

Polymodal decomposition and rectified pseudo cohort analysis

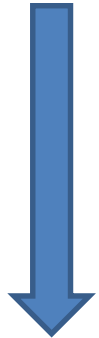
Florian Quemper, Didier Gascuel, Jérôme Guitton, Institut Agro Rennes

Demerstem

Objective : Performing a cohort analysis

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:



Length frequency distribution study to identify proportions / age

→ Catch at age

2. Rectified pseudo-cohort analysis :

→ Stock exploitation ?

Objective : Performing a cohort analysis

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

Length frequency distribution study to identify proportions / age

➔ On fishing data: PI/PA sampling

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Objective : Performing a cohort analysis

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

Length frequency distribution study to identify proportions / age

➡ On fishing data: PI/PA sampling

Polymodal decomposition with constraints on **mean** and **standard deviation**



Growth model to
fix mean at age

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Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

Length frequency distribution study to identify proportions / age

➔ On fishing data: PI/PA sampling

Polymodal decomposition with constraints on **mean** and **standard deviation**

↓
Growth model to
fix mean at age

↓
Linear model

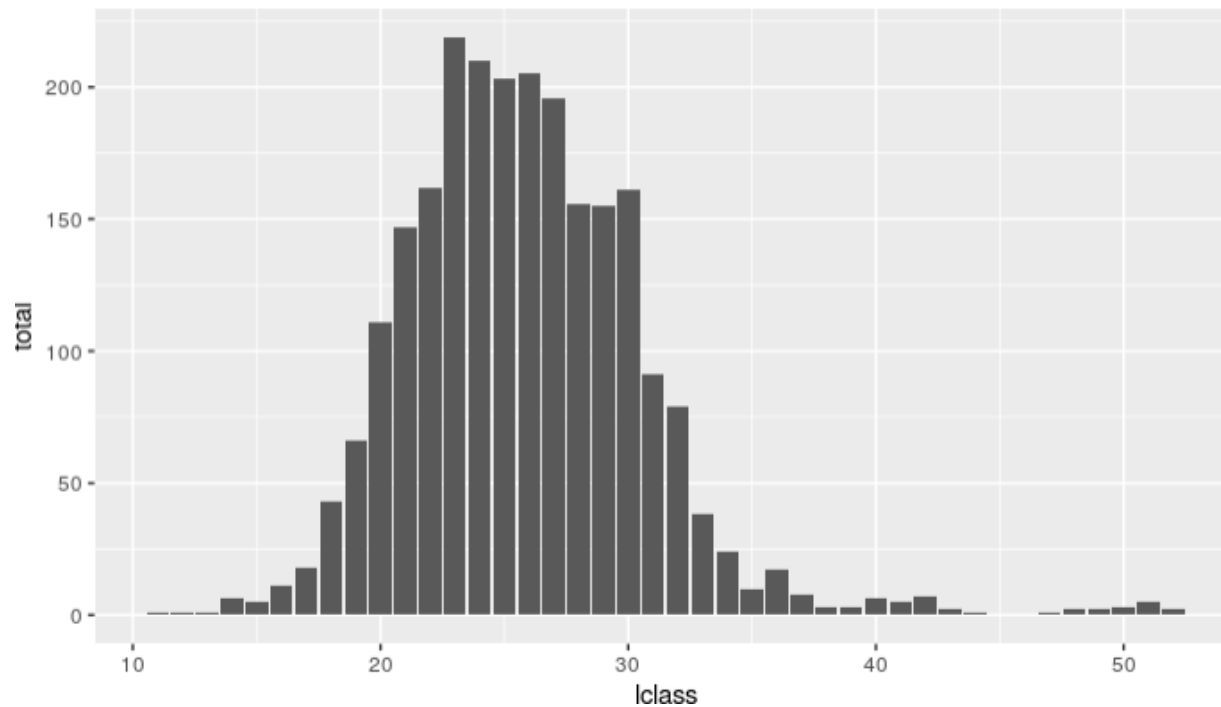
Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

1. Data Exploration / selection

Landings (demerstem project - 2020)



- ➔ Last year of sampling of catch data by fishery
- ➔ Only P.A.

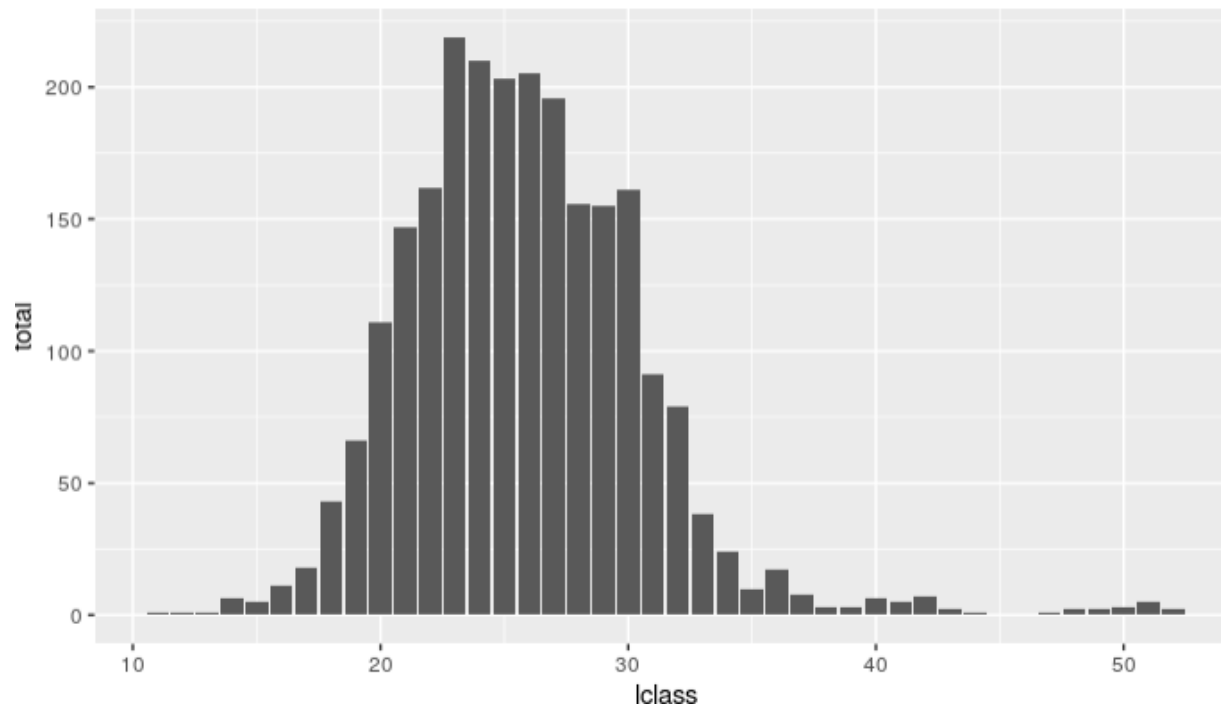
Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

