SAEON Ndlovu Node
Kruger National Park
Private Bag X1021
South Africa
Tel: (013) 735 3536
Int. Code: +27
rion@saeon.ac.za

www.saeon.ac.za

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation

SAEON South African Environmental Observation Network

OLIFANTS, GA-SELATI RIVERS:
2014 WATER-DEPENDENT BIRD SURVEYS IN THE PHALABORWA AREA

Rion Lerm
November 2014

INTRODUCTION AND METHODS

Long-term monitoring of animal communities can assist in understanding the processes that govern community patterns over time. Birds especially, are good indicators of environmental health as they are surrogates for other taxa and are easy to survey. Changes in river water quality and -quantity however, may affect habitat- and food availability of water-dependent birds. These changes may alter community composition, species richness and abundances. The latter is of special concern when Red Data (Taylor, 2014) species are present.

The aim of this monitoring project is to detect any changes in the status of water-dependent birds of the two perennial rivers that flow alongside Palabora Copper Limited properties (the Olifants and Ga-Selati rivers), as well as to assess the suitability of the method used, in terms of the ability to detect annual changes in biodiversity.

Surveys of water-dependent birds of the Olifants and Ga-Selati rivers are conducted during the month of October on an annual basis, since 2012. Certain regions of these rivers were selected for their differing upstream impacts. These regions (1-4) show in Figure 1.

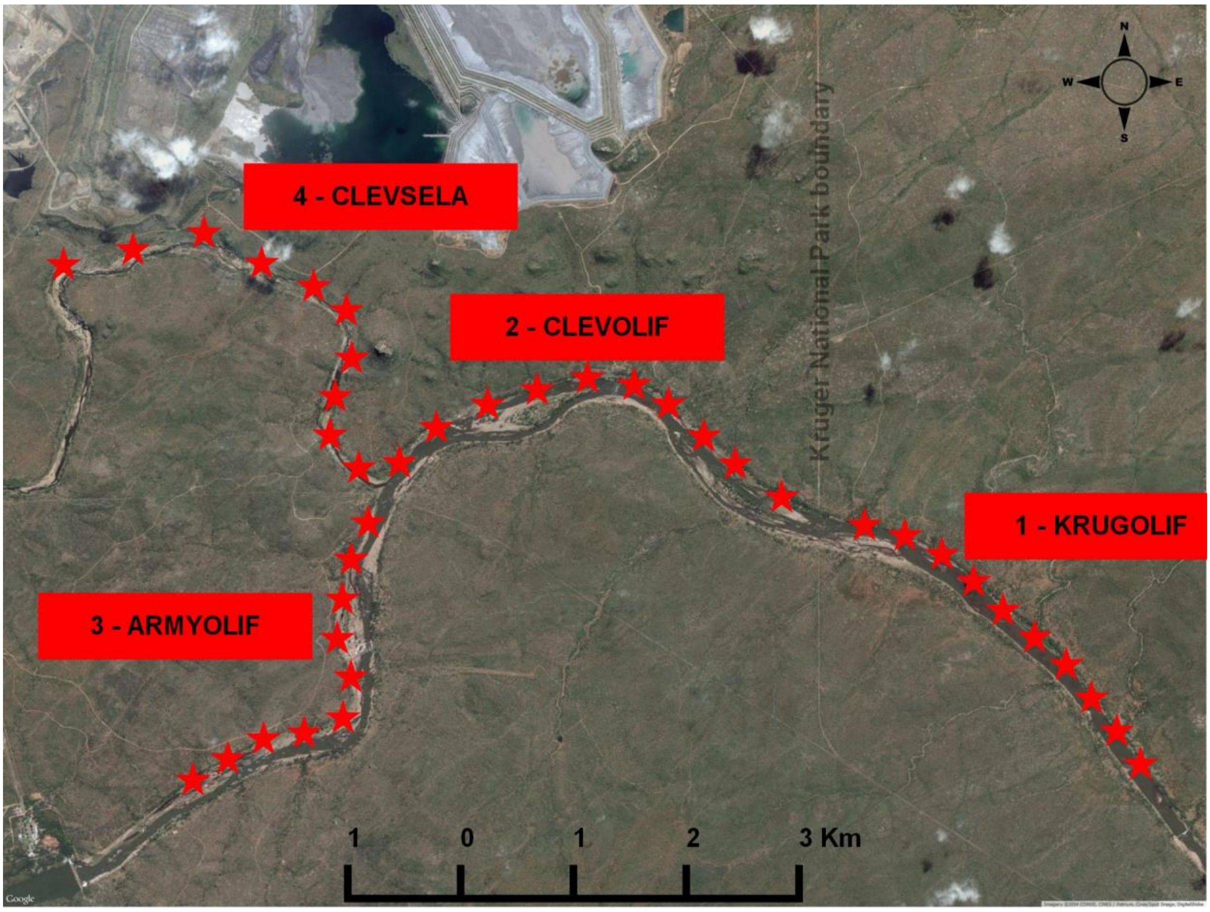


Figure 1: Different river regions (1-4) where water-dependent birds were surveyed. OLIF and SELA are abbreviations for Olifants and Ga-Selati rivers, respectively. KRUG refers to Kruger National Park, CLEV refers to Cleveland Nature Reserve and ARMY is the section of the Olifants River bordering the Mozambique National Resistance's Sawong headquarters. Red stars indicate each region's sample sites wherefrom counts took place. Palabora Copper Limited mine is evident to the North of the rivers.

Prior to 2014, birds were surveyed with teams walking the complete distances on both sides of river regions 1-4. Starting 2014, survey and sampling designs changed to determine the best method for monitoring. This most recent method enabled statistical analyses of results and additional post-processing. The designs are listed below:

- Ten sample sites per region were created and spaced approx. equal distances from one another on the northern banks of both rivers.
- Sample sites were spaced $\geq$400 m equating to the observer only counting birds within a 200 m radius, preventing overlap of site radii.
- The variable circular plot method or point transect with exact distances was employed.
- At each sample site, only water-dependent bird species (Appendix 1) were recorded, their abundances and radial distances.
- Observations spanned 15 minutes upon arrival at each sample site.
- Birds flying overhead were not recorded, but those leaving or entering the radius and perched, were.
- Only bird species from the families (mostly non-passerine) in Table 1 were considered to be water-dependent.

Table 1: Only species of these families were recorded during the water-dependent river bird surveys. Highlighted rows indicate where only certain family members are water-dependent.

Family in order of *Roberts – Birds of Southern Africa*, VIIth ed.	**Water-dependent species**
Dendrocygnidae	Whistling Ducks
Anatidae	Ducks and Geese
Alcedinidae	Excludes African Pygmy-Kingfisher
Cerylidae	Giant Kingfisher and Pied Kingfisher
Strigidae	Includes only Pel's Fishing-Owl
Heliornithidae	Finfoots
Rallidae	Rails, Crakes *et al.**
Scolopacidae	Snipes, 'Shanks', Stints, Sandpipers, Ruff *et al.*
Rostratulidae	Painted-snipes
Jacanidae	Jacanas
Burhinidae	Includes only Water Thick-knee
Recurvirostridae	Stilts and Avocets
Charadriidae	Includes only water-dependent Plovers and Lapwings
Glareolidae	Includes only Pratincoles
Laridae	Skimmers, Terns *et al.*
Accipitridae	Includes only African Fish-Eagle, Osprey and Harriers
Podicipedidae	Grebes
Anhingidae	Darter
Phalacrocoracidae	Cormorants
Ardeidae	Egrets, Herons *et al.*
Scopidae	Hamerkop
Phoenicopteridae	Flamingos
Threskiornithidae	Includes only water-dependent Ibises and Spoonbills
Pelecanidae	Pelicans

Family in order of *Roberts – Birds of Southern Africa*, VIIth ed.	**Water-dependent species**
Ciconiidae	Includes only water-dependent Stork species
Motacillidae	Includes only Wagtails

* *et al.* refers to 'and others'

For comparative reasons, only birds encountered during the 2012/2013 surveys falling within each of the 2014 sample site radii, were included in this report. This process of eliminating certain observations was performed using a GIS (Geographic Information System).

Bird densities were estimated for the most abundant families using DISTANCE software (Thomas *et al.*, 2010). Bird species and accompanying abundance, radial distance values were pooled into families as small sample sizes, e.g. at species-scale, deliver unreliable results. The families used in estimating densities are listed and discussed in the 'Results and Discussion' section and these analyses were only performed for data collected during 2014. The density estimation output for Anatidae computed by DISTANCE shows in Appendix 3. Bird abundances however, were compared between years using sightings only recorded inside the 2014 sample site radii.

Lastly, the most diagnostic/faithful species of the specific river regions were determined from the phi-coefficient (Bruelheide, 2000). A value of 1 indicates a species is most faithful to that specific river region, but values near zero reflect no preference for any river region. A negative value suggests the opposite. This computation was only performed with the 2014 survey data. Diagnostic bird species can be considered as indicator species. A turnover of indicator species may point to changes in habitat, food availability or other disturbances.

RESULTS AND DISCUSSION

2012-2014

The overall water-dependent bird species richness for all river regions surveyed, was 38. This value is larger than found during 2013 (37) and 2012 (34). Annual trends in total species richness for each of the river regions are presented in Figure 2.

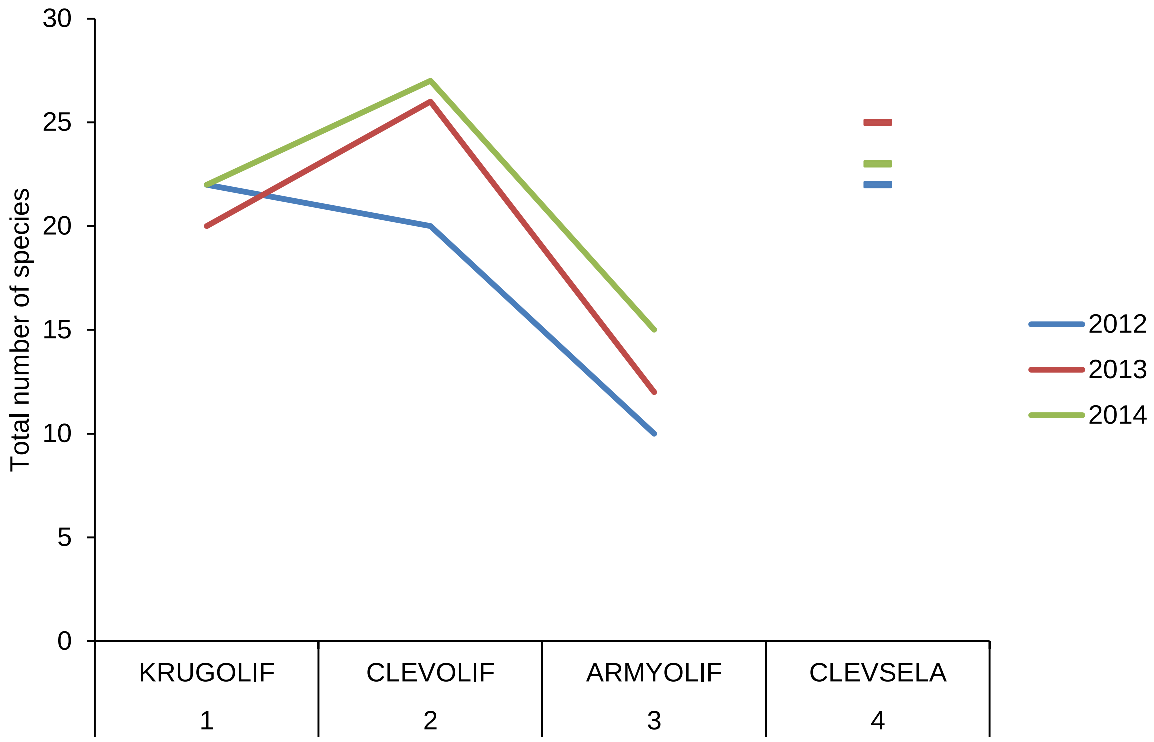


Figure 2: River region-specific total species richness values for all years of water-dependent bird surveys.

Mean (average) species richness±standard deviation was calculated per river region using sample site richness. Standard deviation is the amount of variation from the mean. CLEVOLIF shows that less species are present on average compared to KRUGOLIF (Figure 3). This is possibly due to less habitat in the form of open water. The larger standard deviation value however, points to a more diverse habitat compared to KRUGOLIF. Satellite imagery and prior site visits show that CLEVOLIF contains a mosaic of fast-flowing water over rocks, standing pools with and without marginal vegetation and a split river channel, to mention a few habitat characteristics. Conversely, KRUGOLIF shows large expanses of open water as a single channel and mostly surrounded by open sand bars. Also, a single factor Analysis of Variance (ANOVA) test supported the above results and showed that there was a strongly significant difference between the mean species richness values of the different river regions, i.e. <0.001% probability that the results were obtained by chance/coincidence ($F_{10,3} = 9.9$, $p < 0.001$).

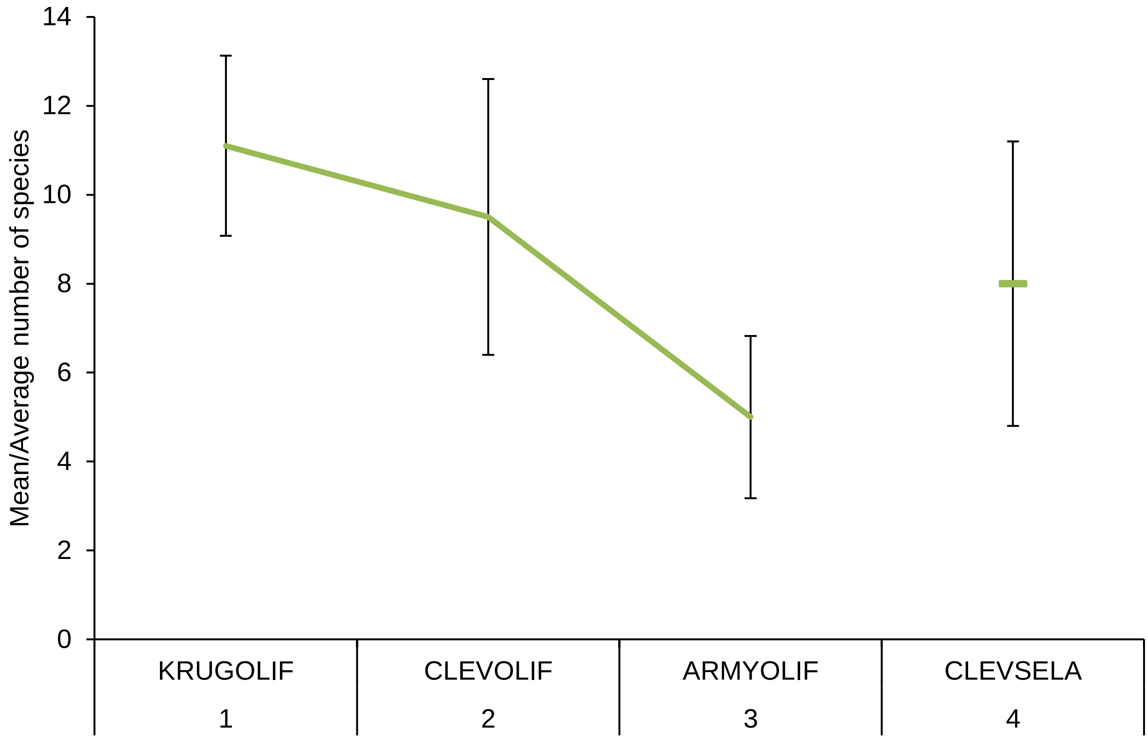


Figure 3: River region-specific mean species richness values for 2014's water-dependent bird survey. Mean values were statistically strongly significantly different from one another. Error bars indicate standard deviation from the mean.

Densities (individuals per square kilometre) were calculated for the five most abundant bird families found across the four river regions (Figure 4; Table 2). Due to low sample sizes, ARMYOLIF were omitted from the analyses of two families: Recurvirostridae and Scolopacidae. Anatidae (ducks and geese), of which 99% consisted of Egyptian Goose, were the most abundant family. The Egyptian Goose is a widespread and common waterfowl with the largest reporting rates of any of its family members. Exclusively a herbivore, it grazes, eats grass or sedge seeds and aquatic plants (Hockey *et al.*, 2005). Its large overall density may be ascribed to food availability in the form of *Cynodon dactylon* and sedges e.g. *Cyperus* spp., abundant food plants that grows on the river channels' sand bars and banks. More specifically, this species' largest density in CLEVOLIF might be due to the many isolated sandbars and vegetated islands created by the splitting river channel. This provides nesting habitat for this species' non-cyclical breeding season. All families showed larger density values when moving upstream from KRUGOLIF to CLEVOLIF. Only Motacillidae (African Pied Wagtail *Motacilla aguimp*) showed the largest densities in CLEVSELA. This insectivorous (mostly insect-eating) species occupies a variety of habitats, but are found only along perennial rivers or permanent water bodies in drier areas. Large densities at this river region may be ascribed to greater food availability, not necessarily in the form of aquatic invertebrates but also caterpillars, ants, termites, larval flies, beetles and grasshoppers. An estimated 4 000 individuals occur inside Kruger National Park (Hockey *et al.*, 2005). Its range may contract however, if water abstraction leads to perennial rivers becoming seasonal.

