Index

Akaike's Information Criterion (AIC) 44, 75–6, 113–14, 151–2
Arapaho point transect songbird surveys 402–9
Assumptions
accurate measurements 18, 34–6, 137, 170–1, 317–35
cue counting 270–4
failure of
double counting of objects 37, 171, 314, 336
movement in response to observer 18, 31–4, 136, 168–70, 314, 336
random object movement 19, 32, 136, 168, 336
g(0) = 1 18, 30–1, 136, 167
independence between detections 36, 135–6
line transect sampling 135–7
migration counts 284, 286–7
point transect sampling 166–71
random distribution of objects 18, 29, 135, 166–7
shoulder to the detection function 36–7, 167–8
trapping webs 278–80
Audio-detectability function 184

Bayesian approach to distance sampling 260, 263
Bias
due to double counting 32
due to g(0) < 1 30, 138
due to measurement error 34–5, 137, 170–1
due to movement in response to observer 32–4, 136, 168–70
due to random object movement 136, 168
in estimates of g0 205–8
model mis-specification 96, 120, 158
Binomial models 173–8, 409–14
Bivariate detection function 81–7, 102–3, 134–5, 235–44
Bootstrap 94–6, 119–20, 155–8

Clusters
as ancillary data 16
definition 12
line transects 122–35
point transects 158–66
size-biased detection 77–87
Clustered populations
estimation in line transect surveys
bivariate approach 102–3, 134–5
cluster size independent of detection distance 122–5
covariate approach 80, 102–3
regression estimator 79–80, 132–4
replacement of cluster by individual objects 131
stratification 132
truncation 130–1
estimation in point transect surveys
cluster size independent of detection distance 159
covariate approach 80, 102
regression estimator 79–80, 165–6
replacement of cluster by individual objects 164
stratification 164–5
truncation 161–4
estimation theory 77–87
modelling theory 77–87
modelling variation in cluster size 199
simulation of 235–44

441
INDEX

Coefficient of detectability 179
Complementary log-log model 61, 184
Confidence intervals
  bootstrap 94–5, 155–8
  jackknife 93
  log-based 88–9, 118, 154
  numerical comparisons 254–60
  profile likelihood intervals 247
  Satterthwaite degrees of freedom for 89–90, 120–1
  standard method 88, 118, 154
Covariates 80, 99–100, 102–3, 193–8, 200, 287–9
Cox method 177–8
Cue counting 8–9, 270–5
‘CumD’ estimator 180–1
Cutpoints 15

Darkling beetle trapping web surveys 282–4

Data
  analysis of grouped or ungrouped 110–11, 149–50
  ancillary 16–17
  grouped 14–15, 67–9, 116, 152–3, 322, 326–33
  recording form 317–18
  spiked 127
  truncation 15, 50, 106–9, 146–8
  ungrouped 13–14, 65–7, 323–6
  units of measurement 16
Density estimation 1, 37–41, 87–8, 116–17, 153–5
Density function 54–7
Design 298–313
Detection function
  bivariate 81–7, 102–3, 134–5, 235–44
  models for see Estimators; Models relationship with pdf
  line transect sampling 54–5
  point transect sampling 56
  shape criterion 37, 42–4, 74
  with covariates 80, 99–100, 102–3
Dispersion parameter 102, 187–93, 199
DISTANCE
  computer program 27–8
  constrained MLE 73, 137
  cue count option 271
  GOF 396
LOOKAHEAD 113, 151, 399
OBJECT 404
PVALUE 401
SAMPLE, use with replicate lines or points 91
Satterthwaite procedure 125
SELECT 113, 151, 400
Distances
  density function of 54–7
  measurement of 34–6, 137, 170–1, 317–35
  simulation of 235–44
  truncation 15, 50, 106–9, 146–8
Dolphin relative abundance estimates 390–6
Doughnut or Donut 170
Duck nest surveys 19–21, 359–80
Effective area 56
Effective strip
  half-width 56
  width 23, 56
Efficiency
  of binomial point transect model 175
  estimator 44, 74
Empirical estimators 178–81
Encounter rate 186–98
Estimation
  of line length to be surveyed 301–6, 308–12
  of number of points to be surveyed 307–8
  of object density
    cue counting 271
    line transects 37–9, 41, 87, 116–17
    nearest neighbour methods 292–3
    point-to-object methods 292–3
    point transects 40–1, 87–8, 153–5
    trapping webs 280
    when objects are in clusters 77–87, 122–35, 158–66
Estimator efficiency 44, 74
Estimators
  Cox 177–8
  ‘CumD’ 180–1
  empirical 178–81
  isotonic regression 180
  kernel 182–3
  maximum likelihood 65–73
INDEX