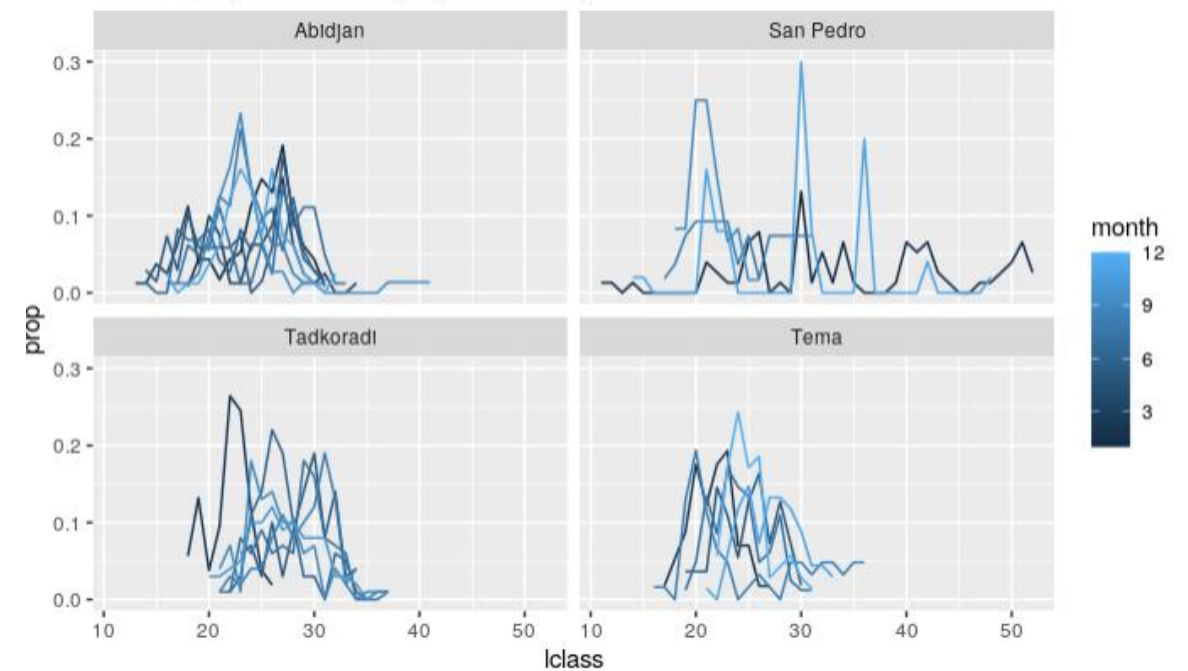
1. Polymodal decomposition:

1. Data Exploration / selection

Landings (demerstem project - 2020)



Landings (demerstem project - 2020)



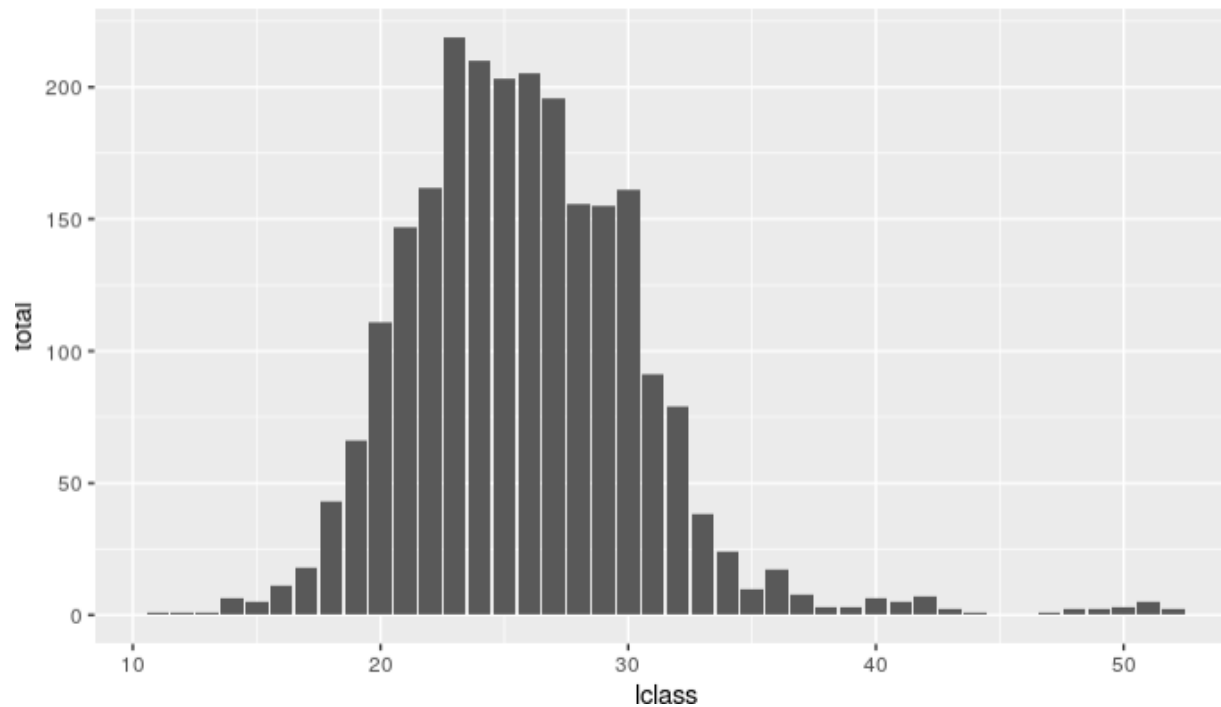
Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

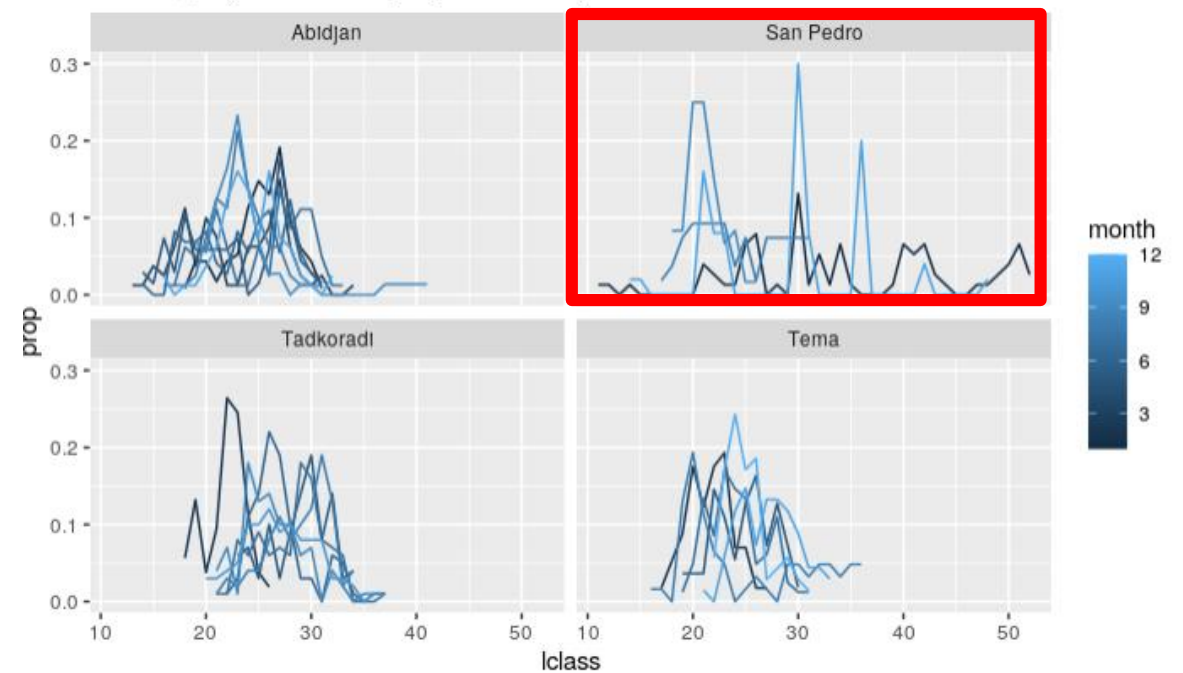
1. Polymodal decomposition:

1. Data Exploration / selection

Landings (demerstem project - 2020)



Landings (demerstem project - 2020)



Demerstem



Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

2. Growth model:

1. Length (Von Bertalanfy)

$$L_t = L_{\infty}(1 - e^{-K(t - t_0)})$$

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

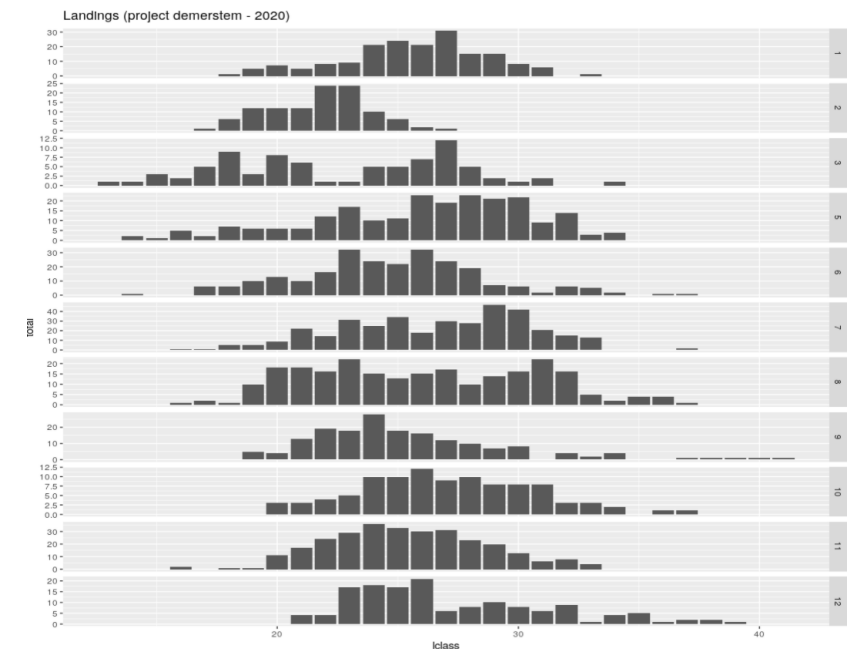
1. Polymodal decomposition:

2. Growth model:

1. Length (Von Bertalanfy)

$$L_t = L_{\infty} (1 - e^{-K(t-t_0)})$$

```
method_shepherd(data_freq, K, L_inf, step_class, plot=F)
```



Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

2. Growth model:

1. Length (Von Bertalanfy)

$$L_t = L_{\infty} (1 - e^{-K(t-t_0)})$$

```
method_shepherd(data_freq, K, L_inf, step_class, plot=F)
```

```
lmax <- 48 # choose lmax according to some bibliography  
K_inf <- seq(0.35, 0.40, 0.01)  
L_inf <- seq(0.95*lmax, 1.05 * lmax, 0.01)
```

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

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K_inf <- seq(0.35, 0.40, 0.01)  
L_inf <- seq(0.95*lmax, 1.05 * lmax, 0.01)
```

```
step_class <- 1
```

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

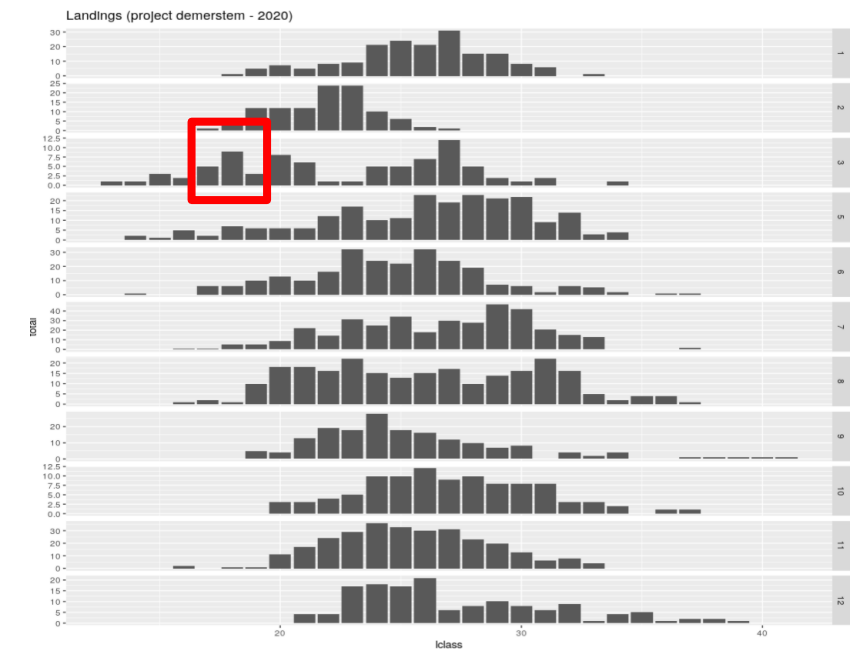
1. Polymodal decomposition:

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$$L_t = L_{\infty} (1 - e^{-K(t-t_0)})$$

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Demerstem



Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. **Polymodal decomposition:**
2. Growth model:
 2. Size-weight relationships

$$W_t = a L_t^b$$

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. **Polymodal decomposition:**
2. Growth model:
 2. Size-weight relationships

$$W_t = a L_t^b$$

W_{tot} → Catch in number

Yield/recrut

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:
2. Growth model:
 2. Size-weight relationships

$$W_t = a L_t^b$$

`model_weight(data_weight_size)`

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

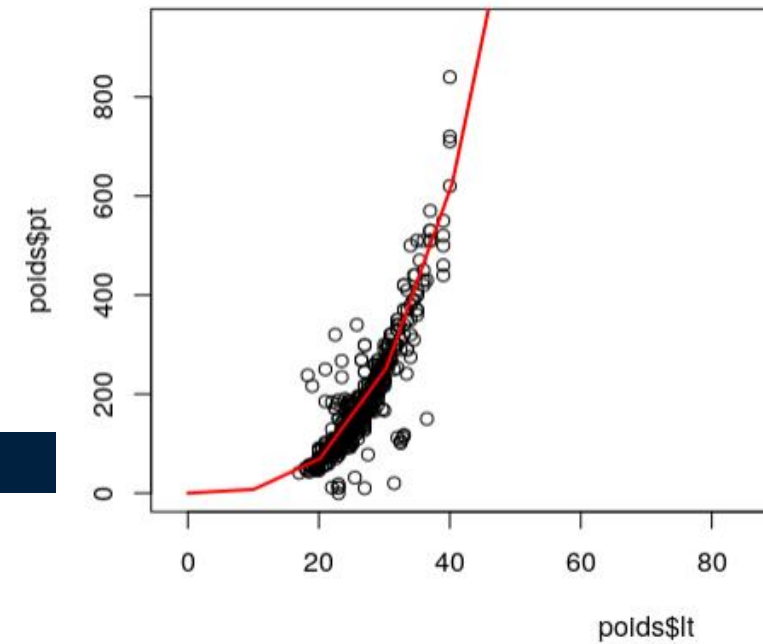
2. Growth model:

2. Size-weight relationships

$$W_t = a L_t^b$$

model_weight(data_weight_size) →

"a = 0.0053 b = 3.1597"



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Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:
 1. Mean constraints
 2. Linear model
 3. Standard deviation constraints

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