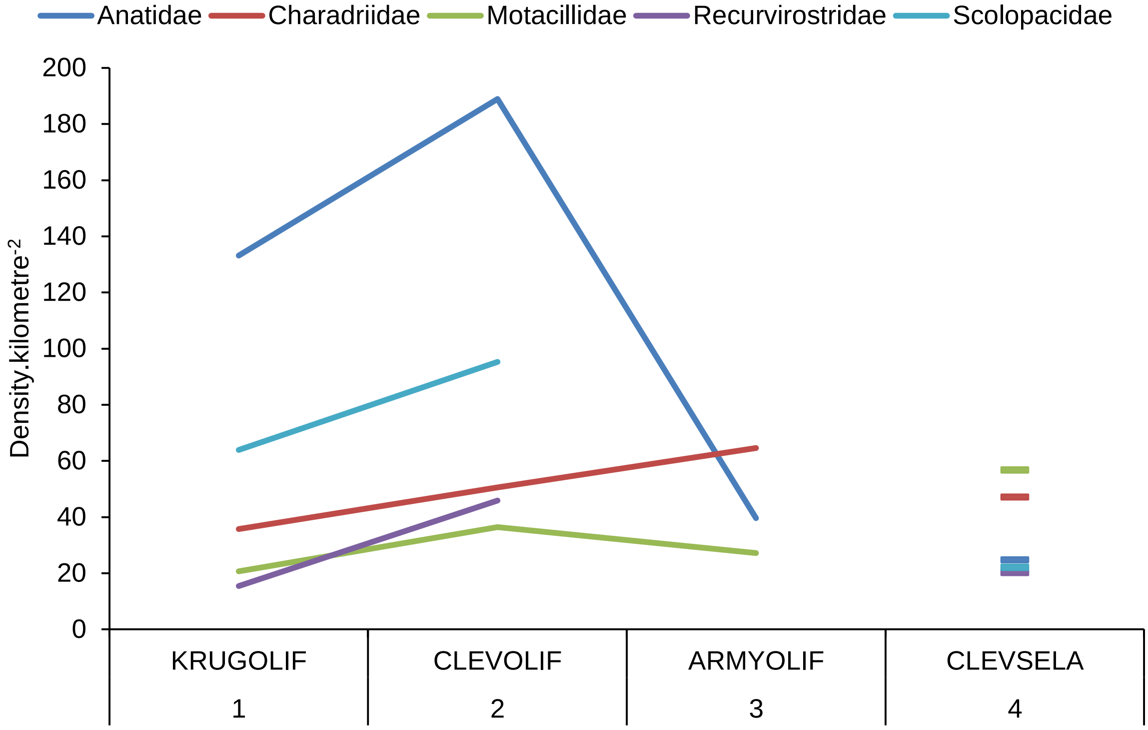


Figure 4: Densities per square kilometre for the five most abundant bird families. Families Recurvirostridae and Scolopacidae had too few representatives in the ARMYOLIF region and were thus omitted from the analyses. All Motacillidae records are of African Pied Wagtail *Motacilla aguimp*. Similarly, 99% of Anatidae records are contributed by Egyptian Goose *Alopochen aegyptiaca*.

The Egyptian Goose *Alopochen aegyptiaca*, was the most abundant water-dependent bird species when comparing annual sightings observed inside the 200 meter sample site radii. 2014 showed a dramatic increase in abundance at CLEVOLIF (Figure 5), similarly to density estimations. The possible explanations for this pattern are covered in the previous paragraph.

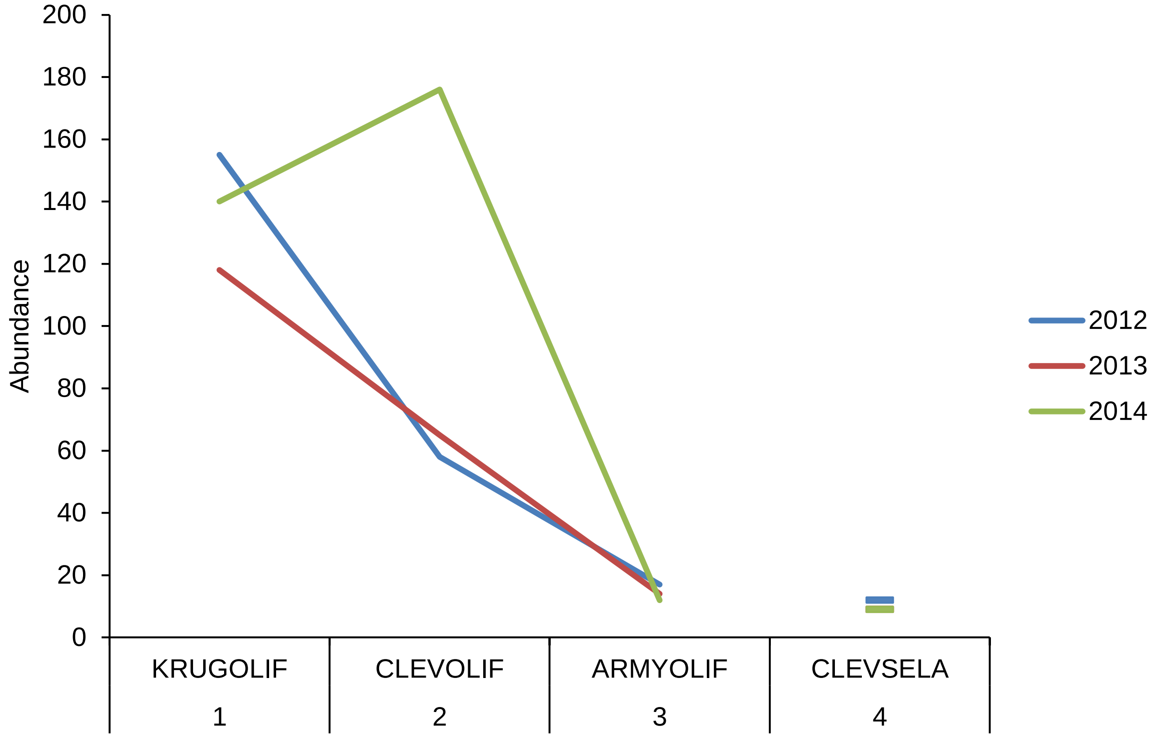


Figure 5: Egyptian Goose *Alopochen aegyptiaca* abundances at river regions one to four. This was the most abundant water-dependent bird species encountered during annual surveys.

Each of the river regions produced a diagnostic species. At region 1 (KRUGOLIF), the White-fronted Plover *Charadrius marginatus* was the most faithful to this area than any of the other species to their regions, suggesting strong preference for this habitat. It favours sandy shores from coastal to rivers and lakes, a habitat that dominated the KRUGOLIF region. This specific population recorded during the 2012-2014 surveys are of an inland population *C. m. mechowi*, but are migratory in response to flooding usually moving to coastal areas from December-May. It is important to note that on the Zambesi River, abundances were reduced after hydrological disturbance (Hockey *et al.*, 2005). At CLEVOLIF the White-crowned Lapwing *Vanellus albiceps* was the most diagnostic species. In South Africa this species is confined to the Limpopo River and the other large perennial rivers that flow through the Kruger National Park. An uncommon bird, it is estimated at 90 pairs inside the Kruger National Park and has been down-listed from a Near-threatened Red Data status to Least Concern. Most often found along sand- and mudbanks in large rivers, it feeds off various prey items incl. beetles, worms, molluscs, crabs and even fish. In Kruger National Park, average linear river territory equates to 680 metres (Hockey *et al.* 2005). A widespread aerial predator and year-round territorial species, the African Fish-Eagle *Haliaeetus vocifer* was the most diagnostic species in the ARMYOLIF region. It occupies a large array of water bodies from flowing to still, with ~0.12 pairs/kilometre of major river in the Kruger National Park (including the Olifants River). Foraging accounts for 5-10% of the day and includes fish ranging up to 3.7 kilograms (Hockey *et al.*, 2005). Larger stands of tall trees flanking the river on both sides, serving as hunting posts, compared to other regions might have resulted in this species large phi-coefficient value compared to other species encountered in this region. Dams <1 Km^2 rarely hold a breeding pair of ‘Fish-Eagle, but the barrage immediately West of ARMYOLIF might be host to a single pair as its size approximates to the above. It cannot be ruled out that the

African Fish-Eagle's status as diagnostic species in this region is due to dispersing chicks from a potential breeding pair as:

1. a potential breeding pair may produce on average 1.25 young/year;
2. Cainism (the stronger, first chick to hatch kills the second, weaker one resulting in most eagles raising a single chick) is facultative in African Fish-Eagles resulting in more than one chick surviving past fledgling stage (Hockey *et al.*, 2005).

The diagnostic species at region CLEVSELA was the Black Crake *Amaurornis flavirostris*. A common species, a habitat preference amongst others is reedbeds dominated by *Phragmites* sp. (Hockey *et al.*, 2005). This vegetation dominated the region and is also evident from satellite imagery, which supports this species' diagnostic status. This crake's diet includes small fish and larvae of various insect orders. Table 2 shows the most diagnostic/faithful species at each of the river regions as well as their Phi-coefficient values.

Table 3: Diagnostic/Faithful species of the various river regions of the Olifants and Ga-Selati rivers. 2014 values are displayed.

River region	**Species – Common name *Latin name***	**Phi-coefficient value**
1 – KRUGOLIF	White-fronted Plover *Charadrius marginatus mechowi*	0.87
2 – CLEVOLIF	White-crowned Lapwing *Vanellus albiceps*	0.42
3 – ARMYOLIF	African Fish-Eagle *Haliaeetus vocifer*	0.38
4 – CLEVSELA	Black Crake *Amaurornis flavirostra*	0.72

Certain species which depend on the Olifants and Ga-Selati rivers for habitat or food have been identified as Species of Conservation Priority in the Palabora Copper Limited (PC) Biodiversity Action Plan (BAP). These are:

- Pel's Fishing-Owl (*Scotopelia peli*)
- Saddle-billed Stork (*Ephippiorhynchus senegalensis*)
- White-crowned Lapwing (*Vanellus albiceps*)
- Yellow-billed Stork (*Mycteria ibis*)
- White-backed Night-Heron (*Gorsachius leuconotus*)

Sightings of the rarely encountered species, i.e. all except White-crowned Lapwing, show in Figure 6 with Latitude/Longitude coordinates included in Table 4. Additionally, each of the species' natural history is explained below. More information on Red Data species and the listing can be found at http://www.iucnredlist.org/. Note that there is a regional and a global status for species. Discussed below, are regional statuses from Barnes (2000) and Taylor (2014).

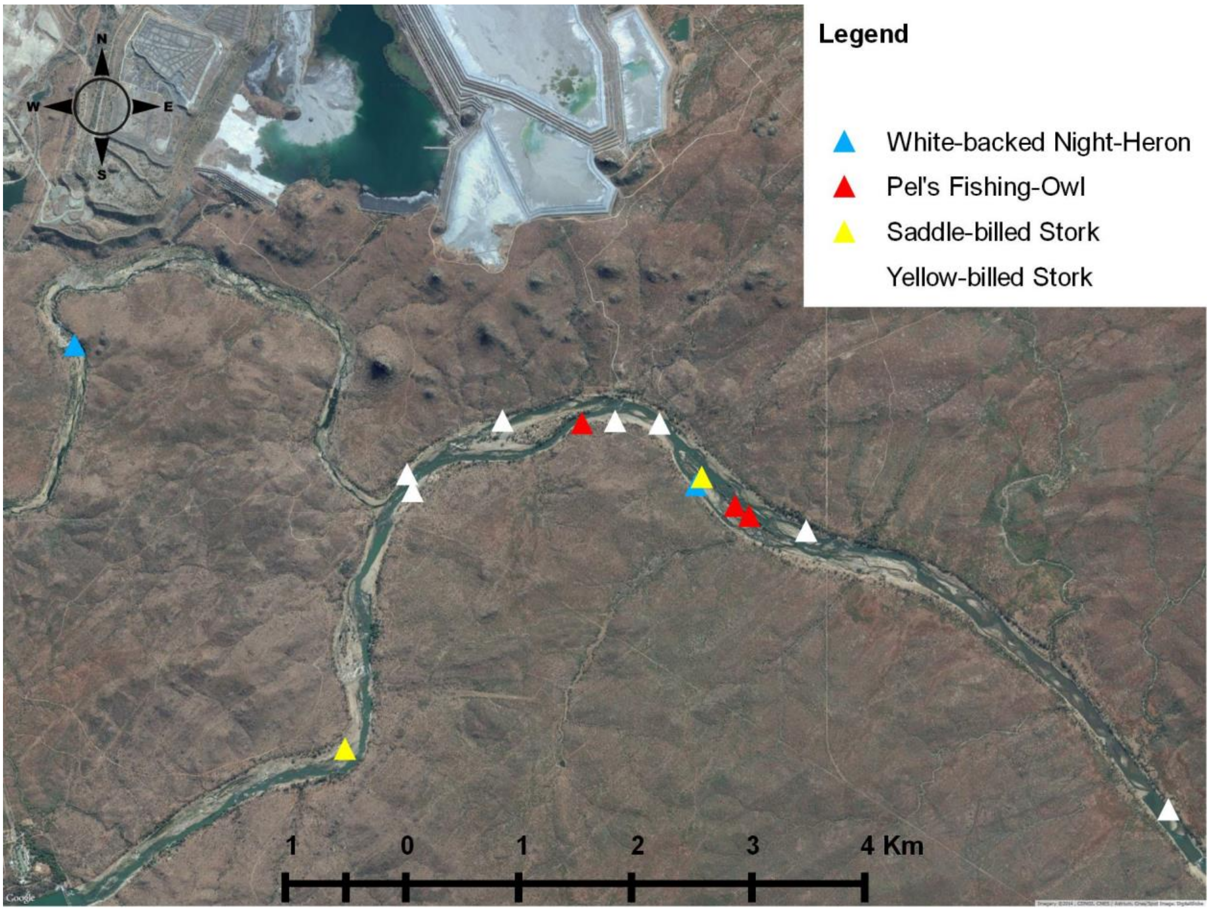


Figure 6: Sightings of four of the Species of Conservation Priority, 2012-2014.

Table 4: Location data for sightings of four of the Species of Conservation Priority, 2012-2014. Location format is in Latitude/Longitude and decimal degrees. Each species' current Red Data status shows.

Date of sighting	Species	Latitude	Longitude	Notes	Red Data status (Taylor, 2014)
2012	Pel's Fishing-Owl	-24.03249667	31.18971833		Endangered
2013	Pel's Fishing-Owl	-24.03895167	31.20280667		
2014	Pel's Fishing-Owl	-24.03973500	31.20401833		
2012	Saddle-billed Stork	-24.05792000	31.16947500		Endangered
2014	Saddle-billed Stork	-24.03670833	31.19996000		
2012	White-backed Night-Heron	-24.03733333	31.19944667		Vulnerable
2013	White-backed Night-Heron	-24.02640500	31.14636333		
2012	Yellow-billed Stork	-24.04090500	31.20888167		Endangered
2013	Yellow-billed Stork	-24.03234333	31.19255833		
2013	Yellow-billed Stork	-24.03231000	31.18293333		
2013	Yellow-billed Stork	-24.03648500	31.17478167		
2013	Yellow-billed Stork	-24.03780167	31.17524167		
2014	Yellow-billed Stork	-24.03253000	31.19635000	Approximate location	
2014	Yellow-billed Stork	-24.06265000	31.23983000	Approximate location	

- Generally uncommon and localised, the Pel's Fishing-Owl is estimated at 15 pairs/100 kilometre on the Olifants River, Kruger National Park. It is dependent on tall riparian trees near rivers and swamps and mostly catches fish between 100-250 grams. The nest is placed 3-12 meters above ground, less than 200 meters from the water inside a cavity or at a junction of branches. Some of the probable greater threats include human disturbance, water abstraction and silting or pollution of rivers (Hockey *et al.*, 2005). Consequently, in South Africa it has been up-listed from Vulnerable (Barnes, 2000) to Endangered (Taylor, 2014).
- The Saddle-billed Stork is still considered Endangered (Taylor, 2014). In South Africa, most of the population is found in the Kruger National Park, estimated at 50-100 pairs. A resident species of large rivers, it forages mostly on fish weighing up to 500 grams. Nests are usually on top of a tree in full sunlight, up to 500 meters away from water and 20-30 meters above ground (Hockey *et al.*, 2005).
- The natural history of the White-crowned Lapwing is discussed above. This species' down-listing as Red Data species (Taylor, 2014), abundances much larger than any of the other Species of Conservation Priority (hence, its diagnostic status at CLEVOLIF) should lend itself to removal from the list of Species of Conservation Priority. Instead, its diagnostic status ought to be carefully monitored in subsequent years since it is the most significant indicator/faithful species at CLEVOLIF.
- The Yellow-billed Stork leaped from Near-threatened (Barnes, 2000) to Endangered (Taylor, 2014). This drastic up-listed status is two steps closer to extinction. Rarely singly and often in pairs, this stork species occupy a wide variety of habitats including wetlands, rivers lakes and small pools. It forages in shallow water free of emergent vegetation, on fish up to 150 grams. Frogs and invertebrates make up the remainder of its diet. A colonial nester sharing colonies with other storks, especially the Marabou', it also nests along-side herons ibises and darters amongst others. Nests built above ground or water, 3-7 meters inside a tree (Hockey *et al.*, 2005). Appendix 2 shows a map indicating areas inside and around Kruger National Park with the largest reporting rates of Yellow-billed Stork.
- A generally rare species, the White-backed Night-Heron's status has not changed since Barnes (2000). Currently considered Vulnerable (Taylor, 2014), its movements and diet are little known about. Overhanging vegetation of slow-flowing rivers and streams are its preferred habitats where it forages on small fish, amphibians and a variety of invertebrates. Usually less than 1 meter above water, nests are rarely exposed but rather inside a tree, bush, reeds or rock pile especially on islands (Hockey *et al.*, 2005).