shape restricted 181–2
see also Models

Examples

cue counting
  Antarctic minke whale surveys 272–7
line transect sampling
dolphins 390–6
duck nests 359–80
fin whales 380–90
Lake Huron brick data 351–3
wooden stakes 353–8
migration counts
  California grey whales 285–93
point transect sampling
  Arapaho NWR songbird surveys 402–9
  house wrens 396–401
  songbird surveys of Welsh conifer plantations 409–41
trapping webs
  darkling beetle surveys, Wyoming 282–4
mouse surveys, New Mexico 282
Exponential power series model 26
Exponential quadratic model 26

Field methods
  for mobile objects 337–8
    when detection on centreline is not certain 338–9
Finite population correction factor 96–8
Fin whale line transect surveys 380–90
Fisher information matrix 66, 68
Fourier series model 48, 63–4

Generalized exponential model 134
Genstat 288
Goodness of fit tests 44–6, 76–7, 114–16, 152–3
Grey whale migration count surveys 285–93

Half-normal model
  binomial 174–6
  bivariate 102–3, 126–7, 134, 154–5
  as a key function 46–8, 63–4
  line transect sampling 70–1, 238–40, 245–8, 257–9

point transect sampling 71–2, 240–3, 252–4
Hazard-rate analysis
  continuous 58–62
  discrete 183–5
Hazard-rate model
  definition 60
  derivation 58–62
  discrete 184
  as a key function 46–8
Heaping 35, 110–1, 149
Hermite polynomial model 46–8, 63–4
Hessian matrix 66
Heterogeneity
  behaviour of animals 207–8
  covariates 99, 205
  environmental 207
  observer 206–8
  platform 206–8
  stratification 99–102, 205
House wren point transect surveys 396–401

Information matrix 66, 68
Innate detectability 217–25
Interval estimation 88–96, 118–21, 154–8

Jackknife 92–4
Kelker strip 23, 54
Kernel estimation methods 182–3
Key function
  definition 46, 62–3
  exponential 49
  formulation for distance data 62–5
  half-normal 46–8, 63–4
  hazard-rate 46–8
  uniform 46–8, 64

Lake Huron brick data 351–3
Likelihood function
  full likelihood approach 244–63
  grouped data 67
  half-normal 70–2
  ungrouped data 65
Likelihood ratio test (LRT) 74–5, 112–13, 150–1
LINETRAN 26
Line transect sampling
INDEX

Line transect sampling contd
analysis guidelines 49–51, 137–40
assumptions 18–19, 29–37, 135–7
examples 351–96
field comparisons with point
transect sampling and mapping
censuses 339–48
field methods 295–349
full likelihood approach 245–51,
257–9
hazard-rate modelling of detection
process 58–61, 183–4
history 23–7
method and analysis 104–40
strengths and weaknesses 141–2,
296–7
survey design 298–306, 308–12
three-dimensional 263–6

Mark–recapture
double counting
in \( g_0 \) estimation 206–7, 210, 216
in migration counts 287–9
likelihood models 262
trapping webs 275, 281
Maximum likelihood estimators
(MLE)
Maximum likelihood methods
full likelihood approach 244–63
grouped data 67–9
theory 65–73
ungrouped data 65–7
Measurements 16, 34–6, 317–35
Migration counts 284–93
Minke whale cue counting surveys
272–7

Modelling
\( g(y) \) 58–64
philosophy and strategy 41–6
\( var(n) \) 90–1, 109–10, 148–9, 186–98
variation in encounter rate 186–98
variation in cluster size 199
Model robustness 42, 73

Model selection
AIC 75–6, 113–14, 151–2
criteria 73–4
goodness of fit 76–7, 114–16, 152–3
guidelines for 50–1
likelihood ratio test 74–5, 112–13,
150–1
line transects 111–16
point transects 150–3