```
library(mixdist)
```

```
mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,  
  step_class = 1, step_time = 4, ngroup = 3, month_recrue = 3,  
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,  
  lmsd = lmsd, get_lmsd = T, plot = T)
```

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

lclass | month | total

```
mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,  
  step_class = 1, step_time = 4, ngroup = 3, month_recru = 3,  
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Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

```
mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,  
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  lmsd = lmsd, get_lmsd = T, plot = T)
```

Demerstem

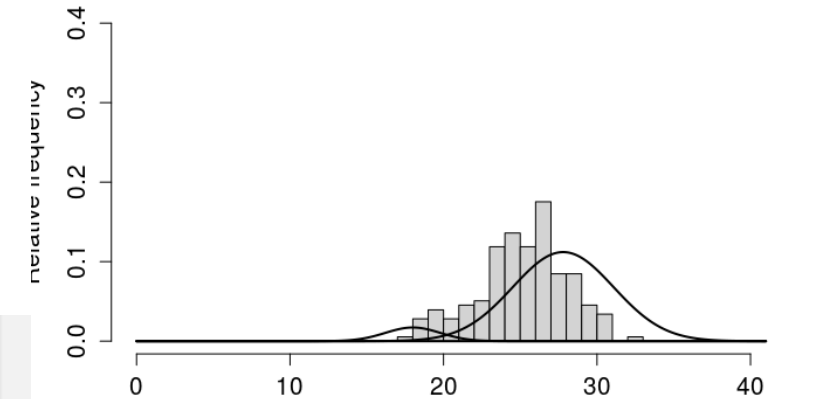
Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

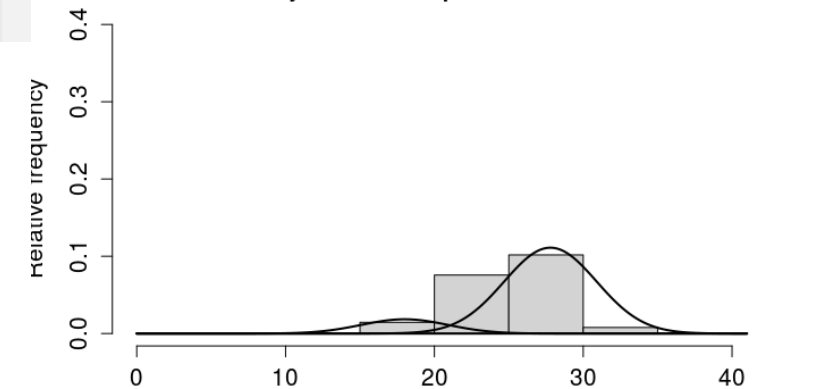
1. Mean constraints

Polymodal decomposition : Month 1



PSEUDOTOLITHUS SENEGALENSIS - landings length (cm)

Polymodal decomposition : Month 1



PSEUDOTOLITHUS SENEGALENSIS - landings length (cm)

```

mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,
  step_class=1, step_time = 4, ngroup = 3, month_recrue = 3,
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,
  lmsd = lmsd, get_lmsd = T, plot = T)
  
```

step_class=1

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Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

```
mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,  
  step_class= 1, step_time = 4, ngroup = 3, month_recruc = 3,  
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,  
  lmsd = lmsd, get_lmsd = T, plot = T)
```

Number of graphics :
Month (= 12)
Quarter analysis (= 4)
Semester (= 2)
Year (= 1)

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Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

```
mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,  
  step_class= 1, step_time = 4, ngroup = 3, month_recruc = 3,  
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,  
  lmsd = lmsd, get_lmsd = T, plot = T)
```

Number of age group

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

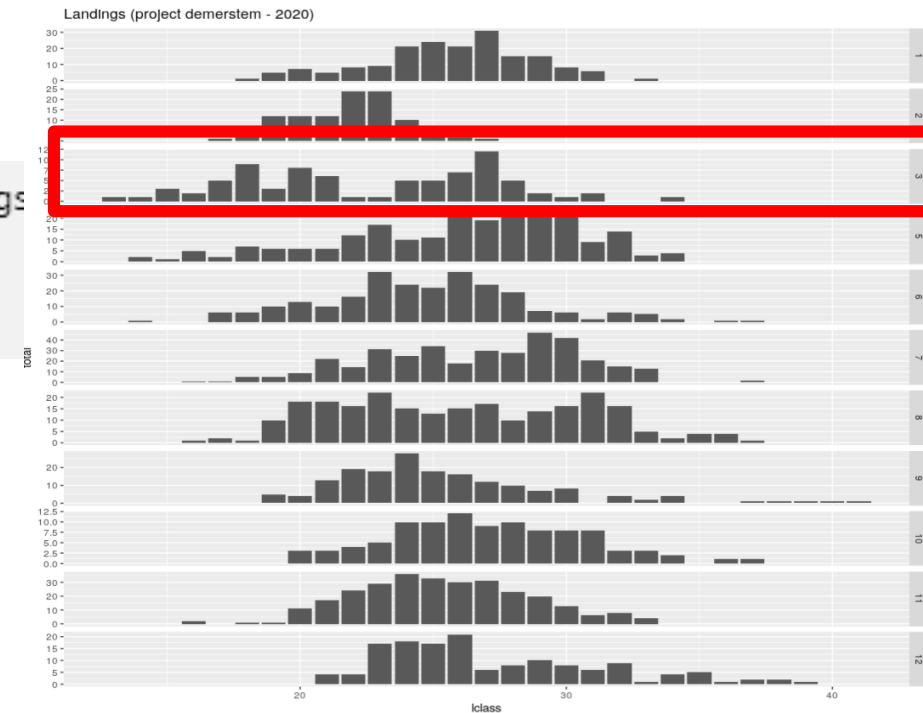
1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

```

mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,
  step_class= 1, step_time = 4, ngroup = 3, month_recrue = 3,
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,
  lmsd = lmsd, get_lmsd = T, plot = T)
  
```



Demerstem

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1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

```
mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,  
  step class = 1, step time = 4, ngroup = 3, month recrue = 3,  
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,  
  lmsd = lmsd, get_lmsd = T, plot = T)
```

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

```
fix_mu <- rep(T, ngroup)
fix_sigma <- rep(F, ngroup)

mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,
  step_class = 1, step_time = 4, ngroup = 3, month_recrue = 3,
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,
  lmsd = lmsd, get_lmsd = F, plot = T)
```