REFERENCES

BARNES, K. (ed.) 2000. *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland,* Johannesburg: BirdLife South Africa.

BRUELHEIDE, H. 2000. A new measure of fidelity and its application to defining species groups. *Journal of Vegetation Science,* 11**,** 167-178.

HOCKEY, P., DEAN, W. & RYAN, P. (eds.) 2005. *Roberts Birds of Southern Africa,* VIIth ed., Cape Town: The Trustees of the John Voelcker Bird Book Fund.

TAYLOR, M. (ed.) 2014. *The Eskom Red Data Book of birds of South Africa, Lesotho and Swaziland,* Johannesburg: BirdLife South Africa. In Press.

THOMAS, L., BUCKLAND, S., REXSTAD, E., LAAKE, J., STRINDBERG, S., HEDLEY, S., BISHOP, J., MARQUES, T. & BURNHAM, K. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology,* 47**,** 5-14.

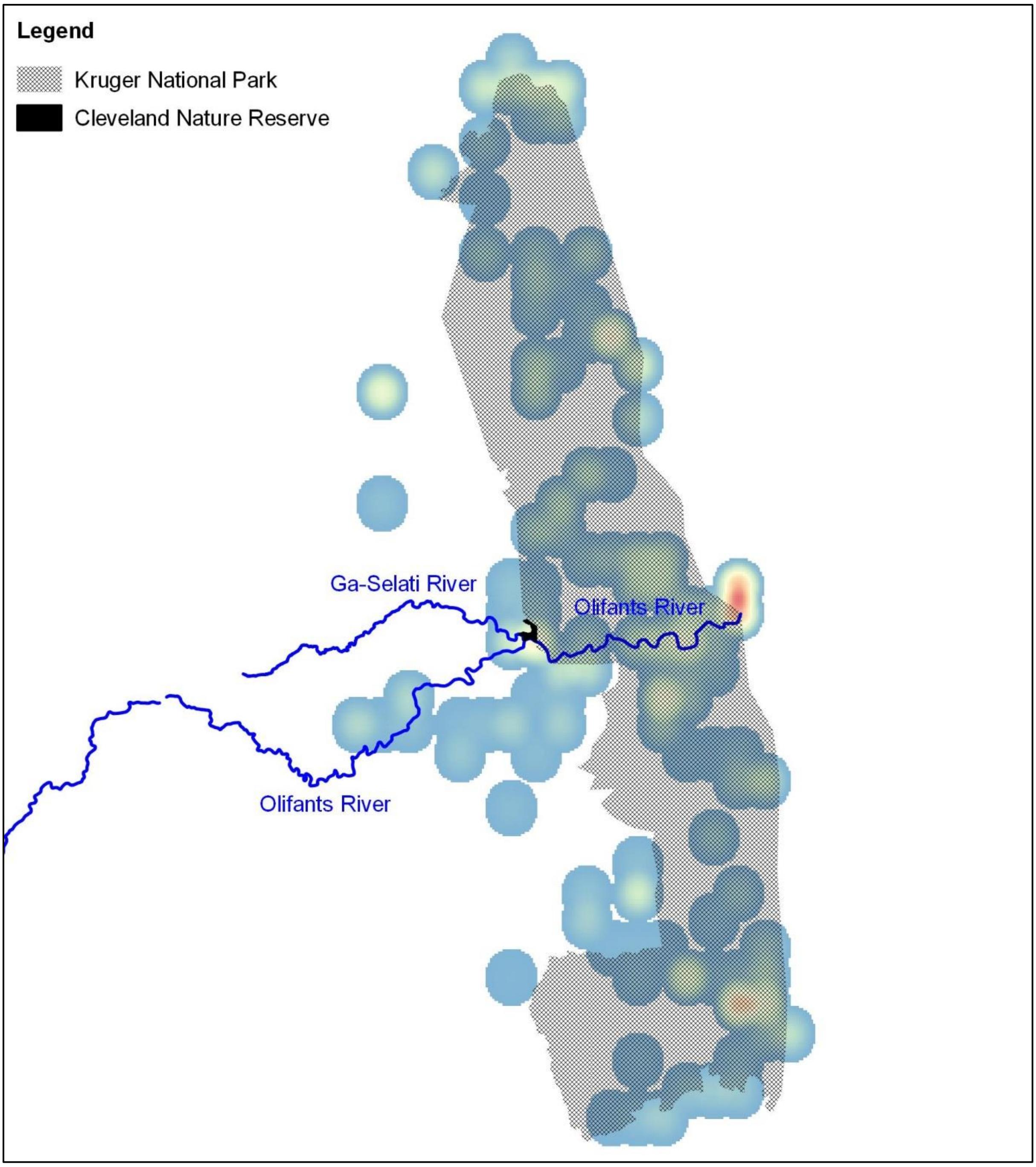
APPENDIX 1

River region	Species - Common name
1 - KRUGOLIF	
	African Pied Wagtail
	Black-crowned Night-Heron
	Blacksmith Lapwing
	Black-winged Stilt
	Common Greenshank
	Common Sandpiper
	Curlew Sandpiper
	Egyptian Goose
	Green-backed Heron
	Grey Heron
	Little Egret
	Little Stint
	Marsh Sandpiper
	Pied Kingfisher
	Reed Cormorant
	Ruff
	Three-banded Plover
	Water Thick-knee
	White-crowned Lapwing
	White-fronted Plover
	Wood Sandpiper
	Yellow-billed Stork
2 - CLEVOLIF	
	African Black Duck
	African Jacana
	African Pied Wagtail
	African Spoonbill
	Black Crake
	Blacksmith Lapwing
	Black-winged Stilt
	Cattle Egret
	Common Greenshank
	Common Sandpiper
	Curlew Sandpiper
	Egyptian Goose
	Goliath Heron
	Greater Painted-snipe
	Green-backed Heron
	Grey Heron
	Hamerkop
	Little Egret

River region	Species - Common name
	Little Stint
	Pied Kingfisher
	Reed Cormorant
	Ruff
	Three-banded Plover
	Water Thick-knee
	White-crowned Lapwing
	White-faced Duck
	Wood Sandpiper
3 - ARMYOLIF	
	African Darter
	African Fish-Eagle
	African Pied Wagtail
	Blacksmith Lapwing
	Common Greenshank
	Common Sandpiper
	Egyptian Goose
	Giant Kingfisher
	Green-backed Heron
	Hamerkop
	Pied Kingfisher
	Reed Cormorant
	Three-banded Plover
	Water Thick-knee
	White-crowned Lapwing
4 - CLEVSELA	
	African Darter
	African Fish-Eagle
	African Jacana
	African Pied Wagtail
	African Spoonbill
	Black Crake
	Blacksmith Lapwing
	Black-winged Stilt
	Cattle Egret
	Common Greenshank
	Egyptian Goose
	Giant Kingfisher
	Great Egret
	Green-backed Heron
	Hamerkop
	Little Egret
	Malachite Kingfisher

River region	Species - Common name
	Pied Kingfisher
	Reed Cormorant
	Squacco Heron
	Three-banded Plover
	Water Thick-knee
	Wood Sandpiper

APPENDIX 2



Yellow-billed Stork *Mycteria ibis* reporting rates inside and outside Kruger National Park. Yellow and red areas indicate larger reporting rates, i.e. more frequent encounters with Yellow-billed Stork. Reporting rates were obtained from the South African Bird Atlas Project 2 (http://sabap2.adu.org.za/index.php).

APPENDIX 3

Estimation Options Listing

Parameter Estimation Specification

Encounter rate by stratum
Detection probability modelled by stratum, and
estimated by stratum
Density by stratum
Pooled estimate of density is made from unweighted stratum estimates

Distances:

Analysis based on exact distances
Width: use measurement/interval endpoint which represents 95.0 percentile.

Estimators:

Estimator 1
Key: Uniform
Adjustments - Function : Cosines
- Term selection mode : Sequential
- Term selection criterion : Akaike Information Criterion (AIC)
- Distances scaled by : W (right truncation distance)
Estimator 2
Key: Half-normal
Adjustments - Function : Cosines
- Term selection mode : Sequential
- Term selection criterion : Akaike Information Criterion (AIC)
- Distances scaled by : W (right truncation distance)
Estimator 3
Key: Half-normal
Adjustments - Function : Hermite poynomials
- Term selection mode : Sequential
- Term selection criterion : Akaike Information Criterion (AIC)
- Distances scaled by : W (right truncation distance)
Estimator 4
Key: Hazard Rate
Adjustments - Function : Simple polynomials
- Term selection mode : Sequential
- Term selection criterion : Akaike Information Criterion (AIC)
- Distances scaled by : W (right truncation distance)

Estimator selection: Choose estimator with minimum AIC
Estimation functions: constrained such that f(0)>=f(x) for nearly all x

Multipliers:	Value	SE	DF
Sampling fraction	.50000	0.00000	Inf

Variances:

Variance of n: Empirical estimate from sample
(design-derived estimator R2/P2)
Variance of f(0): MLE estimate

Goodness of fit:

Cut points chosen by program

Glossary of terms

Data items:
n - number of observed objects (single or clusters of animals)
L - total length of transect line(s)
k - number of samples
K - point transect effort, typically K=k
T - length of time searched in cue counting
ER - encounter rate (n/L or n/K or n/T)
W - width of line transect or radius of point transect

x(i) - distance to i-th observation
s(i) - cluster size of i-th observation
r-p - probability for regression test
chi-p- probability for chi-square goodness-of-fit test

Parameters or functions of parameters:
m - number of parameters in the model
A(I) - i-th parameter in the estimated probability density function(pdf)
f(0) - 1/u = value of pdf at zero for line transects
u - W*p = ESW, effective detection area for line transects
h(0) - 2*PI/v
v - PI*W*W*p, is the effective detection area for point transects
p - probability of observing an object in defined area
ESW - for line transects, effective strip width = W*p
EDR - for point transects, effective detection radius = W*sqrt(p)
rho - for cue counts, the cue rate
DS - estimate of density of clusters
E(S) - estimate of expected value of cluster size
D - estimate of density of animals
N - estimate of number of animals in specified area

Detection Fct/1. CLEVOLIF/Model Fitting

Stratum : 1. CLEVOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 166

Model 1
Uniform key, k(y) = 1/W
Results:
Convergence was achieved with 1 function evaluations.
Final Ln(likelihood) value = -856.70378
Akaike information criterion = 1713.4076
Bayesian information criterion = 1713.4076
AICc = 1713.4076
Final parameter values:

Model 2
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1
Results:
Convergence was achieved with 25 function evaluations.
Final Ln(likelihood) value = -807.35797
Akaike information criterion = 1616.7159
Bayesian information criterion = 1619.8279
AICc = 1616.7404
Final parameter values: 0.93753311

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 98.6916
Probability of a greater value = 0.000000
*** Model 2 selected over model 1 based on minimum AIC

Model 3
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1, 2
Results:
Convergence was achieved with 15 function evaluations.
Final Ln(likelihood) value = -797.80469
Akaike information criterion = 1599.6094
Bayesian information criterion = 1605.8334
AICc = 1599.6830
Final parameter values: 0.76334258 -0.19130727
** Warning: Parameters are being constrained to obtain monotonicity. **

Likelihood ratio test between models 2 and 3
Likelihood ratio test value = 19.1066
Probability of a greater value = 0.000012
*** Model 3 selected over model 2 based on minimum AIC

Detection Fct/1. CLEVOLIF/Model Fitting

Stratum : 1. CLEVOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 166

Model 1
Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
Results:
Convergence was achieved with 26 function evaluations.
Final Ln(likelihood) value = -813.00198
Akaike information criterion = 1628.0039
Bayesian information criterion = 1631.1160
AICc = 1628.0283
Final parameter values: 76.945791

Model 2
Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
Cosine adjustments of order(s) : 2
Results:
Convergence was achieved with 7 function evaluations.
Final Ln(likelihood) value = -803.72376
Akaike information criterion = 1611.4475
Bayesian information criterion = 1617.6715
AICc = 1611.5211
Final parameter values: 74.384859 -0.12970064
** Warning: Parameters are being constrained to obtain monotonicity. **

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 18.5564
Probability of a greater value = 0.000017
*** Model 2 selected over model 1 based on minimum AIC
Detection Fct/1. CLEVOLIF/Model Fitting

Stratum : 1. CLEVOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 166

Model 1
Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
Results:
Convergence was achieved with 26 function evaluations.
Final Ln(likelihood) value = -813.00198
Akaike information criterion = 1628.0039
Bayesian information criterion = 1631.1160
AICc = 1628.0283
Final parameter values: 76.945791

Model 2
Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
Hermite polynomial adjustments of order(s) : 4
Results:
Convergence was achieved with 17 function evaluations.
Final Ln(likelihood) value = -802.11012
Akaike information criterion = 1608.2202
Bayesian information criterion = 1614.4442
AICc = 1608.2938
Final parameter values: 58.490965 -0.23452739
** Warning: Parameters are being constrained to obtain monotonicity. **

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 21.7837
Probability of a greater value = 0.000003
*** Model 2 selected over model 1 based on minimum AIC
Detection Fct/1. CLEVOLIF/Model Fitting

Stratum : 1. CLEVOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 166

Model 1
Hazard Rate key, k(y) = 1 - Exp(-(y/A(1))**-A(2))
Results:
Convergence was achieved with 11 function evaluations.
Final Ln(likelihood) value = -782.17121
Akaike information criterion = 1568.3424
Bayesian information criterion = 1574.5664
AICc = 1568.4160
Final parameter values: 105.93091 7.0490960

Model 2
Hazard Rate key, k(y) = 1 - Exp(-(y/A(1))**-A(2))
Simple polynomial adjustments of order(s) : 4
Results:
Convergence was achieved with 9 function evaluations.
Final Ln(likelihood) value = -782.17048
Akaike information criterion = 1570.3409
Bayesian information criterion = 1579.6769
AICc = 1570.4891
Final parameter values: 106.01818 7.0768661 -0.12296906E-13
** Warning: Parameters are being constrained to obtain monotonicity. **

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 0.0015
Probability of a greater value = 0.969378
*** Model 1 selected over model 2 based on minimum AIC
Detection Fct/1. CLEVOLIF/Model Fitting

Stratum : 1. CLEVOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 166

Model Selection

Minimum AIC = 1568.342
Estimator chosen based on minimum AIC :
Model
Hazard Rate key, k(y) = 1 - Exp(-(y/A(1))**-A(2))
Detection Fct/1. CLEVOLIF/Parameter Estimates

Stratum : 1. CLEVOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 166

Model
Hazard Rate key, k(y) = 1 - Exp(-(y/A(1))**-A(2))

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95 Percent Confidence Interval	
A(1)	105.9	4.996			
A(2)	7.049	1.050			
h(0)	0.14305E-03	0.98266E-05	6.87	0.12493E-03	0.16381E-03
p	0.43151	0.29642E-01	6.87	0.37684	0.49412
EDR	118.24	4.0611	3.43	110.49	126.54

Sampling Correlation of Estimated Parameters

```
       A( 1)   A( 2)
A( 1)  1.000   0.723
A( 2)  0.723   1.000
```

Detection Fct/1. CLEVOLIF/Plot: Qq-plot

Detection Fct/1. CLEVOLIF/K-S GOF Test

Kolmogorov-Smirnov test

D_n = 0.3614   p = 0.0000

Cramer-von Mises family tests

W-sq (uniform weighting) = 4.8116   0.000 < p <= 0.001
  Relevant critical values:
    W-sq crit(alpha=0.001) = 1.1779

C-sq (cosine weighting) = 4.0154   0.000 < p <= 0.001
  Relevant critical values:
    C-sq crit(alpha=0.001) = 0.8164

