldwork to obtain a 10% CV for estimated density

Method	Common chaffinch	Great tit	European robin	Winter wren
Conventional point sampling	28	60	131	61
Snapshot	29	70	44	14
Cue-count	56	352	57	40
Line transect	22	49	29	11

Simulation study, three investigations

1. All assumptions satisfied:
half-normal model, 1000 replicates
2. Overlapping points:
Point separation 100m, effective detection radius 106m
3. Edge effect (similar to Montrave study area),
no sampling in buffer zone, birds detected outside study area
boundary not recorded

Edge effect simulation



Simulation results – true density = 1

	Popn 1	Popn 2	Popn 3	Popn 3, w=80m
\bar{n}	353	354	41	32
mean	1.0029	1.0056	0.9509	0.9961
sd	0.0706	0.0815	0.1924	0.3160
se(mean)	0.0022	0.0026	0.0061	0.0100
mean(se)	0.0754	0.0750	0.2099	0.3557

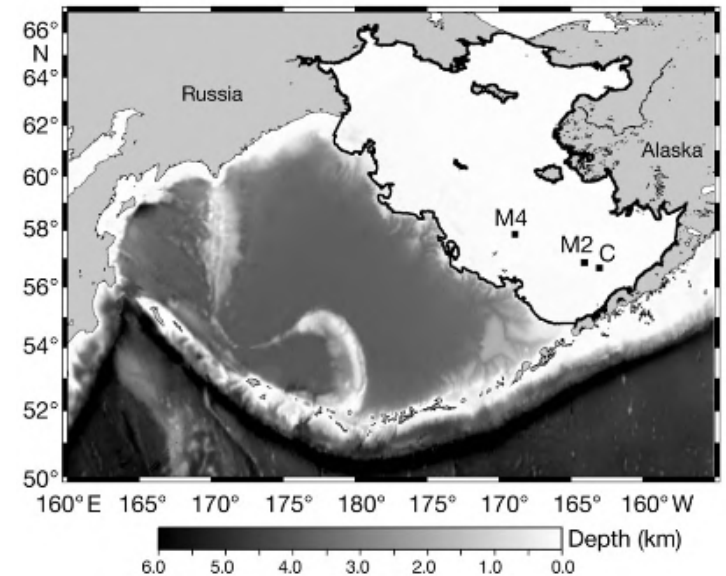
Popn 1: all assumptions hold

Popn 2: overlapping plots

Popn 3: edge effect

Point transects with marine mammals

- Seafloor mounted acoustic recording packages deployed and listening for right whale “up-calls”
- Constitutes an example of cue counting
- Analysis incorporated
 - false-positive proportion in call classification,
 - ambient noise as covariate,
 - left truncation because of inexact distance estimation at small distances



Not a recommended allocation of survey effort; proof of concept

Right whale abundance estimates

- Detection probability of 0.29 (CV=2%) from fitted model
- Density estimate of 0.26 whales per 10000km² (CV=29%)
- Abundance in shelf region of Bering Sea: 25 (CI: 13-47)

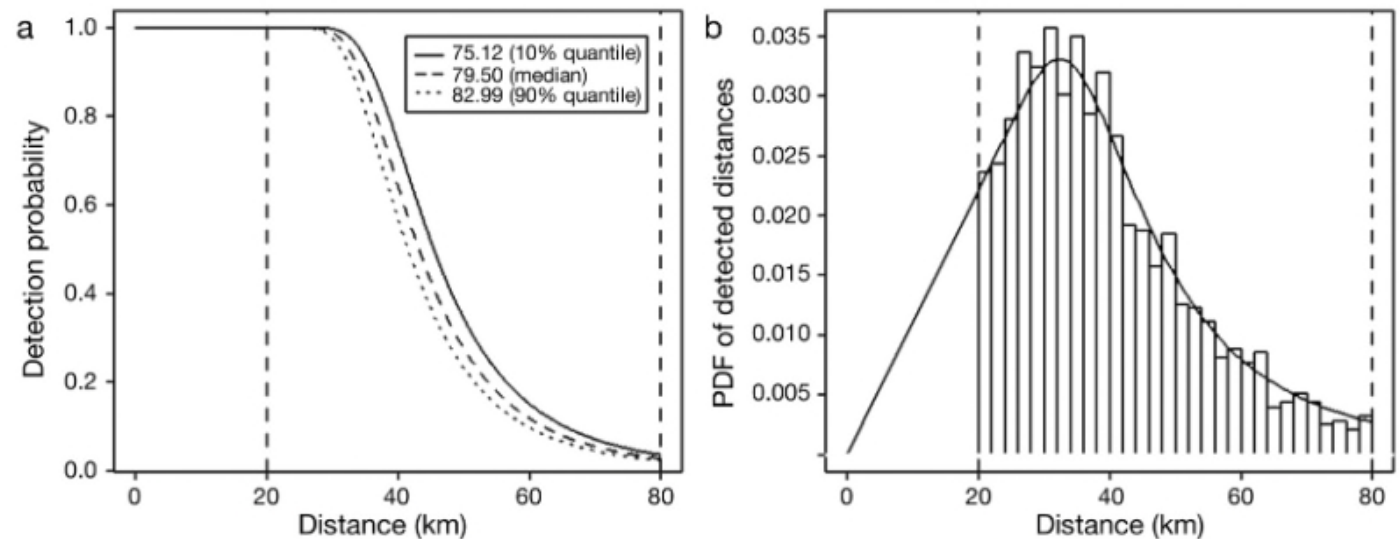


Fig. 2. Distances to detected right whale calls and fitted model: (a) shows the detection function (as a function of distance, for 3 values of the noise covariate, namely the 10, 50, and 90% quantile of the observed distribution) and (b) corresponds to the probability density function (PDF) of detection distances, and goodness-of-fit could be judged based on this plot. Vertical dashed lines represent the left and right truncation distances

See Marques, Munger, Thomas, Wiggins and Hildebrand (2011) Estimating North Pacific right whale density using passive acoustic cue counting. *Endangered Species Research* 13:163-172.