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Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

```
fix_mu <- rep(T, ngroup)
fix_sigma <- rep(F, ngroup)

mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,
  step_class = 1, step_time = 4, ngroup = 3, month_recrue = 3,
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,
  lmsd = lmsd, get_lmsd = F, plot = T)
```

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

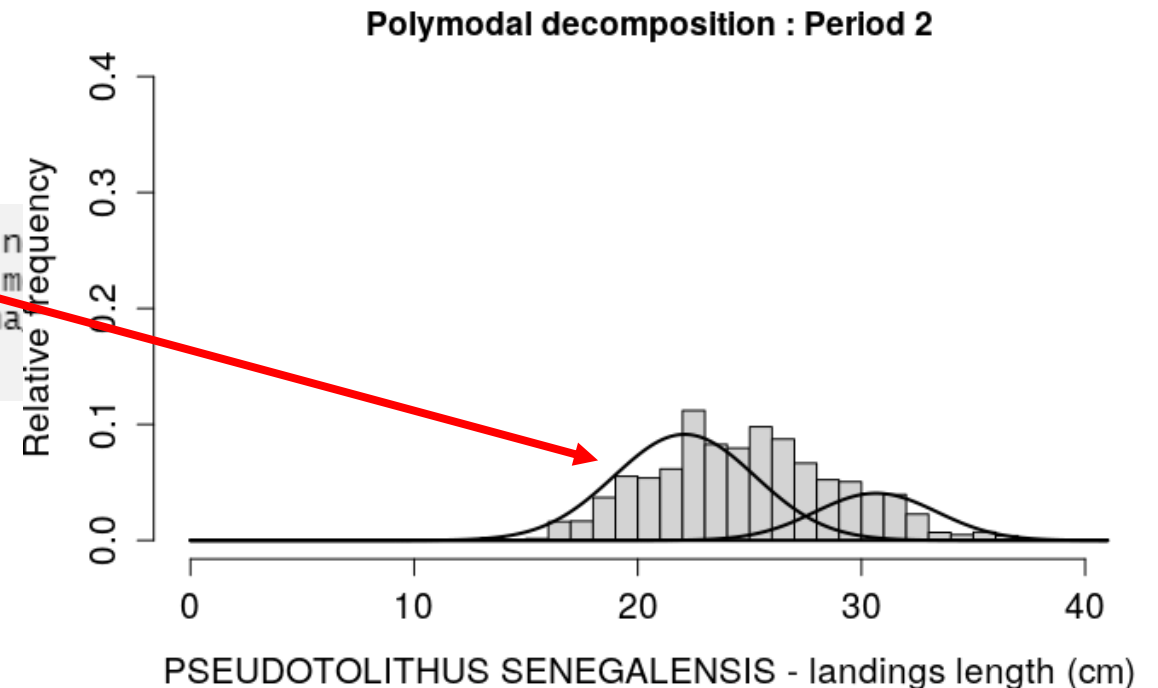
1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

```
fix_mu <- rep(T, ngroup)
fix_sigma <- rep(F, ngroup)

mixdist_polymod(data_freq, K = K_landings, L_inf = L_landin
  step_class= 1, step_time = 4, ngroup = 2, m
  fix_mu = fixmu, fix_sigma = fixsigma, sigma
  lmsd = lmsd, get_lmsd = F, plot = T)
```



Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

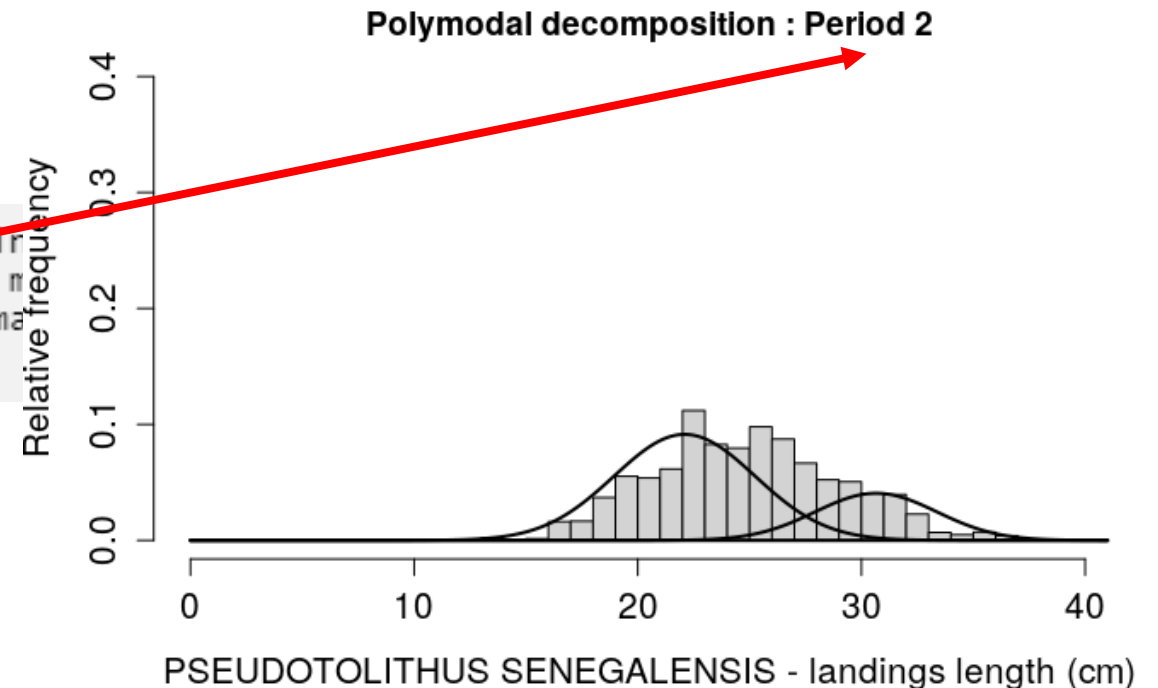
1. Polymodal decomposition:

3. Polymodal decomposition:

1. Mean constraints

```
fix_mu <- rep(T, ngroup)
fix_sigma <- rep(F, ngroup)

mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings,
  step_class= 1, step_time = 4, ngroup = 3, #
  fix_mu = fixmu, fix_sigma = fixsigma, sigma
  lmsd = lmsd, get_lmsd = T, plot = T)
```



Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

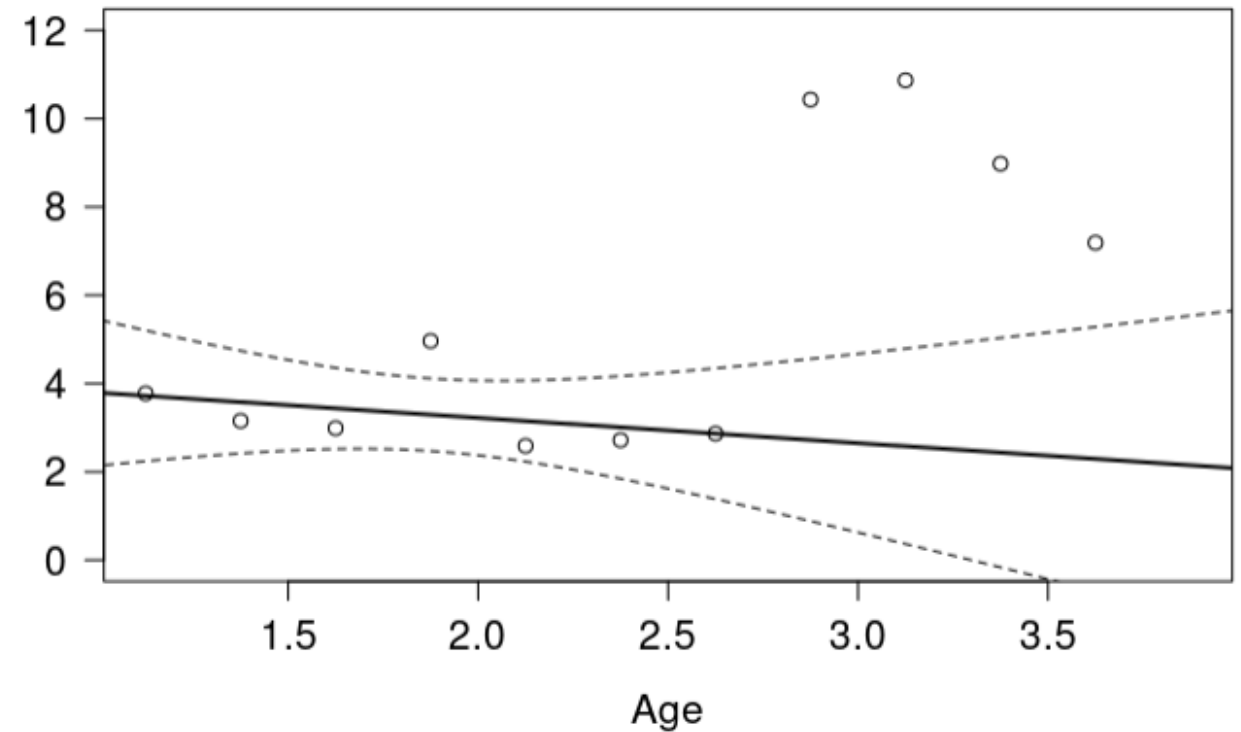
1. Polymodal decomposition:

3. Polymodal decomposition:

2. Linear model

```
fix_mu <- rep(T, ngroup)
fix_sigma <- rep(F, ngroup)

mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings,
  step_class = 1, step_time = 4, ngroup = 3,
  fix_mu = fix_mu, fix_sigma = fix_sigma, sig
  lmsd = lmsd, get_lmsd = T, plot = T)
```



Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

3. Standard deviation constraints

```
fix_mu <- rep(T, ngroup)
fix_sigma <- c(T, T, F)
mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,
  step_class= 1, step_time = 4, ngroup = 3, month_recrue = 3,
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,
  lmsd = lmsd, get_lmsd = F, plot = T)
```


Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

3. Standard deviation constraints

```
fix_mu <- rep(T, ngroup)
fix_sigma <- c(T, T, F)

mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,
  step_class= 1, step_time = 4, ngroup = 3, month_recrue = 3,
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,
  lmsd = lmsd, get_lmsd = F, plot = T)
```

Demerstem

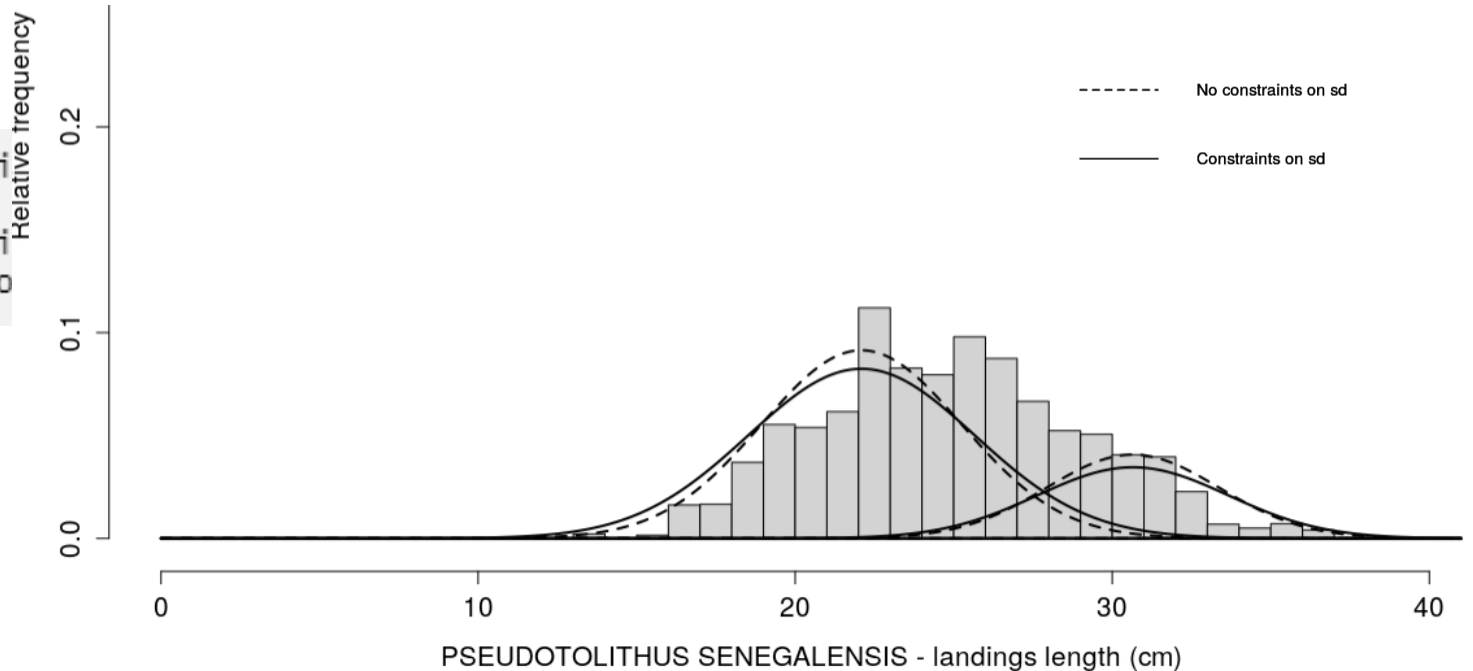
Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

3. Polymodal decomposition:

3. Standard deviation constraints

```
fix_mu <- rep(T, ngroup)
fix_sigma <- c(T, T, F)
mixdist_polymod(data_freq, K = K_landings, L_i
                 step_class= 1, step_time = 4,
                 fix_mu = fixmu, fix_sigma = fi
                 lmsd = lmsd, get_lmsd = F, plo
```



Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

1. Polymodal decomposition:

4. Catch Matrix

```
fix_mu <- rep(T, ngroup)
fix_sigma <- c(T, T, F)

mixdist_polymod(data_freq, K = K_landings, L_inf = L_landings, t0 = t0_landings,
  step_class = 1, step_time = 4, ngroup = 3, month_recrue = 3,
  fix_mu = fixmu, fix_sigma = fixsigma, sigma_adjust = 0,
  lmsd = lmsd, get_lmsd = F, plot = T)
```