Detection Fct/1. CLEVOLIF/Plot: Detection Probability 1

```
          |+-------+-------+-------+--------+-------+-------+-------+-------+|
   2.5882 +                                                          +
          |                                                          |
          |                                                          |
          |                                                          |
          |                  **********                              |
   2.2725 +                     *       *                            +
          |                  *       *                               |
          |                  *       *                               |
          |                  *       *                               |
          |                  *       *                               |
D  1.9569 +                     *       *                            +
e         |                  *       *                               |
t         |                  *       *                               |
e         |                  *       *                               |
c         |                  *       *                               |
t  1.6413 +                     *       *                            +
i         |                  *       *                               |
o         |                  *       *                               |
n         |                  *       *                               |
          |                  *       *                               |
P  1.3257 +                     *       *                            +
r         |                  *       *                               |
o         |                  *       *                               |
b         |                  *       *                               |
a         |                  *       *                               |
b  1.0100 + fffffffffffffffffffffffffffffff *                        +
i         |                  *       ff                              |
l         |                  *       *f                              |
i         |                  *       * f                             |
t         |                  *       *  f                            |
y  0.6944 +                     *       ****f****                    +
          |                  *       *    f *                        |
          |                  *       *     f *                       |
          |                  *       *      f*                       |
          |                  *       *       f                       |
   0.3788 +                     *       *      *ff                   +
          |                  *       *       *  f                    |
          |                  *       *       *  ff                   |
          |            *********       *      ******fff              |
          |            *       *       *       *      *ffff          |
   0.0631 +                  *       *       *       *      *****fffffffff***+
          |*****************                                     fff|
          |+-------+-------+-------+--------+-------+-------+-------+-------+|
        0.000     45.000     90.000     135.000     180.000
             22.500     67.500     112.500     157.500

                     Radial distance in meters
```

Detection Fct/1. CLEVOLIF/Plot: Pdf 1

```
         |+-------+-------+-------+--------+-------+-------+-------+-------+|
   0.0292 +                                                  +
         |                                                  |
         |                                                  |
         |                                                  |
         |                  **********                         |
   0.0256 +                      *       *                      +
         |                  *       *                        |
         |                  *       *                        |
         |                  *       *                        |
         |                  *       *                        |
   0.0220 +                      *       *                      +
         |                  *       *                        |
P        |                   *       *                        |
r        |                  *       *                        |
o        |                   *       *                        |
b   0.0185 +                      *       *                      +
a        |                   *       *                        |
b        |                   *       *                        |
i        |                  *       *                        |
l        |                  *       *                        |
i   0.0149 +                     *       *                      +
t        |                  *       *                        |
y        |                   *       *                        |
         |                  *       *                        |
D        |                   *     fffff                      |
e   0.0114 +                     *   ff   * ff                  +
n        |                   *  f     *   f                   |
s        |                   *ff       *****f***                |
i        |                 ff        *     f *                 |
t        |               ff *        *      f*                 |
y   0.0078 +                   ff   *       *       *           +
         |              f     *       *      f              |
         |            ff      *       *      *ff             |
         |          ff        *       *      *  f            |
         |        ff          *       *      *   f           |
   0.0043 +          ff           *       *       *    f        +
         |       f             *       *      ******ff*        |
         |     ff              *       *      *      fff       |
         |   ff                *       *      *      * fff     |
         |  ff         *********       *       *      ******fffff******|
   0.0007 + ff           *       *       *       *       *      *  ffffff+
         |*****************                                   |
         |+-------+-------+-------+--------+-------+-------+-------+-------+|
       0.000        45.000         90.000        135.000       180.000
             22.500         67.500         112.500        157.500
```

Radial distance in meters

Detection Fct/1. CLEVOLIF/Chi-sq GOF Test 1

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	22.5	0	6.01	6.011
2	22.5	45.0	0	18.03	18.033
3	45.0	67.5	6	30.05	19.252
4	67.5	90.0	99	41.80	78.266
5	90.0	112.	37	39.43	0.150
6	112.	135.	12	19.33	2.782
7	135.	158.	6	7.91	0.463
8	158.	180.	6	3.42	1.943

Total Chi-square value = 126.8997 Degrees of Freedom = 5.00

Probability of a greater chi-square value, P = 0.00000

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Detection Fct/1. CLEVOLIF/Plot: Detection Probability 2

```
         |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
   3.3689 +                                                  +
         |                                                  |
         |                                                  |
         |                                                  |
         |                     *******                        |
```

```
    2.9581 +                  *    *                        +
           |                *    *                        |
           |                *    *                        |
           |                *    *                        |
           |                *    *                        |
D   2.5472 +                  *    *                        +
e          |                *    *                        |
t          |                *    *                        |
e          |                *    *                        |
c          |                *    *                        |
t   2.1364 +                  *    *                        +
i          |                *    *                        |
o          |                *    *                        |
n          |                *    *                        |
           |                *    *                        |
P   1.7255 +                  *    *                        +
r          |                *    *                        |
o          |                *    *                        |
b          |                *    *                        |
a          |                *    *                        |
b   1.3147 +                  *    *                        +
i          |                *    *                        |
l          |                *    *                        |
i          |                *    *                        |
t          | ffffffffffffffffffffffffffffff*                |
y   0.9039 +                  *    ff                       +
           |                *    * ff                     |
           |                *    *  f                     |
           |                *    *****f                   |
           |                *    *   *f                   |
    0.4930 +                ******    *    **ff**           +
           |            *    *    *    *   f*             |
           |            *    *    *    *    ff            |
           |            *    *    *    *   * fff          |
           |        *******   *    *    *   *****ffff     |
    0.0822 +            *    *    *    *    *    *    ***ffffffff******+
           |*****************                      ffffff|
           |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
        0.000       45.000    75.000   105.000   135.000   165.000
           15.000        60.000    90.000   120.000   150.000   180.000

                  Radial distance in meters
         Detection Fct/1. CLEVOLIF/Plot: Pdf 2
           |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
    0.0398 +                                                +
           |                                              |
           |                                              |
           |                                              |
           |                *******                       |
    0.0349 +                  *    *                        +
           |                *    *                        |
           |                *    *                        |
           |                *    *                        |
           |                *    *                        |
    0.0301 +                  *    *                        +
           |                *    *                        |
P          |                *    *                        |
r          |                *    *                        |
o          |                *    *                        |
b   0.0252 +                  *    *                        +
a          |                *    *                        |
b          |                *    *                        |
i          |                *    *                        |
l          |                *    *                        |
i   0.0204 +                  *    *                        +
t          |                *    *                        |
y          |                *    *                        |
           |                *    *                        |
D          |                *    *                        |
e   0.0155 +                  *    *                        +
n          |                *    *                        |
s          |                *    *                        |
i          |                *   fff                       |
t          |                * ff  *fff                    |
y   0.0107 +                  fff    *   f                  +
```

```
        |                ff *     *****f                    |
        |              fff   *     *    *f                 |
        |             ff      *     *    **ff**             |
        |           fff       *     *     *   f*            |
  0.0058 +           ff          *     *     *    ff                +
        |         ff        ******     *     *    * f              |
        |       fff         *     *     *     *    *  fff          |
        |      ff           *     *     *     *    *     fff       |
        |    fff            *     *     *     *    *******  fffff****     |
  0.0010 +  ff            *******    *     *     *     *     ******  fffffffff+
        |*f***************                                         |
        |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
      0.000         45.000     75.000    105.000    135.000    165.000
         15.000          60.000     90.000   120.000     150.000     180.000

                    Radial distance in meters
           Detection Fct/1. CLEVOLIF/Chi-sq GOF Test 2
```

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	15.0	0	2.67	2.672
2	15.0	30.0	0	8.01	8.015
3	30.0	45.0	0	13.36	13.358
4	45.0	60.0	3	18.70	13.182
5	60.0	75.0	12	24.04	6.033
6	75.0	90.0	90	29.11	127.352
7	90.0	105.	23	28.49	1.060
8	105.	120.	20	19.34	0.023
9	120.	135.	6	10.93	2.224
10	135.	150.	3	6.00	1.497
11	150.	165.	6	3.37	2.050
12	165.	180.	3	1.97	0.540

Total Chi-square value = 178.0039 Degrees of Freedom = 9.00

Probability of a greater chi-square value, P = 0.00000

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	15.0	0	2.67	2.672
2	15.0	30.0	0	8.01	8.015
3	30.0	45.0	0	13.36	13.358
4	45.0	60.0	3	18.70	13.182
5	60.0	75.0	12	24.04	6.033
6	75.0	90.0	90	29.11	127.352
7	90.0	105.	23	28.49	1.060
8	105.	120.	20	19.34	0.023
9	120.	135.	6	10.93	2.224
10	135.	150.	3	6.00	1.497
11	150.	180.	9	5.34	2.508

Total Chi-square value = 177.9223 Degrees of Freedom = 8.00

Probability of a greater chi-square value, P = 0.00000

```
           Detection Fct/1. CLEVOLIF/Plot: Detection Probability 3
        |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
  4.4326 +                                                      +
        |                                                      |
        |                                                      |
        |                                                      |
        |                 *****                                 |
  3.8920 +                    *   *                                 +
        |                 *   *                                 |
        |                 *   *                                 |
        |                 *   *                                 |
        |                 *   *                                 |
D   3.3515 +                    *   *                                 +
e        |                 *   *                                 |
```

```
t        |                    *  *                         |
e        |                    *  *                         |
c        |                    *  *                         |
t   2.8109 +                      *  *                         +
i        |                    *  *                         |
o        |                    *  *                         |
n        |                    *  *                         |
         |                    *  *                         |
P   2.2704 +                      *  *                         +
r        |                    *  *                         |
o        |                    *  *                         |
b        |                    *  *                         |
a        |                    *  *                         |
b   1.7298 +                      *  *                         +
i        |                    *  *                         |
l        |                    *  *                         |
i        |                    *  *                         |
t        |                    *  *                         |
y   1.1892 +                      *  *                         +
         |                    *  *                         |
         | fffffffffffffffffffffffffffffffff    ****        |
         |                    *   ***ff  *  *               |
         |                    *   *  * ff*  *               |
    0.6487 +                      *   *  *   f  *                +
         |                 ****   *  *****ff*               |
         |                 *  *   *  *   *  ff              |
         |              ****  *   *  *   *  * fff           |
         |              *  *  *   *  *   *  *****fff         |
    0.1081 +               *****  *  *   *  *   *  *  *   *fffffffff*   ****+
         |******************                         *****  ffffffff|
         |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
       0.000        37.895    66.316    94.737   123.158    151.579  180.000
          9.474        47.368    75.789    104.211   132.632   161.053

                       Radial distance in meters
              Detection Fct/1. CLEVOLIF/Plot: Pdf 3
         |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
    0.0511 +                                                   +
         |                                                 |
         |                                                 |
         |                                                 |
         |                    *****                        |
    0.0448 +                      *  *                         +
         |                    *  *                         |
         |                    *  *                         |
         |                    *  *                         |
         |                    *  *                         |
    0.0386 +                      *  *                         +
         |                    *  *                         |
P        |                    *  *                         |
r        |                    *  *                         |
o        |                    *  *                         |
b   0.0324 +                      *  *                         +
a        |                    *  *                         |
b        |                    *  *                         |
i        |                    *  *                         |
l        |                    *  *                         |
i   0.0262 +                      *  *                         +
t        |                    *  *                         |
y        |                    *  *                         |
         |                    *  *                         |
D        |                    *  *                         |
e   0.0199 +                      *  *                         +
n        |                    *  *                         |
s        |                    *  *                         |
i        |                    *  *     ****                |
t        |                    *  *     *  *                |
y   0.0137 +                      *  *     *  *                 +
         |                    *  fffff   *  *              |
         |                    fff ****ff *  *               |
         |                 fff*   *  *  ff  *               |
         |              fff   *   *  *   *ff*               |
    0.0075 +               fff     *  *  *****  f                +
         |         fff      ****  *  *   *  *ff             |
         |       fff        *  *  *  *   *  *  ff           |
```

```
       |       ffff        ****  *   *  *   *  *****fff              |
       |    fff            *  *  *   *  *   *  *  *   *fffff ****   ****|
  0.0012 +  fff             *****  *  *   *  *   *  *  *   *  * fffffffffff*+
       |*f****************                              *****        f|
       |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
     0.000       37.895    66.316    94.737   123.158    151.579   180.000
        9.474       47.368    75.789    104.211   132.632   161.053
```

Radial distance in meters

Detection Fct/1. CLEVOLIF/Chi-sq GOF Test 3

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	9.47	0	1.07	1.066
2	9.47	18.9	0	3.20	3.197
3	18.9	28.4	0	5.33	5.328
4	28.4	37.9	0	7.46	7.460
5	37.9	47.4	0	9.59	9.591
6	47.4	56.8	1	11.72	9.808
7	56.8	66.3	5	13.85	5.658
8	66.3	75.8	9	15.98	3.052
9	75.8	85.3	73	18.07	166.916
10	85.3	94.7	18	19.24	0.080
11	94.7	104.	11	17.57	2.457
12	104.	114.	25	13.72	9.265
13	114.	123.	6	9.79	1.469
14	123.	133.	5	6.74	0.448
15	133.	142.	4	4.60	0.079
16	142.	152.	0	3.16	3.165
17	152.	161.	4	2.21	1.459
18	161.	171.	2	1.56	0.123
19	171.	180.	3	1.12	3.138

Total Chi-square value = 233.7579 Degrees of Freedom = 16.00

Probability of a greater chi-square value, P = 0.00000

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
2	0.000	18.9	0	4.26	4.263
3	18.9	28.4	0	5.33	5.328
4	28.4	37.9	0	7.46	7.460
5	37.9	47.4	0	9.59	9.591
6	47.4	56.8	1	11.72	9.808
7	56.8	66.3	5	13.85	5.658
8	66.3	75.8	9	15.98	3.052
9	75.8	85.3	73	18.07	166.916
10	85.3	94.7	18	19.24	0.080
11	94.7	104.	11	17.57	2.457
12	104.	114.	25	13.72	9.265
13	114.	123.	6	9.79	1.469
14	123.	133.	5	6.74	0.448
15	133.	142.	4	4.60	0.079
16	142.	152.	0	3.16	3.165
17	152.	161.	4	2.21	1.459
18	161.	180.	5	2.68	1.998

Total Chi-square value = 232.4943 Degrees of Freedom = 14.00

Probability of a greater chi-square value, P = 0.00000

Detection Fct/2. CLEVSELA/Model Fitting

Stratum : 2. CLEVSELA
Effort : 6.000000
samples : 6
Width : 180.0000
observations: 9

Model 1
Uniform key, k(y) = 1/W
Results:
Convergence was achieved with 1 function evaluations.
Final Ln(likelihood) value = -48.809136
Akaike information criterion = 97.618271
Bayesian information criterion = 97.618271
AICc = 97.618271
Final parameter values:

Model 2
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1
Results:
Convergence was achieved with 21 function evaluations.
Final Ln(likelihood) value = -44.772918
Akaike information criterion = 91.545837
Bayesian information criterion = 91.743057
AICc = 92.117264
Final parameter values: 1.0000000

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 8.0724
Probability of a greater value = 0.004494
*** Model 2 selected over model 1 based on minimum AIC

Model 3
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1, 2
Results:
Convergence was achieved with 301 function evaluations.
Final Ln(likelihood) value = -44.767466
Akaike information criterion = 93.534935
Bayesian information criterion = 93.929382
AICc = 95.534935
Final parameter values: 0.99443626 -0.16104676E-01

Likelihood ratio test between models 2 and 3
Likelihood ratio test value = 0.0109
Probability of a greater value = 0.916834
*** Model 2 selected over model 3 based on minimum AIC
Detection Fct/2. CLEVSELA/Model Fitting

Stratum : 2. CLEVSELA
Effort : 6.000000
samples : 6
Width : 180.0000
observations: 9

Model 1
Half-normal key, k(y) = Exp(-y**2/(2*A(3)**2))
Results:
Convergence was achieved with 11 function evaluations.
Final Ln(likelihood) value = -44.852389
Akaike information criterion = 91.704781
Bayesian information criterion = 91.902000
AICc = 92.276207
Final parameter values: 65.537246

Model 2
Half-normal key, k(y) = Exp(-y**2/(2*A(3)**2))
Cosine adjustments of order(s) : 2
Results:
Convergence was achieved with 24 function evaluations.
Final Ln(likelihood) value = -44.852073
Akaike information criterion = 93.704147
Bayesian information criterion = 94.098595
AICc = 95.704147

Final parameter values: 65.536924 0.16610953E-01

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 0.0006
Probability of a greater value = 0.979945
*** Model 1 selected over model 2 based on minimum AIC
Detection Fct/2. CLEVSELA/Model Fitting

Stratum : 2. CLEVSELA
Effort : 6.000000
samples : 6
Width : 180.0000
observations: 9

Model 1
Half-normal key, k(y) = Exp(-y**2/(2*A(3)**2))
Results:
Convergence was achieved with 11 function evaluations.
Final Ln(likelihood) value = -44.852389
Akaike information criterion = 91.704781
Bayesian information criterion = 91.902000
AICc = 92.276207
Final parameter values: 65.537246