Models
binomial 173–8, 409–14
bivariate 81–7, 102–3, 134–5, 235–44
complementary log-log 61, 184
exponential power series 26
exponential quadratic 26
Fourier series 48, 63–4
generalized exponential 134
half-normal
as a key function 46–8, 63–4
binomial 174–6
bivariate 102–3, 126–7, 134, 154–5
line transect sampling 70–1,
238–40, 245–8, 257–9
point transect sampling 71–2,
240–3, 252–4
hazard-rate 46–8, 58–62, 184
Hermite polynomial 46–8, 63–4
multinomial 67–9
negative exponential 24, 134,
248–52
reversed logistic 134
see also Estimators
Monte Carlo simulation 235–44
Mouse trapping web surveys 282
Multinomial model 67–9

Nearest neighbour methods 9, 292–4
Negative exponential model 24, 134,
248–52
Newton–Raphson 66
Non-parametric estimators 177–83

Outliers 35–6

Parsimony 44, 76, 102, 188, 200
Pilot study 295, 303–8, 349
Point process model 183, 193–200
Point-to-object methods 9, 292–4
Point transect sampling
analysis guidelines 49–51, 171–2
assumptions 18–19, 29–37, 166–71
examples 396–414
field comparisons with line
transect sampling and mapping
censuses 339–48
field methods 295–349
full likelihood approach 251–4
hazard-rate modelling of detection
process 61–2, 184–5
INDEX

Point transect sampling contd
  history 27
  method and analysis 141–72
  strengths and weaknesses 141–2, 296–7
  survey design 298–303, 307–8
  three-dimensional 266–70
Poisson
  distribution of objects 18, 29, 36
  variance of $n$ 50, 88, 109–10, 119, 148–9, 188
Polynomials
  Hermite 46–8, 63–4
  simple 46–8, 62–4
Pooling robustness 42, 74
Post-stratification 77–9, 99, 308, 392
Precision, measures of see Variance
Probability density function (pdf) 54–7
Profile likelihood
  definition 247
  line transects 247–51, 254–60
  point transects 251–6, 259–60
Quasi-likelihood 189, 192–3
Regression
  estimator of mean cluster size 79–80, 132–4, 165–6
  isotonic 180
  linear 79–80
  logistic 288–9
  weighted linear 363
Replicate lines or points
  bootstrap 95–6
  jackknife 92–4
  in survey design 6–7, 298–301
  variance estimation 90–2, 109–10, 148–9
Reversed logistic model 134
Robust estimation
  criteria for 41–2, 73–4
  models for 46–9
  variance 94–6, 119–20, 155–8
Sample size
  fixed or random 225–35
  modelling variation in 186–98
Sampling in three dimensions
  line transects 263–6
  point transects 266–70
Satterthwaite correction 89–90, 120–1, 125
Searching behaviour 313–16
Semiparametric model 42, 73
Series expansions
  cosine series 46–8, 63–4
  Fourier series 48, 63–4
  Hermite polynomials 46–8, 63–4
  simple polynomials 46–8, 62–4
Shape criterion 36–7, 42–4, 54, 74, 167–8
Shape restriction estimator 181–2
Shoulder 36–7, 42–4, 54, 74, 167–8, 217–25
Simple polynomials 46–8, 62–4
Simplex procedure 66
Simulations 235–44
Size-biased sampling 13, 77–87, 125–35, 158–66
SIZETRAN 103, 134
Smearing 319–22
Smoothing methods 392–6
Statistical theory 52–103
Stratification
  by cluster size 77–9, 132, 164–5
  post-stratification 77–9, 99, 308, 392
  to reduce heterogeneity 99–102, 205
Strip transect sampling 3–4, 12, 41, 296, 337
Survey design 298–313
Test power 44–6
Training 319, 325, 335–6
TRANSECT 26, 73
Trapping webs 7–8, 275–84
Truncation
  for reducing bias in estimating mean cluster size 130–1, 161–4
  for robust estimation of detection function 15, 50, 106–9
  left-truncation 15, 273–7, 377–9
  line transects 106–9
  point transects 146–8
Units of measurement 16
Variable circular plots see Point transect sampling
Variance
  bootstrap 94–6, 119–20, 155–8
  delta method 53

445
INDEX

Variance contd
finite population correction factor
  96–8
inflation factor 102, 187–93, 199
jackknife 92–4
of mean cluster size 77–81, 123, 159, 199
reduction using spatial models
  186–200

of sample size 90–1, 109–10, 148–9, 186–98
use of information matrix
  66, 68
use of replicate lines or points
  90–2, 109–10, 148–9
Visual-detectability function 184

Welsh point transect surveys in
conifer plantations 409–14
Wooden stake data 353–8