Demerstem



Exemple : *Pseudolithus senegalensis* – **GHA/CIV**



Demerstem



Exemple : *Pseudolithus senegalensis* – **GHA/CIV**



$$a = 0,005$$

$$b = 3,16$$

$$L_{\text{inf}} = 50,4$$

$$K_{\text{inf}} = 0,36$$

$$t_0 = -0,22$$

Demerstem



Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

2. Rectified cohort analysis :

1. Pseudo_Rectif_R

```
pseudo_rectif_R(Mat_Cage, Mat_C, Mat_R, Mat_E, Mat_M, Rinit)
```

Demerstem

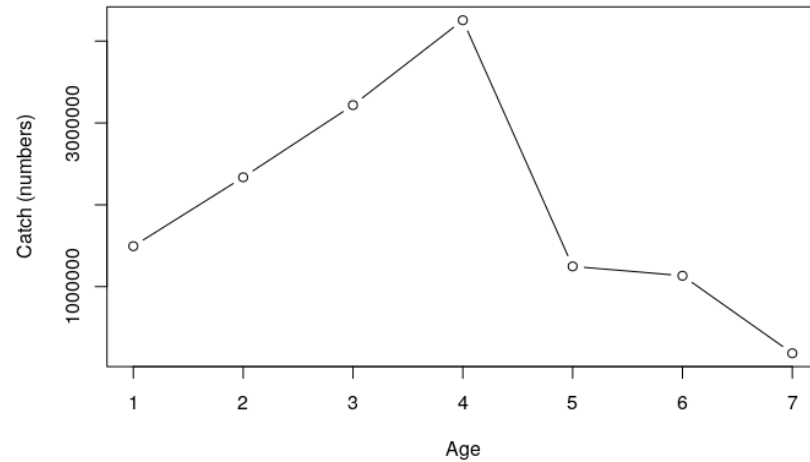
Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

2. Rectified cohort analysis :

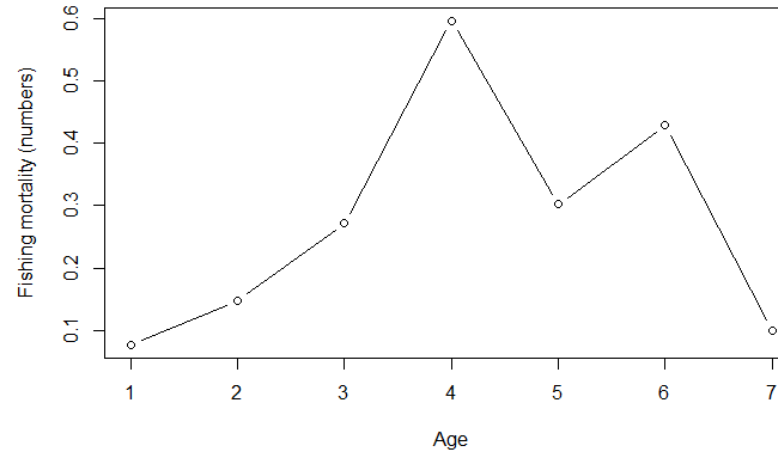
1. Pseudo_Rectif_R

```
pseudo_rectif_R(Mat_Cage, Mat_C, Mat_R, Mat_E, Mat_M, Rinit)
```

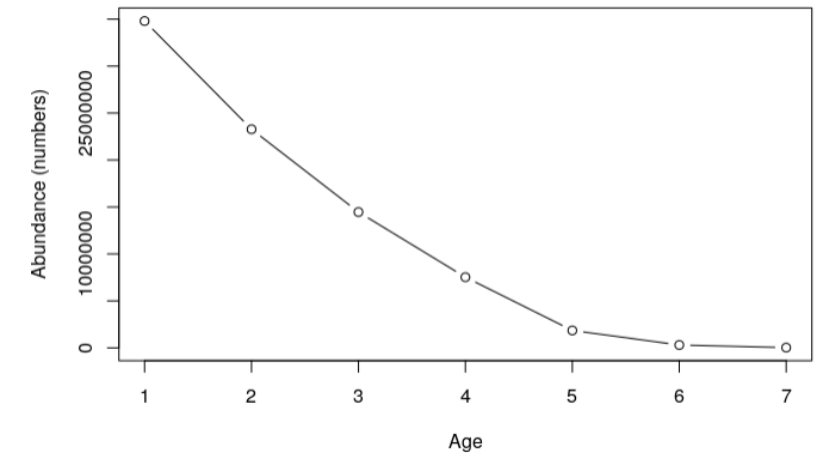
Catch at age - *Pseudolithus senegalensis*



F at age - *Pseudolithus senegalensis*



Abundance at age - *Pseudolithus senegalensis*



Demerstem



Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

2. Rectified cohort analysis :

1. yield_recrut

```
yield_recrut(a, b, Linf, K, t0, age, Mat_N3, Mat_Y, Mat_F3)
```

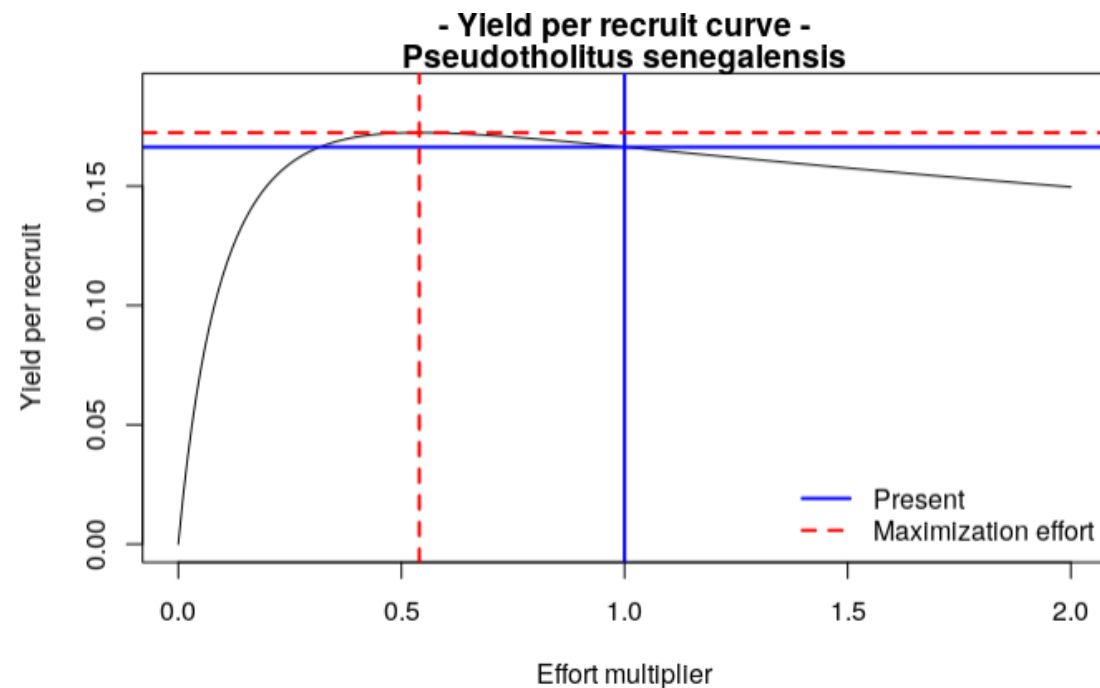

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

2. Rectified cohort analysis :

1. yield_recruit

```
yield_recruit(a, b, Linf, K, t0, age, Mat_N3, Mat_Y, Mat_F3)
```