Model 2
Half-normal key, k(y) = Exp(-y**2/(2*A(3)**2))
Hermite polynomial adjustments of order(s) : 4
Results:
Convergence was achieved with 22 function evaluations.
Final Ln(likelihood) value = -44.846146
Akaike information criterion = 93.692291
Bayesian information criterion = 94.086739
AICc = 95.692291
Final parameter values: 58.489940 -0.14930813

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 0.0125
Probability of a greater value = 0.911033
*** Model 1 selected over model 2 based on minimum AIC
Detection Fct/2. CLEVSELA/Model Fitting

Stratum : 2. CLEVSELA
Effort : 6.000000
samples : 6
Width : 180.0000
observations: 9

Model 1
Hazard Rate key, k(y) = 1 - Exp(-(y/A(3))**-A(4))
Results:
Convergence was achieved with 9 function evaluations.
Final Ln(likelihood) value = -44.815610
Akaike information criterion = 93.631218
Bayesian information criterion = 94.025673
AICc = 95.631218
Final parameter values: 73.246456 3.2587575

Model 2
Hazard Rate key, k(y) = 1 - Exp(-(y/A(3))**-A(4))
Simple polynomial adjustments of order(s) : 4
Results:
Convergence was achieved with 64 function evaluations.
Final Ln(likelihood) value = -44.525515
Akaike information criterion = 95.051033
Bayesian information criterion = 95.642708
AICc = 99.851036
Final parameter values: 73.647057 1.7163311 -1.4266430

Likelihood ratio test between models 1 and 2

Likelihood ratio test value = 0.5802
Probability of a greater value = 0.446238
*** Model 1 selected over model 2 based on minimum AIC
Detection Fct/2. CLEVSELA/Model Fitting

Stratum : 2. CLEVSELA
Effort : 6.000000
samples : 6
Width : 180.0000
observations: 9

Model Selection

Minimum AIC = 91.54584
Estimator chosen based on minimum AIC :
Model
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1
Detection Fct/2. CLEVSELA/Parameter Estimates

Stratum : 2. CLEVSELA
Effort : 6.000000
samples : 6
Width : 180.0000
observations: 9

Model
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95 Percent Confidence Interval	
A(3)	1.000	0.2116			
h(0)	0.20758E-03	0.51902E-04	25.00	0.11765E-03	0.36627E-03
p	0.29737	0.74350E-01	25.00	0.16853	0.52469
EDR	98.156	12.271	12.50	73.655	130.81

Detection Fct/2. CLEVSELA/Plot: Qq-plot
Detection Fct/2. CLEVSELA/K-S GOF Test

Kolmogorov-Smirnov test

D_n = 0.2063 p = 0.8385

Cramer-von Mises family tests

W-sq (uniform weighting) = 0.0596 0.800 < p <= 0.900
Relevant critical values:
W-sq crit(alpha=0.900) = 0.0482
W-sq crit(alpha=0.800) = 0.0645

C-sq (cosine weighting) = 0.0396 0.800 < p <= 0.900
Relevant critical values:
C-sq crit(alpha=0.900) = 0.0300
C-sq crit(alpha=0.800) = 0.0406
Detection Fct/2. CLEVSELA/Plot: Detection Probability 1

```
         |+-------+-------+-------+--------+-------+-------+-------+-------+|
  1.5507 +                                                                  +
         |                                                                  |
         |                                                                  |
         |                                                                  |
         |     *********                                                    |
  1.3616 +     *       *                                                    +
         |     *       *                                                    |
         |     *       *                                                    |
         |     *       *                                                    |
         |     *       *                                                    |
D 1.1725 +     *       *                                                    +
```

```
e        |       *      *                                       |
t        |       *      *                                       |
e        |       *      *                                       |
c        |       *      *                                       |
t  0.9834 + fffffff*       *                                       +
i        |       ffff    *                                      |
o        |       *   fff *       **********                        |
n        |       *      ff      *       *                          |
         |       *      *ff     *       *                          |
P   0.7943 +       *      *  ff   *       *                         +
r        |       *      *   ff *       *                          |
o        |       *      *     f*       *                          |
b        |       *      *      ff      *                          |
a        |       *      *      * ff     *                          |
b  0.6052 +       *      *      *  f    *                          +
i        |       *      *      *    ff  *                          |
l        |       *      *      *     ff*                          |
i        |       *      *      *       f                          |
t        |       *      *      *       *ff                        |
y   0.4160 +       *      *********       *  f                       +
         |       *      *      *       *  ff                       |
         |       *      *      *       *    ff                     |
         |       *      *      *       *      f                    |
         |       *      *      *       *       ff                  |
   0.2269 +       *      *      *       *********  ff                 +
         |       *      *      *       *       *****ff**           |
         |       *      *      *       *      *      ff********    |
         |       *      *      *       *      *       *fff    *    |
         |       *      *      *       *      *       *  fff *     |
   0.0378 +       *      *      *       *      *       *      ffff     +
         |*********                                       ***ffffff|
         |+-------+-------+-------+--------+-------+-------+-------+-------+|
      0.000         45.000          90.000        135.000       180.000
             22.500          67.500         112.500        157.500

                         Radial distance in meters
             Detection Fct/2. CLEVSELA/Plot: Pdf 1
         |+-------+-------+-------+--------+-------+-------+-------+-------+|
   0.0163 +                                                        +
         |                                                        |
         |                                                        |
         |                                                        |
         |                 **********                             |
   0.0143 +                     *       *                             +
         |                 *       *                              |
         |                 *       *                              |
         |                 *       *                              |
         |                 *       *                              |
   0.0123 +                     *       *                             +
         |                 *       *                              |
P        |                  *       *                             |
r        |                 *       *                              |
o        |                  *       *                             |
b  0.0103 +                     *       *                             +
a        |       *********       * ffff   *                         |
b        |       *      *     ffff    fff*                          |
i        |       *      *  ff  *       ff                           |
l        |       *      * f    *       * ff                         |
i  0.0083 +       *      *ff     *       *   f                         +
t        |       *      f      *       *   f                        |
y        |       *      f*      *       *     ff                     |
         |       *     f *      *       *      f                     |
D        |       *    f *      *       *       f                     |
e  0.0064 +       *   f   *      *       *        f                    +
n        |       *  f    *      *       *        f                   |
s        |       * f     *      *       *         f                  |
i        |       *      *      *       *         f                  |
t        |       *f      *********       **************f**********      |
y  0.0044 +       f      *      *       *      *      f*      *       +
         |      f*      *      *       *      *      f      *      |
         |       *      *      *       *      *      *f     *      |
         |     f *      *      *       *      *      * f    *      |
         |    f  *      *      *       *      *      * f    *      |
   0.0024 +    f   *      *      *       *      *      *  f   *       +
         |       *      *      *       *      *      *  ff *       |
```

```
        |  f     *       *       *        *       *       *      f*        |
        | f      *       *       *        *       *       *      f         |
        |        *       *       *        *       *       *      *ff       |
  0.0004 + f       *       *       *        *       *       *      *  ff    +
        |*********                                            *****ffff|
        |+--------+--------+--------+---------+--------+--------+--------+--------+|
      0.000        45.000         90.000       135.000        180.000
           22.500         67.500         112.500        157.500

                     Radial distance in meters
              Detection Fct/2. CLEVSELA/Chi-sq GOF Test 1
```

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	22.5	0	0.46	0.464
2	22.5	45.0	2	1.29	0.395
3	45.0	67.5	1	1.82	0.371
4	67.5	90.0	3	1.96	0.551
5	90.0	112.	1	1.70	0.289
6	112.	135.	1	1.15	0.020
7	135.	158.	1	0.53	0.428
8	158.	180.	0	0.09	0.087

Total Chi-square value =   2.6042 Degrees of Freedom = 6.00

Probability of a greater chi-square value, P = 0.85663

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
3	0.000	67.5	3	3.57	0.092
4	67.5	90.0	3	1.96	0.551
5	90.0	180.	3	3.47	0.063

Total Chi-square value =   0.7051 Degrees of Freedom = 1.00

Probability of a greater chi-square value, P = 0.40107

```
              Detection Fct/2. CLEVSELA/Plot: Detection Probability 2
        |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
  2.0935 +                                                        +
        |                                                     |
        |                                                     |
        |                                                     |
        |         ******                                        |
  1.8382 +           *    *                                       +
        |         *    *                                        |
        |         *    *                                        |
        |         *    *                                        |
        |         *    *                                        |
D  1.5829 +          *    *     ******                              +
e       |         *    *    *    *                                |
t       |         *    *    *    *                                |
e       |         *    *    *    *                                |
c       |         *    *    *    *                                |
t  1.3276 +          *    *    *    *                             +
i       |         *    *    *    *                                |
o       |         *    *    *    *                                |
n       |         *    *    *    *                                |
        |         *    *    *    *                                |
P  1.0723 +          *    *    *    *                              +
r       | ff      *    *    *    *                                |
o       |  fffffff *    *    *    *                                |
b       |         ffff  *    *    *                                |
a       |          *  fff    *    *                                |
b  0.8170 +          *    *fff  *    *                              +
i       |         *    *   fff   *                                |
l       |         *    *    *ff  *                                |
i       |         *    *******  ff*                                |
t       |         *    *    *    ff                                |
```

```
y  0.5617 +          *    *     *    * fff                          +
         |        *    *     *    *    ff                          |
         |        *    *     *    *     ff                         |
         |        *    *     *    *       ff                       |
         |        *    *     *    *         ff                     |
   0.3064 +          *    *     *    *          **ff**                 +
         |        *    *     *    *         *   fff**********        |
         |        *    *     *    *         *    * ff  *    *        |
         |        *    *     *    *         *    *   fff    *        |
         |        *    *     *    *         *    *     *ffff*        |
   0.0511 +          *    *     *    *          *    *    *   fffff      +
         |************           ************           *****fffffff|
         |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
       0.000        45.000    75.000   105.000   135.000   165.000
           15.000          60.000    90.000  120.000   150.000   180.000

                    Radial distance in meters
          Detection Fct/2. CLEVSELA/Plot: Pdf 2
         |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
   0.0244 +                                                          +
         |                                                         |
         |                                                         |
         |                                                         |
         |                ******                                     |
   0.0215 +                     *    *                                  +
         |                *    *                                   |
         |                *    *                                   |
         |                *    *                                   |
         |                *    *                                   |
   0.0185 +                     *    *                                  +
         |                *    *                                   |
P        |                 *    *                                   |
r        |                *    *                                   |
o        |                 *    *                                   |
b  0.0155 +                      *    *                                  +
a        |         ******     *    *                                 |
b        |         *    *     *    *                                 |
i        |        *    *     *    *                                 |
l        |        *    *     *    *                                 |
i  0.0125 +          *    *     *    *                                  +
t        |        *    *     *    *                                 |
y        |         *    *     *    *                                 |
         |        *    *     *    *                                 |
D        |         *    *     *    *                                 |
e  0.0095 +          *    *     fffffffffff                             +
n        |         *    * fff*    *      ff                          |
s        |         *    *ff   *    *       fff                        |
i        |        *  ff    *    *        f                          |
t        |        *  f *******    *        **fff*************          |
y  0.0066 +          *ff *     *    *         *   ff    *    *          +
         |        f   *     *    *         *    *f   *    *          |
         |       f*   *     *    *         *    * ff  *    *          |
         |      f *   *     *    *         *    *   f *    *          |
         |    ff *   *     *    *         *    *    ff    *          |
   0.0036 +     f    *     *    *    *          *    *     *f   *        +
         |    f     *    *     *    *         *    *     * ff *        |
         |   f      *    *     *    *         *    *     *  ff        |
         |  f       *    *     *    *         *    *     *   *ff      |
         | f        *    *     *    *         *    *     *   * ff     |
   0.0006 + f        *    *     *    *          *    *     *    *   fff   +
         |************           ************           ********ffff|
         |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
       0.000        45.000    75.000   105.000   135.000   165.000
           15.000          60.000    90.000  120.000   150.000   180.000

                    Radial distance in meters
          Detection Fct/2. CLEVSELA/Chi-sq GOF Test 2
```

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	15.0	0	0.21	0.208
2	15.0	30.0	0	0.60	0.604
3	30.0	45.0	2	0.94	1.201
4	45.0	60.0	1	1.18	0.027

5	60.0	75.0	3	1.30	2.212
6	75.0	90.0	0	1.30	1.302
7	90.0	105.	0	1.18	1.184
8	105.	120.	1	0.97	0.001
9	120.	135.	1	0.70	0.130
10	135.	150.	1	0.41	0.828
11	150.	165.	0	0.17	0.172
12	165.	180.	0	0.03	0.027

Total Chi-square value = 7.8963 Degrees of Freedom = 10.00

Probability of a greater chi-square value, P = 0.63897

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
4	0.000	60.0	3	2.93	0.002
5	60.0	75.0	3	1.30	2.212
6	75.0	90.0	0	1.30	1.302
7	90.0	105.	0	1.18	1.184
8	105.	180.	3	2.28	0.226

Total Chi-square value = 4.9253 Degrees of Freedom = 3.00

Probability of a greater chi-square value, P = 0.17735

```
          Detection Fct/2. CLEVSELA/Plot: Detection Probability 3
        |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
   3.7487 +                                                        +
        |                                                        |
        |                                                        |
        |                                                        |
        |       *****                                            |
   3.2915 +         *   *                                        +
        |       *  *                                             |
        |       *  *                                             |
        |       *  *                                             |
        |       *  *                                             |
D  2.8344 +         *   *                                        +
e       |        *  *                                            |
t       |       *  *                                             |
e       |        *  *                                            |
c       |        *  *                                            |
t  2.3772 +         *   *        ****                            +
i       |       *   *       * *                                  |
o       |        *  *        * *                                 |
n       |        *  *        * *                                 |
        |       *   *       * *                                  |
P  1.9201 +         *   *        * *                             +
r       |       *   *       * *                                  |
o       |        *  *        * *                                 |
b       |        *  *        * *                                 |
a       |        *  *        * *                                 |
b  1.4629 +         *   *        * *                             +
i       |       *   *       * *                                  |
l       |       *   *       * *                                  |
i       |       *   *       * *                                  |
t       |       *   *       * *                                  |
y  1.0057 + fffffff *   *        * *                             +
        |      fffffff    **** *                                 |
        |       *  * fffff* * *                                  |
        |       *  *    ffff *                                   |
        |       *  *    * *ffff                                  |
   0.5486 +         *   *     * * * ffff     ****                +
        |       *  *    * * *    ffff *  *  *****                |
        |       *  *    * * *       ffff*  *   *  *****          |
        |       *  *    * * *        *  ffff   *  *  *           |
        |       *  *    * * *        *  * *fffff *   *           |
   0.0914 +         *   *     * * *        * * *  * fffffff      +
        |***********  ********    ************  ****   ****  **fffffffff|
        |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
```

```
   0.000      37.895   66.316   94.737  123.158    151.579  180.000
      9.474      47.368   75.789   104.211  132.632  161.053

                     Radial distance in meters
            Detection Fct/2. CLEVSELA/Plot: Pdf 3
         |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
    0.0387 +                                                        +
         |                                                      |
         |                                                      |
         |                                                      |
         |                ****                                   |
    0.0340 +                   * *                                 +
         |                * *                                    |
         |                * *                                    |
         |                * *                                    |
         |                * *                                    |
    0.0293 +                   * *                                 +
         |                * *                                    |
P        |                 * *                                   |
r        |                * *                                    |
o        |                 * *                                   |
b   0.0245 +                   * *                                 +
a        |        *****       * *                                |
b        |        *  *       * *                                 |
i        |       *  *       * *                                  |
l        |       *  *       * *                                  |
i   0.0198 +       *  *        * *                               +
t        |       *  *       * *                                  |
y        |        *  *       * *                                 |
         |       *  *       * *                                  |
D        |        *  *       * *                                 |
e   0.0151 +       *  *        * *                                 +
n        |        *  *       * *                                 |
s        |        *  *       * *                                 |
i        |       *  *       * *                                  |
t        |       *  *    ****  *       ****  *****  *****        |
y   0.0104 +       *  *    * * *       * * *  * * *  *            +
         |       *  *   ffffffffffffff  * * *  * * *             |
         |       *  * fff * * *      ffff  * *  * * *            |
         |       *  fff   * * *       *ff* *  * * *              |
         |       * ff*    * * *       *  fff*  * * *             |
    0.0057 +       ff *    * * *       * *  fff * *  *           +
         |     ff*  *     * * *       * * *  ff  *  *            |
         |    ff *  *     * * *       * * *  *ff*  *             |
         |   f   *  *     * * *       * * *  *  fff *            |
         |  ff   *  *     * * *       * * *  * * fff             |
    0.0009 + ff      *  *    * * *       * * *  * *  * ffff     +
         |***********  ********     ************  ****   ****   ******fffff|
         |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
   0.000      37.895   66.316   94.737  123.158    151.579  180.000
      9.474      47.368   75.789   104.211  132.632  161.053

                     Radial distance in meters
            Detection Fct/2. CLEVSELA/Chi-sq GOF Test 3
```

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	9.47	0	0.08	0.084
2	9.47	18.9	0	0.25	0.247
3	18.9	28.4	0	0.40	0.401
4	28.4	37.9	2	0.54	3.970
5	37.9	47.4	0	0.65	0.654
6	47.4	56.8	0	0.74	0.743
7	56.8	66.3	1	0.80	0.048
8	66.3	75.8	3	0.83	5.653
9	75.8	85.3	0	0.83	0.829
10	85.3	94.7	0	0.80	0.795
11	94.7	104.	0	0.73	0.734
12	104.	114.	1	0.65	0.188
13	114.	123.	0	0.55	0.549
14	123.	133.	1	0.44	0.727
15	133.	142.	0	0.32	0.322
16	142.	152.	1	0.21	2.924
17	152.	161.	0	0.12	0.117

18	161.	171.	0	0.05	0.046
19	171.	180.	0	0.01	0.007

Total Chi-square value = 19.0399 Degrees of Freedom = 17.00

Probability of a greater chi-square value, P = 0.32625

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
6	0.000	56.8	2	2.67	0.167
7	56.8	66.3	1	0.80	0.048
8	66.3	75.8	3	0.83	5.653
9	75.8	85.3	0	0.83	0.829
10	85.3	94.7	0	0.80	0.795
11	94.7	104.	0	0.73	0.734
12	104.	180.	3	2.34	0.186

Total Chi-square value = 8.4130 Degrees of Freedom = 5.00

Probability of a greater chi-square value, P = 0.13490

One or more expected values is < 1.
Try pooling some some cells by hand to obtain a more reliable test.
Detection Fct/3. ARMYOLIF/Model Fitting

Stratum : 3. ARMYOLIF
Effort : 5.000000
samples : 5
Width : 180.0000
observations: 12

Model 1
Uniform key, k(y) = 1/W
Results:
Convergence was achieved with 1 function evaluations.
Final Ln(likelihood) value = -63.956313
Akaike information criterion = 127.91263
Bayesian information criterion = 127.91263
AICc = 127.91263
Final parameter values:

Model 2
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1
Results:
Convergence was achieved with 135 function evaluations.
Final Ln(likelihood) value = -58.578506
Akaike information criterion = 119.15701
Bayesian information criterion = 119.64192
AICc = 119.55701
Final parameter values: 1.0000008

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 10.7556
Probability of a greater value = 0.001040
*** Model 2 selected over model 1 based on minimum AIC

Model 3
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1, 2
Results:
Convergence was achieved with 24 function evaluations.
Final Ln(likelihood) value = -58.453496
Akaike information criterion = 120.90699
Bayesian information criterion = 121.87681

AICc = 122.24033
Final parameter values: 0.79960508 -0.20039532
** Warning: Parameters are being constrained to obtain monotonicity. **

Likelihood ratio test between models 2 and 3
Likelihood ratio test value = 0.2500
Probability of a greater value = 0.617061
*** Model 2 selected over model 3 based on minimum AIC
Detection Fct/3. ARMYOLIF/Model Fitting

Stratum : 3. ARMYOLIF
Effort : 5.000000
samples : 5
Width : 180.0000
observations: 12

Model 1
Half-normal key, k(y) = Exp(-y**2/(2*A(4)**2))
Results:
Convergence was achieved with 11 function evaluations.
Final Ln(likelihood) value = -59.170379
Akaike information criterion = 120.34076
Bayesian information criterion = 120.82566
AICc = 120.74076
Final parameter values: 67.675646

Model 2
Half-normal key, k(y) = Exp(-y**2/(2*A(4)**2))
Cosine adjustments of order(s) : 2
Results:
Convergence was achieved with 9 function evaluations.
Final Ln(likelihood) value = -58.909816
Akaike information criterion = 121.81963
Bayesian information criterion = 122.78944
AICc = 123.15297
Final parameter values: 67.090997 -0.15487685
** Warning: Parameters are being constrained to obtain monotonicity. **

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 0.5211
Probability of a greater value = 0.470362
*** Model 1 selected over model 2 based on minimum AIC
Detection Fct/3. ARMYOLIF/Model Fitting

Stratum : 3. ARMYOLIF
Effort : 5.000000
samples : 5
Width : 180.0000
observations: 12

Model 1
Half-normal key, k(y) = Exp(-y**2/(2*A(4)**2))
Results:
Convergence was achieved with 11 function evaluations.
Final Ln(likelihood) value = -59.170379
Akaike information criterion = 120.34076
Bayesian information criterion = 120.82566
AICc = 120.74076
Final parameter values: 67.675646

Model 2
Half-normal key, k(y) = Exp(-y**2/(2*A(4)**2))
Hermite polynomial adjustments of order(s) : 4
Results:
Convergence was achieved with 23 function evaluations.
Final Ln(likelihood) value = -58.803844
Akaike information criterion = 121.60769
Bayesian information criterion = 122.57750
AICc = 122.94102

Final parameter values: 53.763561 -0.24585857
** Warning: Parameters are being constrained to obtain monotonicity. **

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 0.7331
Probability of a greater value = 0.391890
*** Model 1 selected over model 2 based on minimum AIC
Detection Fct/3. ARMYOLIF/Model Fitting

Stratum : 3. ARMYOLIF
Effort : 5.000000
samples : 5
Width : 180.0000
observations: 12

Model 1
Hazard Rate key, k(y) = 1 - Exp(-(y/A(5))**-A(6))
Results:
Convergence was achieved with 8 function evaluations.
Final Ln(likelihood) value = -58.401667
Akaike information criterion = 120.80334
Bayesian information criterion = 121.77315
AICc = 122.13667
Final parameter values: 132.68803 20.000000
** Warning: Parameter 6 is at an upper bound. **

Model 2
Hazard Rate key, k(y) = 1 - Exp(-(y/A(5))**-A(6))
Simple polynomial adjustments of order(s) : 4
Results:
Convergence was achieved with 16 function evaluations.
Final Ln(likelihood) value = -57.787542
Akaike information criterion = 121.57508
Bayesian information criterion = 123.02980
AICc = 124.57508
Final parameter values: 141.44293 20.000000 -2.0926387
** Warning: Parameter 6 is at an upper bound. **

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 1.2283
Probability of a greater value = 0.267748
*** Model 1 selected over model 2 based on minimum AIC
Detection Fct/3. ARMYOLIF/Model Fitting

Stratum : 3. ARMYOLIF
Effort : 5.000000
samples : 5
Width : 180.0000
observations: 12

Model Selection

Minimum AIC = 119.1570
Estimator chosen based on minimum AIC :
Model
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1
Detection Fct/3. ARMYOLIF/Parameter Estimates

Stratum : 3. ARMYOLIF
Effort : 5.000000
samples : 5
Width : 180.0000
observations: 12

Model
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1

Point Standard Percent Coef. 95 Percent

```
 Parameter   Estimate      Error      of Variation     Confidence Interval
 ---------  -----------  -----------  --------------  ----------------------
   A( 4)      1.000       0.2965
   h(0)     0.20758E-03  0.72708E-04      35.03      0.98181E-04  0.43889E-03
   p        0.29737      0.10415         35.03      0.14065      0.62872
   EDR       98.156       17.190          17.51      66.954       143.90
 ---------  -----------  -----------  --------------  ----------------------
            Detection Fct/3. ARMYOLIF/Plot: Qq-plot
            Detection Fct/3. ARMYOLIF/K-S GOF Test


Kolmogorov-Smirnov test
-----------------------

D_n                   = 0.1945              p  = 0.7542


Cramer-von Mises family tests
-----------------------------

W-sq (uniform weighting) = 0.0775          0.700 < p <= 0.800
  Relevant critical values:
    W-sq crit(alpha=0.800) = 0.0638
    W-sq crit(alpha=0.700) = 0.0802

C-sq (cosine weighting)  = 0.0522          0.600 < p <= 0.700
  Relevant critical values:
    C-sq crit(alpha=0.700) = 0.0510
    C-sq crit(alpha=0.600) = 0.0633
            Detection Fct/3. ARMYOLIF/Plot: Detection Probability 1
```

```
         |+-------+-------+-------+--------+-------+-------+-------+-------+|
   1.1630 +                                                                 +
         |                                                                 |
         |                                                                 |
         |                                                                 |
         |        *********                                                |
   1.0212 +       *       *                                                 +
         | ffffff *       *                                                |
         |       fff      *                                                |
         |        * ff    *                                                |
         |        *  ff  *                                                 |
D   0.8794 +       *     ff*                                                +
e        |       *       ff                                                |
t        |       *       * f                                               |
e        |       *       *  ff                                             |
c        |       *       *    f                                            |
t   0.7375 +       *       *     f                                          +
i        |       *       *      ff                                         |
o        |       *       *       *f********                                |
n        |       *       *       * f      *                                |
         |       *       *********  f     *                                |
P   0.5957 +       *       *       *   ff   *                               +
r        |       *       *       *    f  *                                 |
o        |       *       *       *     f *                                 |
b        |       *       *       *      f*                                 |
a        |       *       *       *       f                                 |
b   0.4539 +       *       *       *        *ff                             +
i        |       *       *       *        *  f    *********                |
l        |       *       *       *        *   f   *       *                |
i        |       *       *       *        *    f  *       *                |
t        |       *       *       *       ******f**        *                |
y   0.3120 +       *       *       *       *      ff       *                +
         |       *       *       *       *       *f       *                |
         |       *       *       *       *       * f      *                |
         |       *       *       *       *       *  ff    *                |
         |       *       *       *       *       *    f   *                |
   0.1702 +       *       *       *       *       *      ff*                +
         |       *       *       *       *       *       f                 |
         |       *       *       *       *       *       *ff               |
         |       *       *       *       *       *       *  ff             |
         |       *       *       *       *       *       *    fff          |
   0.0284 +       *       *       *       *       *       *       ffff      +
         |*********                                        ************fffff|
         |+-------+-------+-------+--------+-------+-------+-------+-------+|
       0.000          45.000          90.000          135.000         180.000
```

```
          22.500       67.500       112.500      157.500

                    Radial distance in meters
          Detection Fct/3. ARMYOLIF/Plot: Pdf 1
       |+-------+-------+-------+--------+-------+-------+-------+-------+|
  0.0122 +                                                       +
       |                                                   |
       |                                                   |
       |                                                   |
       |                 **********     *********               |
  0.0107 +                    *      *      *      *             +
       |                 *      *      *      *              |
       |                 *      *      *      *              |
       |                 *fffff  *      *      *              |
       |               fff    fff*      *      *              |
  0.0092 +                 f  *      f      *      *             +
       |               f   *      *ff    *      *             |
P      |              ff   *      * f   *      *             |
r      |             f      *      * f  *      *             |
o      |                    *      *   f *      *             |
b  0.0078 +               f      *      *   f *      *           +
a      |      *******f*********      *******f*      *          |
b      |      *    f *      *      *      f      *             |
i      |     *   f *      *      *      *f      *             |
l      |     *      *      *      *      *      *             |
i  0.0063 +      *  f  *      *      *      * f    *           +
t      |     * f    *      *      *      * f    *             |
y      |     *      *      *      *      *  f  *             |
       |     * f    *      *      *      *      *             |
D      |      *f     *      *      *      *    f *            |
e  0.0048 +      *      *      *      *      *    f *          +
n      |     f      *      *      *      *    f*             |
s      |     *      *      *      *      *      *            |
i      |    f*      *      *      *      *      f            |
t      |     *      *      *      *      *      *f           |
y  0.0033 +     f *      *      *      *      *      * f         +
       |   f *      *      *      *      *      * f           |
       |     *      *      *      *      *      *             |
       |   f *      *      *      *      *      *  f          |
       |     *      *      *      *      *      *   f         |
  0.0018 +  f   *      *      *      *      *      *      f      +
       |     *      *      *      *      *      *    f        |
       | f   *      *      *      *      *      *     f       |
       |     *      *      *      *      *      *      f      |
       | f   *      *      *      *      *      *     ff      |
  0.0003 +      *      *      *      *      *      *        ff  +
       |*********                                **************fff|
       |+-------+-------+-------+--------+-------+-------+-------+-------+|
     0.000      45.000       90.000       135.000      180.000
          22.500       67.500       112.500      157.500

                    Radial distance in meters
          Detection Fct/3. ARMYOLIF/Chi-sq GOF Test 1
```

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	22.5	0	0.62	0.619
2	22.5	45.0	2	1.72	0.047
3	45.0	67.5	2	2.43	0.076
4	67.5	90.0	3	2.61	0.057
5	90.0	112.	2	2.27	0.032
6	112.	135.	3	1.54	1.394
7	135.	158.	0	0.70	0.701
8	158.	180.	0	0.12	0.117

Total Chi-square value = 3.0413 Degrees of Freedom = 6.00

Probability of a greater chi-square value, P = 0.80365

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
2	0.000	45.0	2	2.33	0.048
3	45.0	67.5	2	2.43	0.076
4	67.5	90.0	3	2.61	0.057
5	90.0	112.	2	2.27	0.032
6	112.	180.	3	2.35	0.177

Total Chi-square value = 0.3893 Degrees of Freedom = 3.00

Probability of a greater chi-square value, P = 0.94245

```
        Detection Fct/3. ARMYOLIF/Plot: Detection Probability 2
        |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
  1.5701 +                                                               +
         |                                                               |
         |                                                               |
         |                                                               |
         |      ******                                                   |
  1.3786 +     *    *                                                    +
         |    *   *                                                      |
         |    *   *                                                      |
         |    *   *                                                      |
         |    *   *                                                      |
D 1.1871 +     *    *                                                    +
e        |    *   *                                                      |
t        |    *   *                                                      |
e        |    *   *                                                      |
c        |    *   *******                                                |
t 0.9957 + ffffff   *    *    *                                          +
i        |  ffff*   *    *                                               |
o        |    fff *    *                                                 |
n        |    * ff*    *                                                 |
         |    *   ff   *                                                 |
P 0.8042 +     *    * ff  *                                              +
r        |    *   *  ff*                                                 |
o        |    *   *    ff        ******                                  |
b        |    *   *    * ff       *    *                                 |
a        |    *   *    *  f*******   *    *                              |
b 0.6127 +     *    *    *   ff   *    *    *                            +
i        |    *   *    *    * ff *   *    *                              |
l        |    *   *    *    *  f *   *    *                              |
i        |    *   *    *    *   ff   *    *                              |
t        |    *   *    *    *    *f   *    *                             |
y 0.4212 +     *    *    *    *    * ff *    *******                     +
         |    *   *   ******   *  ff   *    *                            |
         |    *   *    *    *    *   *f   *    *                         |
         |    *   *    *    *    *   * ff *    *                         |
         |    *   *    *    *    *   *  ff    *                          |
  0.2298 +     *    *    *    *    *    *   *ff   *                      +
         |    *   *    *    *    *    *    *  ff *                       |
         |    *   *    *    *    *    *    *    ff                       |
         |    *   *    *    *    *    *    *    *ff                      |
         |    *   *    *    *    *    *    *    * fff                    |
  0.0383 +     *    *    *    *    *    *    *    *    *    fffff         +
         |************             ******        ***********ffffff|
        |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
      0.000      45.000    75.000   105.000   135.000   165.000
         15.000      60.000    90.000  120.000   150.000   180.000

                    Radial distance in meters
```

```
        Detection Fct/3. ARMYOLIF/Plot: Pdf 2
        |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
  0.0183 +                                                               +
         |                                                               |
         |                                                               |
         |                                                               |
         |                            ******                             |
  0.0161 +                               *    *                          +
         |                            *    *                             |
         |                            *    *                             |
         |                            *    *                             |
         |                            *    *                             |
  0.0139 +                               *    *                          +
         |                            *    *                             |
```

```
P        |                          *   *                  |
r        |                         *   *                  |
o        |                          *   *                  |
b   0.0116 +                            *   *                  +
a        |       ************    *******    *    *******           |
b        |       *   *    *    *    *    *    *    *           |
i        |      *   *    *    *    *    *    *    *           |
l        |      *   *    * fffffff *    *    *    *           |
i   0.0094 +        *   *    fff  *  fff   *    *    *           +
t        |      *   * ff *    *    *ff *    *    *           |
y        |       *   * f  *    *    * ff*    *    *           |
         |      *   ff   *    *    *   f   *    *           |
D        |       *  f*    *    *    *   *ff *    *           |
e   0.0072 +        * f *    *    *    *    * f *    *           +
n        |       * f *    *    *    *    *  f*    *           |
s        |       *f  *    *    *    *    *   f    *           |
i        |      f   *    *    *    *    *   *f   *           |
t        |      f*   *    ******    *    *   * ff  *           |
y   0.0049 +       f *    *    *    *    *    *    *  f *           +
         |     f *    *    *    *    *    *    *   f*           |
         |    f  *    *    *    *    *    *    *    f           |
         |   f   *    *    *    *    *    *    *    *f           |
         |       *    *    *    *    *    *    *    * f           |
   0.0027 +    f    *    *    *    *    *    *    *    *  * ff         +
         |  f    *    *    *    *    *    *    *    *    f       |
         |  f    *    *    *    *    *    *    *    *    f       |
         | f     *    *    *    *    *    *    *    *     ff     |
         |       *    *    *    *    *    *    *    *      ff    |
   0.0004 + f       *    *    *    *    *    *    *    *      ff   +
         |************              ******         *************ffff|
         |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
       0.000        45.000    75.000   105.000   135.000   165.000
            15.000         60.000    90.000  120.000   150.000   180.000
```