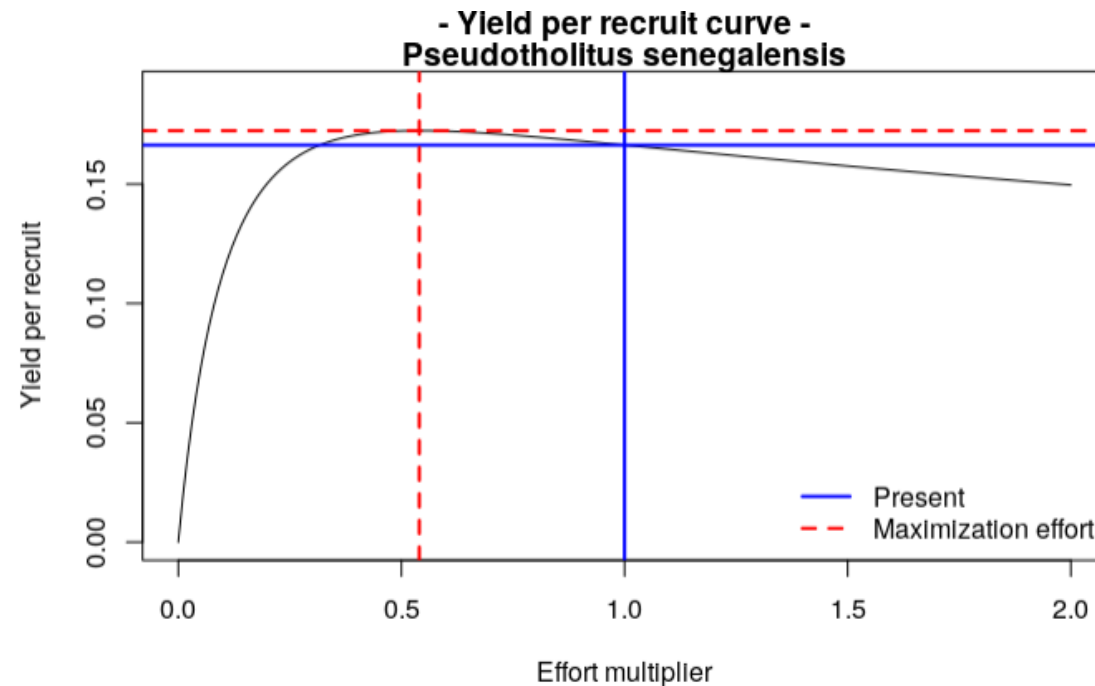
Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

2. Rectified cohort analysis :

1. yield_recruit

```
yield_recruit(a, b, Linf, K, t0, age, Mat_N3, Mat_Y, Mat_F3)
```



- Adapt to other cases
- Add an estimation of M and Rinit
- Add some graphics (biomass/effort)
- ...

Demerstem



Exemple : *Pseudolithus senegalensis* – **GHA/CIV**



Demerstem



Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

From sampling to catch number:

Total_samplng by **length class** (in number) => sampling weight : $w_{sampling} = aLt^b * \text{Total_samplng_by_length}$

Total catch / month fro the last year (or mean over some years) (in kg) => W_{catch}

$$\sum w_{sampling} \rightarrow W_{catch}$$

$$\sum n_{sampling} \rightarrow N_{tot}$$

$$N_{tot} = W_{catch} * \frac{\sum n_{sampling}}{\sum w_{sampling}}$$

$$\text{Sampling_équivalent_abundance_by_length} = \text{Total_samplng_by_lenght} * \frac{N_{tot}}{\sum n_{sampling}}$$

Demerstem

Exemple : *Pseudolithus senegalensis* – **GHA/CIV**

Captures en 2016

<i>Pseudolithus</i> spp.	Côte d'Ivoire, Ghana, Togo et Bénin	2 831 (2 621)
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→ $W_{tot} = 180 T/month$

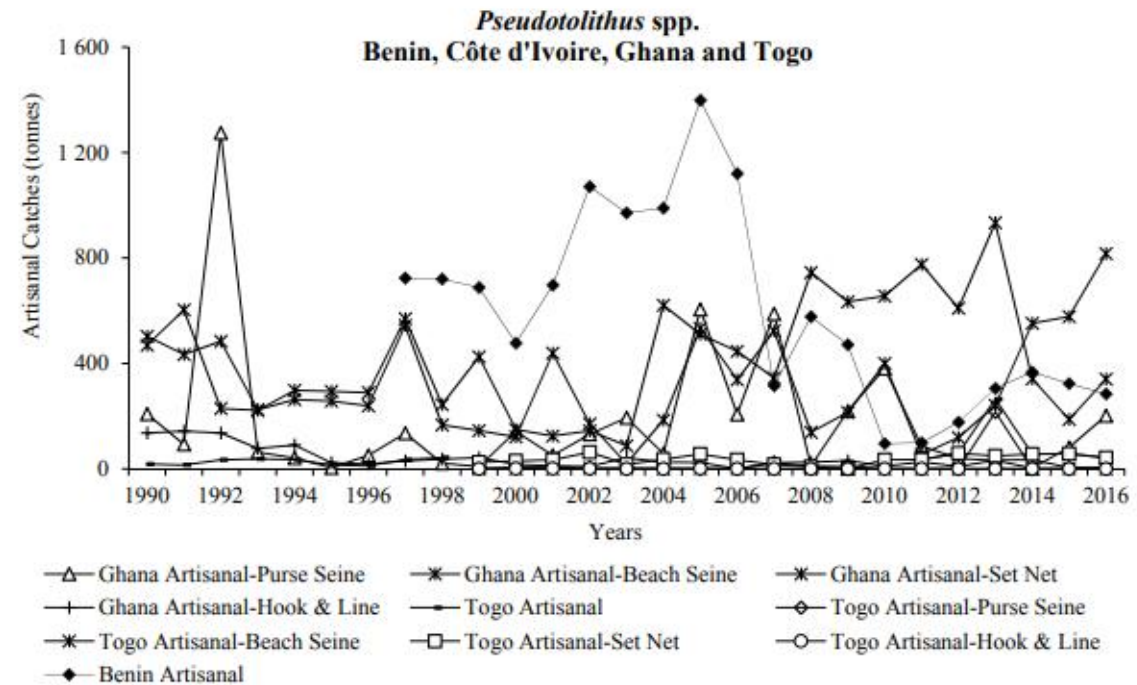


Figure 3.7.3a: *Pseudolithus* spp.-Industrial and artisanal catches (tonnes) of Côte d'Ivoire, Ghana, Togo and Benin, 1990-2016 / Captures industrielles et artisanales (tonnes) au Bénin, en Côte d'Ivoire, au Ghana et au Togo, 1990-2016.