Radial distance in meters

Detection Fct/3. ARMYOLIF/Chi-sq GOF Test 2

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	15.0	0	0.28	0.278
2	15.0	30.0	0	0.81	0.805
3	30.0	45.0	2	1.25	0.448
4	45.0	60.0	2	1.57	0.117
5	60.0	75.0	1	1.74	0.313
6	75.0	90.0	2	1.74	0.040
7	90.0	105.	0	1.58	1.578
8	105.	120.	3	1.29	2.248
9	120.	135.	2	0.93	1.227
10	135.	150.	0	0.55	0.552
11	150.	165.	0	0.23	0.229
12	165.	180.	0	0.04	0.036

Total Chi-square value = 7.8721 Degrees of Freedom = 10.00

Probability of a greater chi-square value, P = 0.64133

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
3	0.000	45.0	2	2.33	0.048
4	45.0	60.0	2	1.57	0.117
5	60.0	75.0	1	1.74	0.313
6	75.0	90.0	2	1.74	0.040
7	90.0	105.	0	1.58	1.578
8	105.	180.	5	3.04	1.258

Total Chi-square value = 3.3542 Degrees of Freedom = 4.00

Probability of a greater chi-square value, P = 0.50039

```
           Detection Fct/3. ARMYOLIF/Plot: Detection Probability 3
         |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
   2.1867 +                                                              +
         |                                                              |
         |                                                              |
         |                                                              |
         |             ****                                              |
   1.9201 +                 *  *                                          +
         |             * *                                              |
         |             * *                                              |
         |             * *                                              |
         |             * *                                              |
D  1.6534 +                 *  *                                          +
e        |             *  *****                                          |
t        |             *  *   *                                         |
e        |             *  *   *                                          |
c        |             *  *   *                                          |
t  1.3867 +                 *  *   *                                      +
i        |             *  *   *                                         |
o        |             *  *   *                                          |
n        |             *  *   *                                          |
         |             *  *   *            ****                           |
P  1.1200 +                 *  *   *            *  *                       +
r        |             *  *   *    *****     *  *                         |
o        | ffff        *  *   *    *   *     *  *                         |
b        |    ffffff   *  *   *    *   *     *  *                         |
a        |         ffff  *   *    *   *     *  *                         |
b  0.8534 +               *fff   *    *   *     *  *                      +
i        |             *  *fff*    *   *     *  *                       |
l        |             *  *   fff  *   *     *  *                       |
i        |             *  *   *  ff *   *     *  *                       |
t        |             *  *   *    ff  *     *  *     ****               |
y  0.5867 +               *  *   *  ****fff*     *  *     *  *              +
         |             *  *   *  *  *  ff    *  *     *  *              |
         |             *  *   *  *  *  * ff   *  *     *  *              |
         |             *  *   *  *  *  *   ff *  *     *  *              |
         |             *  *   *  *  *  *    ff  *     *  *              |
   0.3200 +               *  *   *  *  *  *     *fff      *  *            +
         |             *  *   *  *  *  *      *  *ff    *  *             |
         |             *  *   *  *  *  *      *  *  fff *  *             |
         |             *  *   *  *  *  *      *  *    fff *              |
         |             *  *   *  *  *  *      *  *     * ffff            |
   0.0533 +               *  *   *  *  *  *      *  *     *  *  fffff       +
         |***************      ****      ********  ********  ********fffffff|
         |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
       0.000        37.895    66.316    94.737    123.158    151.579   180.000
          9.474        47.368    75.789    104.211    132.632    161.053

                          Radial distance in meters
           Detection Fct/3. ARMYOLIF/Plot: Pdf 3
         |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
   0.0290 +                                                              +
         |                                                              |
         |                                                              |
         |                                                              |
         |                            ****                               |
   0.0255 +                                *  *                           +
         |                            *  *                              |
         |                            *  *                              |
         |                            *  *                              |
         |                            *  *                              |
   0.0219 +                                *  *                           +
         |                            *  *                              |
P        |                             *  *                              |
r        |                            *  *                              |
o        |                             *  *                              |
b  0.0184 +                                 *  *                          +
a        |             ********     *****     *  *     ****               |
b        |             *  *   *    *  *     *  *     *  *                |
i        |             *  *   *    *  *     *  *     *  *                |
l        |             *  *   *    *  *     *  *     *  *                |
i  0.0149 +               *  *   *    *  *     *  *     *  *               +
t        |             *  *   *    *  *     *  *     *  *                |
y        |             *  *   *    *  *     *  *     *  *                |
         |             *  *   *    *  *     *  *     *  *                |
```

```
D       |          *  *  *    *  *    *  *    *  *          |
e  0.0113 +          *  *  *    *  *    *  *    *  *          +
n       |          *  *  *    *  *    *  *    *  *          |
s       |          *  *  *  ffffff*    *  *    *  *          |
i       |          *  *  ffff  *  ffff  *  *    *  *          |
t       |          *  fff *  ****  *  fff*  *    *  *          |
y  0.0078 +          *ff*  *  *  *  *    ff *    *  *          +
        |        ff  *  *  *  *  *    * ff    *  *          |
        |       f *  *  *  *  *  *    *  *ff   *  *          |
        |      ff  *  *  *  *  *  *    *  * ff  *  *          |
        |     f   *  *  *  *  *  *    *  *   ff*  *          |
   0.0042 +     ff    *  *  *  *  *  *    *  *    ff *          +
        |   f     *  *  *  *  *  *    *  *    * ff          |
        |   f     *  *  *  *  *  *    *  *    *  *ff        |
        |  f      *  *  *  *  *  *    *  *    *  * ff       |
        | ff      *  *  *  *  *  *    *  *    *  *  ff      |
   0.0007 + f        *  *  *  *  *  *    *  *    *  *    fff    +
        |***************     ****     ********  ********  **********fffff|
        |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
       0.000     37.895    66.316    94.737   123.158    151.579   180.000
          9.474      47.368    75.789    104.211   132.632   161.053
```

Radial distance in meters
Detection Fct/3. ARMYOLIF/Chi-sq GOF Test 3

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	9.47	0	0.11	0.111
2	9.47	18.9	0	0.33	0.330
3	18.9	28.4	0	0.53	0.534
4	28.4	37.9	0	0.72	0.718
5	37.9	47.4	2	0.87	1.460
6	47.4	56.8	2	0.99	1.028
7	56.8	66.3	0	1.07	1.071
8	66.3	75.8	1	1.11	0.011
9	75.8	85.3	2	1.10	0.725
10	85.3	94.7	0	1.06	1.060
11	94.7	104.	0	0.98	0.979
12	104.	114.	3	0.87	5.246
13	114.	123.	0	0.73	0.732
14	123.	133.	0	0.58	0.582
15	133.	142.	2	0.43	5.760
16	142.	152.	0	0.28	0.283
17	152.	161.	0	0.16	0.157
18	161.	171.	0	0.06	0.062
19	171.	180.	0	0.01	0.009

Total Chi-square value = 20.8574 Degrees of Freedom = 17.00

Probability of a greater chi-square value, P = 0.23273

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
5	0.000	47.4	2	2.56	0.124
6	47.4	56.8	2	0.99	1.028
7	56.8	66.3	0	1.07	1.071
8	66.3	75.8	1	1.11	0.011
9	75.8	85.3	2	1.10	0.725
10	85.3	94.7	0	1.06	1.060
11	94.7	104.	0	0.98	0.979
12	104.	114.	3	0.87	5.246
13	114.	180.	2	2.25	0.028

Total Chi-square value = 10.2728 Degrees of Freedom = 7.00

Probability of a greater chi-square value, P = 0.17364

One or more expected values is < 1.

Try pooling some some cells by hand to obtain a more reliable test.
Detection Fct/4. KRUGOLIF/Model Fitting

Stratum : 4. KRUGOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 134

Model 1
Uniform key, k(y) = 1/W
Results:
Convergence was achieved with 1 function evaluations.
Final Ln(likelihood) value = -624.77004
Akaike information criterion = 1249.5400
Bayesian information criterion = 1249.5400
AICc = 1249.5400
Final parameter values:

Model 2
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1
Results:
Convergence was achieved with 2 function evaluations.
Final Ln(likelihood) value = -624.77004
Akaike information criterion = 1251.5400
Bayesian information criterion = 1254.4379
AICc = 1251.5703
Final parameter values: 0.00000000
** Warning: Parameters are being constrained to obtain monotonicity. **

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 0.0000
Probability of a greater value = 1.000000
*** Model 1 selected over model 2 based on minimum AIC
Detection Fct/4. KRUGOLIF/Model Fitting

Stratum : 4. KRUGOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 134

Model 1
Half-normal key, k(y) = Exp(-y**2/(2*A(5)**2))
Results:
Convergence was achieved with 39 function evaluations.
Final Ln(likelihood) value = -624.77004
Akaike information criterion = 1251.5400
Bayesian information criterion = 1254.4379
AICc = 1251.5703
Final parameter values: 1000000.0
** Warning: Parameter 5 is at an upper bound. **

Model 2
Half-normal key, k(y) = Exp(-y**2/(2*A(5)**2))
Cosine adjustments of order(s) : 2
Results:
Convergence was achieved with 3 function evaluations.
Final Ln(likelihood) value = -560.00752
Akaike information criterion = 1124.0150
Bayesian information criterion = 1129.8107
AICc = 1124.1066
Final parameter values: 1000000.0 1.0250272
** Warning: Parameter 5 is at an upper bound. **

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 129.5250
Probability of a greater value = 0.000000

```
*** Model  2 selected over model  1 based on minimum AIC
            Detection Fct/4. KRUGOLIF/Model Fitting

Stratum      : 4. KRUGOLIF
Effort       :   10.00000
# samples    :   10
Width        :   180.0000
# observations:   134



Model  1
   Half-normal key, k(y) = Exp(-y**2/(2*A(5)**2))
      Results:
      Convergence was achieved with   39 function evaluations.
      Final Ln(likelihood) value =  -624.77004
      Akaike information criterion =   1251.5400
      Bayesian information criterion =   1254.4379
      AICc =   1251.5703
      Final parameter values:   1000000.0
     ** Warning: Parameter  5 is at an upper bound. **


Model  2
   Half-normal key, k(y) = Exp(-y**2/(2*A(5)**2))
   Hermite polynomial adjustments of order(s) :  4
      Results:
      Convergence was achieved with    2 function evaluations.
      Final Ln(likelihood) value =  -624.77004
      Akaike information criterion =   1253.5400
      Bayesian information criterion =   1259.3357
      AICc =   1253.6316
      Final parameter values:   1000000.0        0.00000000
     ** Warning: Parameters are being constrained to obtain monotonicity. **
     ** Warning: Parameter  5 is at an upper bound. **

   Likelihood ratio test between models  1 and  2
      Likelihood ratio test value    =     0.0000
      Probability of a greater value =   1.000000
*** Model  1 selected over model  2 based on minimum AIC
            Detection Fct/4. KRUGOLIF/Model Fitting

Stratum      : 4. KRUGOLIF
Effort       :   10.00000
# samples    :   10
Width        :   180.0000
# observations:   134



Model  1
   Hazard Rate key, k(y) = 1 - Exp(-(y/A(7))**-A(8))
      Results:
      Convergence was achieved with   59 function evaluations.
      Final Ln(likelihood) value =  -623.78516
      Akaike information criterion =   1251.5703
      Bayesian information criterion =   1257.3660
      AICc =   1251.6619
      Final parameter values:   178.15930      20.000000
     ** Warning: Parameter  8 is at an upper bound. **


Model  2
   Hazard Rate key, k(y) = 1 - Exp(-(y/A(7))**-A(8))
   Simple polynomial adjustments of order(s) :  4
      Results:
      Convergence was achieved with   17 function evaluations.
      Final Ln(likelihood) value =  -623.77347
      Akaike information criterion =   1253.5470
      Bayesian information criterion =   1262.2405
      AICc =   1253.7316
      Final parameter values:   178.83114      20.000000    -0.88891639E-08
     ** Warning: Parameters are being constrained to obtain monotonicity. **
     ** Warning: Parameter  8 is at an upper bound. **
```

Likelihood ratio test between models 1 and 2
Likelihood ratio test value = 0.0234
Probability of a greater value = 0.878492
*** Model 1 selected over model 2 based on minimum AIC
Detection Fct/4. KRUGOLIF/Model Fitting

Stratum : 4. KRUGOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 134

Model Selection

Minimum AIC = 1124.015
Estimator chosen based on minimum AIC :
Model
Half-normal key, k(y) = Exp(-y**2/(2*A(5)**2))
Cosine adjustments of order(s) : 2
Detection Fct/4. KRUGOLIF/Parameter Estimates

Stratum : 4. KRUGOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 134

Model
Half-normal key, k(y) = Exp(-y**2/(2*A(5)**2))
Cosine adjustments of order(s) : 2

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95 Percent Confidence Interval	
A(5)	0.1000E+07	0.8639E+05			
A(6)	1.025	0.1757			
h(0)	0.12486E-03	0.92413E-05	7.40	0.10787E-03	0.14451E-03
p	0.49439	0.36592E-01	7.40	0.42714	0.57223
EDR	126.56	4.6838	3.70	117.63	136.17

Sampling Correlation of Estimated Parameters

	A(5)	A(6)
A(5)	1.000	0.000
A(6)	0.000	1.000

Detection Fct/4. KRUGOLIF/Plot: Qq-plot
Detection Fct/4. KRUGOLIF/K-S GOF Test

Kolmogorov-Smirnov test

D_n = 0.4204 p = 0.0000

Cramer-von Mises family tests

W-sq (uniform weighting) = 5.6675 0.000 < p <= 0.001
Relevant critical values:
W-sq crit(alpha=0.001) = 1.1792

C-sq (cosine weighting) = 3.9262 0.000 < p <= 0.001
Relevant critical values:
C-sq crit(alpha=0.001) = 0.8183
Detection Fct/4. KRUGOLIF/Plot: Detection Probability 1

```
      |+-------+-------+-------+--------+-------+-------+-------+-------+|
1.9913 +                                                        +
      |                                                         |
      |                                                         |
```

```
          |                                                  |
          |                                           *********|
    1.7485 +                                               *      *+
          |                                          *      *|
          |                                          *      *|
          |                                          *      *|
          |                                          *      *|
D   1.5056 +                                               *      *+
e         |                                          *      *|
t         |                                          *      *|
e         |                                          *      *|
c         |                                          *      *|
t   1.2628 +                                               *      *+
i         |                                          *      *|
o         |                                          *      *|
n         |                                          *      *|
          |                                          *      *|
P   1.0200 + f                                             *      ff+
r         |  fff                                     *   fff *|
o         |     ff                                   * ff    *|
b         |       ff                                 ff      *|
a         |         f                                f*      *|
b   0.7771 +          f                                    f *      *+
i         |          f                              f *      *|
l         |           f                            f  *      *|
i         |            f                           f  *      *|
t         |             f                         f   *      *|
y   0.5343 +               f                           f     *      *+
          |              f                       f     *      *|
          |               f                     f      *      *|
          |                f                   f       *      *|
          |                 f           *****f***      *      *|
    0.2914 +                    ff                 *  ff  *      *      *+
          |*********            f             * f    *      *      *|
          |*       *           f            *f     *      *      *|
          |*       *            f           f      *      *      *|
          |*       *             ff        ff*      *      *      *|
    0.0486 +*       *              ***ff*****  ff  *      *********      *+
          |       *****************    ffffffff*****                 |
          |+--------+-------+--------+--------+-------+--------+-------+-------+|
        0.000          45.000          90.000          135.000          180.000
               22.500          67.500          112.500          157.500

                           Radial distance in meters
                    Detection Fct/4. KRUGOLIF/Plot: Pdf 1
          |+--------+-------+--------+--------+-------+--------+-------+-------+|
    0.0420 +                                                         +
          |                                                  |
          |                                                  |
          |                                                  |
          |                                           *********|
    0.0368 +                                               *      *+
          |                                          *      *|
          |                                          *      *|
          |                                          *      *|
          |                                          *      *|
    0.0317 +                                               *      *+
          |                                          *      *|
P         |                                          *      *|
r         |                                          *      *|
o         |                                          *      *|
b   0.0266 +                                               *      *+
a         |                                          *      *|
b         |                                          *      *|
i         |                                          *      *|
l         |                                          *     ff|
i   0.0215 +                                               *    ff *+
t         |                                          *   f   *|
y         |                                          *  f    *|
          |                                          * f     *|
D         |                                          *f      *|
e   0.0164 +                                               ff      *+
n         |                                         f *      *|
s         |                                          *      *|
i         |                                       f  *      *|
```

```
t        |                                         f   *      *|
y   0.0113 +                                         f    *      *+
         |                                       f     *      *|
         |                                      f      *      *|
         |                                     f       *      *|
         |                                    f        *      *|
    0.0061 +                                    ff        *      *+
         |                           ****f****       *      *|
         |                           *  f    *       *      *|
         |         ffffffff          *ff     *       *      *|
         |   fffff       fffff      ff       *       *      *|
    0.0010 +  fff                fffff        ff *      *********      *+
         |*f****************************fffffffff****                  |
         |+-------+-------+-------+--------+-------+-------+-------+-------+|
       0.000      45.000      90.000      135.000     180.000
           22.500      67.500      112.500     157.500

                    Radial distance in meters
```

Detection Fct/4. KRUGOLIF/Chi-sq GOF Test 1

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	22.5	1	3.92	2.171
2	22.5	45.0	0	8.42	8.418
3	45.0	67.5	0	6.20	6.205
4	67.5	90.0	1	1.10	0.009
5	90.0	112.	0	1.64	1.637
6	112.	135.	15	14.46	0.020
7	135.	158.	2	37.83	33.940
8	158.	180.	115	60.43	49.289

Total Chi-square value = 101.6881 Degrees of Freedom = 5.00

Probability of a greater chi-square value, P = 0.00000

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Detection Fct/4. KRUGOLIF/Plot: Detection Probability 2

```
         |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
    2.7273 +                                                   +
         |                                               |
         |                                               |
         |                                               |
         |                                   *******     |
    2.3947 +                                        *     *     +
         |                                   *     *     |
         |                                   *     *     |
         |                                   *     *     |
         |                                   *     *     |
D   2.0621 +                                        *     *     +
e        |                                    *     *     |
t        |                                   *     *     |
e        |                                    *     *     |
c        |                                    *     *     |
t   1.7295 +                                       *     *     +
i        |                                   *     *     |
o        |                                    *     *     |
n        |                                    *     *     |
         |                                   *     *     |
P   1.3969 +                                        *     *     +
r        |                                   *     *     |
o        |                                    *     *     |
b        |                                    *     *     |
a        |                                    *     *     |
b   1.0643 +                                        *     *     +
i        | fff                               *    * ffff|
l        |    fff                            *    fff    |
i        |       ff                          *  ff *     |
t        |         ff                        *ff   *     |
y   0.7317 +          f                              f     *     +
         |           ff                     ff*    *     |
         |             f                    f *     *     |
         |******        ff                  ff   *     *     |
         |*    *          f             *****f*    *     ******|
```

```
  0.3991 +*    *           f                      *   f *    *     *    *+
         |*    *           ff                  * ff  *    *     *    *|
         |*    *            f                  *f    *    *     *    *|
         |*    *             ff                ff    *    *     *    *|
         |*    *              ff            ff *    *    *     *    *|
  0.0665 +*    *              ****fff       fff  *    *    *     *    *+
         |    *****************    **ffffffff*******     ******         |
         |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
       0.000        45.000    75.000   105.000   135.000   165.000
          15.000        60.000    90.000  120.000   150.000   180.000

                    Radial distance in meters
          Detection Fct/4. KRUGOLIF/Plot: Pdf 2
         |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
  0.0536 +                                                          +
         |                                                      |
         |                                                      |
         |                                                      |
         |                                        *******     |
  0.0471 +                                            *     *     +
         |                                        *     *     |
         |                                        *     *     |
         |                                        *     *     |
         |                                        *     *     |
  0.0406 +                                            *     *     +
         |                                        *     *     |
P        |                                         *     *     |
r        |                                        *     *     |
o        |                                         *     *     |
b   0.0340 +                                           *     *     +
a        |                                         *     *     |
b        |                                         *     *     |
i        |                                        *     *     |
l        |                                        *     *     |
i   0.0275 +                                          *     *     +
t        |                                        *     *     |
y        |                                         *     *     |
         |                                        *     *     |
D        |                                         *     *   ff|
e   0.0209 +                                           *     *fff  +
n        |                                         *     f     |
s        |                                         *   ff*     |
i        |                                        *  f  *     |
t        |                                        * f   *     |
y   0.0144 +                                           ff    *     +
         |                                       f*    *     |
         |                                       f *    *     |
         |                                      f *    *     |
         |                                     ff  *    ******|
  0.0078 +                                     *****f*    *     *    *+
         |                                 *   f *    *     *    *|
         |                                 * ff  *    *     *    *|
         |                                 ff    *    *     *    *|
         |      ffffffffffffff              ff*    *    *     *    *|
  0.0013 +  fffff            ffffff         fff  *    *    *     *    *+
         |*f*************************fffffffffff******     ******         |
         |+----+----------+-----+----+-----+----+----+-----+----+-----+----+|
       0.000        45.000    75.000   105.000   135.000   165.000
          15.000        60.000    90.000  120.000   150.000   180.000

                    Radial distance in meters
          Detection Fct/4. KRUGOLIF/Chi-sq GOF Test 2
```

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	15.0	1	1.82	0.368
2	15.0	30.0	0	4.73	4.728
3	30.0	45.0	0	5.79	5.787
4	45.0	60.0	0	4.72	4.720
5	60.0	75.0	1	2.31	0.745
6	75.0	90.0	0	0.27	0.271
7	90.0	105.	0	0.36	0.357
8	105.	120.	0	4.01	4.010
9	120.	135.	15	11.74	0.908

10	135.	150.	0	22.37	22.371
11	150.	165.	98	33.56	123.706
12	165.	180.	19	42.32	12.854

Total Chi-square value = 180.8259 Degrees of Freedom = 9.00

Probability of a greater chi-square value, P = 0.00000

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
2	0.000	30.0	1	6.55	4.699
3	30.0	45.0	0	5.79	5.787
4	45.0	60.0	0	4.72	4.720
5	60.0	75.0	1	2.31	0.745
6	75.0	90.0	0	0.27	0.271
7	90.0	105.	0	0.36	0.357
8	105.	120.	0	4.01	4.010
9	120.	135.	15	11.74	0.908
10	135.	150.	0	22.37	22.371
11	150.	165.	98	33.56	123.706
12	165.	180.	19	42.32	12.854

Total Chi-square value = 180.4286 Degrees of Freedom = 8.00

Probability of a greater chi-square value, P = 0.00000

One or more expected values is < 1.
Try pooling some some cells by hand to obtain a more reliable test.

```
             Detection Fct/4. KRUGOLIF/Plot: Detection Probability 3
         |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
   4.3065 +                                                      +
          |                                                 |
          |                                                 |
          |                                                 |
          |                                       ****      |
   3.7813 +                                           * *      +
          |                                       * *       |
          |                                       * *       |
          |                                       * *       |
          |                                       * *       |
D  3.2561 +                                           * *      +
e         |                                       * *       |
t         |                                       * *       |
e         |                                       * *       |
c         |                                       * *       |
t  2.7309 +                                           * *      +
i         |                                       * *       |
o         |                                       * *       |
n         |                                       * *       |
          |                                       * *       |
P  2.2058 +                                           * *      +
r         |                                       * *       |
o         |                                       * *       |
b         |                                       * *       |
a         |                                       * *       |
b  1.6806 +                                           * *      +
i         |                                       * *       |
l         |                                       * *       |
i         |****                                    * *       |
t         |* *                                     * *       |
y  1.1554 +* *                                        * *      +
          |* *                                     * *      f|
          |*ffffff                                 * *ffffff |
          |* *   fff                               *fff      |
          |* *      fff                          fff *       |
   0.6302 +* *         ff                      ***** ff * *      +
          |* *          ff                  * *ff  * *****  |
          |* *            ff                * ff     * * *  |
          |* *              fff             fff *    * * *  |
```

```
        |* *              ff               ff*  *     * *  ****|
   0.1050 +* *               ffff        ffff *  ****  * *  * *+
        |  ********************  *fffffffff*******     *****      |
        |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
      0.000      37.895   66.316    94.737   123.158    151.579  180.000
         9.474       47.368    75.789    104.211   132.632   161.053
```

Radial distance in meters
Detection Fct/4. KRUGOLIF/Plot: Pdf 3

```
        |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
   0.0841 +                                                     +
        |                                                   |
        |                                                   |
        |                                                   |
        |                                          ****      |
   0.0738 +                                             * *      +
        |                                          * *      |
        |                                          * *      |
        |                                          * *      |
        |                                          * *      |
   0.0636 +                                             * *      +
        |                                          * *      |
P       |                                           * *      |
r       |                                          * *      |
o       |                                           * *      |
b  0.0533 +                                             * *      +
a       |                                           * *      |
b       |                                           * *      |
i       |                                          * *      |
l       |                                          * *      |
i  0.0431 +                                            * *      +
t       |                                          * *      |
y       |                                           * *      |
        |                                          * *      |
D       |                                           * *      |
e  0.0328 +                                             * *      +
n       |                                           * *      |
s       |                                           * *      |
i       |                                          * *      |
t       |                                          * *      |
y  0.0226 +                                             * *   fff+
        |                                          * * fff  |
        |                                          *  ff    |
        |                                          *ff*     |
        |                                         ff  *     |
   0.0123 +                                            ff * *      +
        |                                  ***** ff  *  *****  |
        |                                  *   ff    * *  *  |
        |                                  * ff*     * *  ****|
        |                                 fff  *     * *  * *|
   0.0021 +   fffffffffffffffffff           ffff *  ****  * *  * *+
        |*fff********************fffffffffffff******     *****      |
        |+--+----------+--+------+--+------+---+-----+---+------+--+------+|
      0.000      37.895   66.316    94.737   123.158    151.579  180.000
         9.474       47.368    75.789    104.211   132.632   161.053
```

Radial distance in meters
Detection Fct/4. KRUGOLIF/Chi-sq GOF Test 3

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	9.47	1	0.74	0.091
2	9.47	18.9	0	2.10	2.100
3	18.9	28.4	0	3.12	3.120
4	28.4	37.9	0	3.64	3.640
5	37.9	47.4	0	3.60	3.597
6	47.4	56.8	0	3.04	3.037
7	56.8	66.3	0	2.11	2.112
8	66.3	75.8	1	1.07	0.005
9	75.8	85.3	0	0.22	0.220
10	85.3	94.7	0	0.00	0.000
11	94.7	104.	0	0.29	0.286
12	104.	114.	0	1.67	1.674
13	114.	123.	0	4.11	4.113

14	123.	133.	13	7.52	3.987
15	133.	142.	2	11.68	8.021
16	142.	152.	0	16.22	16.223
17	152.	161.	97	20.71	281.124
18	161.	171.	13	24.63	5.493
19	171.	180.	7	27.53	15.308

Total Chi-square value = 354.1508 Degrees of Freedom = 16.00

Probability of a greater chi-square value, P = 0.00000

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
2	0.000	18.9	1	2.84	1.193
3	18.9	28.4	0	3.12	3.120
4	28.4	37.9	0	3.64	3.640
5	37.9	47.4	0	3.60	3.597
6	47.4	56.8	0	3.04	3.037
7	56.8	66.3	0	2.11	2.112
8	66.3	75.8	1	1.07	0.005
9	75.8	85.3	0	0.22	0.220
10	85.3	94.7	0	0.00	0.000
11	94.7	104.	0	0.29	0.286
12	104.	114.	0	1.67	1.674
13	114.	123.	0	4.11	4.113
14	123.	133.	13	7.52	3.987
15	133.	142.	2	11.68	8.021
16	142.	152.	0	16.22	16.223
17	152.	161.	97	20.71	281.124
18	161.	171.	13	24.63	5.493
19	171.	180.	7	27.53	15.308

Total Chi-square value = 353.1523 Degrees of Freedom = 15.00

Probability of a greater chi-square value, P = 0.00000

One or more expected values is < 1.
Try pooling some some cells by hand to obtain a more reliable test.

Density Estimates/1. CLEVOLIF

Stratum : 1. CLEVOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 166

Model
Hazard Rate key, k(y) = 1 - Exp(-(y/A(1))**-A(2))

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% Percent Confidence Interval	
D	188.97	113.72	60.18	53.996	661.33

Measurement Units

Density: Numbers/Sq. kilometers
EDR: meters

Component Percentages of Var(D)

Detection probability : 1.3
Encounter rate : 98.7

Density Estimates/2. CLEVSELA

Stratum : 2. CLEVSELA
Effort : 6.000000

samples : 6
Width : 180.0000
observations: 9

Model
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% Percent Confidence Interval	
D	24.779	7.2129	29.11	13.328	46.067

Measurement Units

Density: Numbers/Sq. kilometers
EDR: meters

Component Percentages of Var(D)

Detection probability : 73.8
Encounter rate : 26.2

Density Estimates/3. ARMYOLIF

Stratum : 3. ARMYOLIF
Effort : 5.000000
samples : 5
Width : 180.0000
observations: 12

Model
Uniform key, k(y) = 1/W
Cosine adjustments of order(s) : 1

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% Percent Confidence Interval	
D	39.646	16.241	40.97	17.123	91.791

Measurement Units

Density: Numbers/Sq. kilometers
EDR: meters

Component Percentages of Var(D)

Detection probability : 73.1
Encounter rate : 26.9

Density Estimates/4. KRUGOLIF

Stratum : 4. KRUGOLIF
Effort : 10.00000
samples : 10
Width : 180.0000
observations: 134

Model
Half-normal key, k(y) = Exp(-y**2/(2*A(5)**2))
Cosine adjustments of order(s) : 2

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% Percent Confidence Interval	
D	133.14	83.412	62.65	36.423	486.68

Measurement Units

Density: Numbers/Sq. kilometers
EDR: meters

Component Percentages of Var(D)

Detection probability   :   1.4
Encounter rate   : 98.6

Estimation Summary - Encounter rates

```
                Estimate      %CV     df     95% Confidence Interval
               ------------------------------------------------------
Stratum: 1. CLEVOLIF
           n       166.00
           k       10.000
           K       10.000
           n/K     16.600      59.79     9.00  4.7535       57.970
           Left    0.0000
           Width   180.00
Stratum: 2. CLEVSELA
           n       9.0000
           k       6.0000
           K       6.0000
           n/K     1.5000      14.91     5.00  1.0247       2.1958
           Left    0.0000
           Width   180.00
Stratum: 3. ARMYOLIF
           n       12.000
           k       5.0000
           K       5.0000
           n/K     2.4000      21.25     4.00  1.3392       4.3010
           Left    0.0000
           Width   180.00
Stratum: 4. KRUGOLIF
           n       134.00
           k       10.000
           K       10.000
           n/K     13.400      62.21     9.00  3.6743       48.870
           Left    0.0000
           Width   180.00
```

Estimation Summary - Detection probability

```
                Estimate      %CV     df     95% Confidence Interval
               ------------------------------------------------------
Stratum: 1. CLEVOLIF
Hazard/Polynomial
           m       2.0000
           LnL    -782.17
           AIC     1568.3
           AICc    1568.4
           BIC     1574.6
           Chi-p   0.0000
           h(0)   0.14305E-03    6.87   164.00 0.12493E-03  0.16381E-03
           p      0.43151        6.87  164.00 0.37684      0.49412
           EDR    118.24         3.43   164.00  110.49       126.54
Stratum: 2. CLEVSELA
Uniform/Cosine
           m       1.0000
           LnL    -44.773
           AIC     91.546
           AICc    92.117
           BIC     91.743
           Chi-p  0.13490
           h(0)   0.20758E-03   25.00     8.00 0.11765E-03  0.36627E-03
           p      0.29737       25.00     8.00 0.16853      0.52469
           EDR    98.156        12.50     8.00  73.655       130.81
Stratum: 3. ARMYOLIF
Uniform/Cosine
           m       1.0000
           LnL    -58.579
           AIC     119.16
           AICc    119.56
           BIC     119.64
           Chi-p  0.17364
           h(0)   0.20758E-03   35.03    11.00 0.98181E-04  0.43889E-03
           p      0.29737       35.03    11.00 0.14065      0.62872
           EDR    98.156        17.51    11.00  66.954       143.90
Stratum: 4. KRUGOLIF
```

Half-normal/Cosine

m	2.0000				
LnL	-560.01				
AIC	1124.0				
AICc	1124.1				
BIC	1129.8				
Chi-p	0.0000				
h(0)	0.12486E-03	7.40	132.00	0.10787E-03	0.14451E-03
p	0.49439	7.40	132.00	0.42714	0.57223
EDR	126.56	3.70	132.00	117.63	136.17

Estimation Summary - Density&Abundance

	Estimate	%CV	df	95% Confidence Interval	
Stratum: 1. CLEVOLIF					
Hazard/Polynomial					
D	188.97	60.18	9.24	53.996	661.33
Stratum: 2. CLEVSELA					
Uniform/Cosine					
D	24.779	29.11	12.23	13.328	46.067
Stratum: 3. ARMYOLIF					
Uniform/Cosine					
D	39.646	40.97	15.00	17.123	91.791
Stratum: 4. KRUGOLIF					
Half-normal/Cosine					
D	133.14	62.65	9.26	36.423	486.68

Estimation Summary - Density&Abundance

Pooled Estimates:

	Estimate	%CV	df	95% Confidence Interval	
D	386.53	36.77	17.50	182.62	818.12