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**R TOOLBOX GUIDELINES FOR AGE READING
ANALYSES**

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R TOOLBOX GUIDELINES FOR AGE READING ANALYSES

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RESUMO

As calibrações e intercâmbios entre instituições e para a atribuição de idades a partir de otólitos de peixes são realizados regularmente por forma a melhorar a qualidade dos dados de idades que são usados para a gestão de *stocks* de peixes. Nestas intercalibrações são usadas ferramentas online para a análise das leituras de idade e as análises estatísticas são geralmente realizadas na folha de cálculo Eltink 2000. Devido à substituição desta ferramenta, houve a necessidade de desenvolver as análises estatísticas em programação R. Esta alteração mostrou ter vantagens uma vez que funciona de forma automática e rápida com um elevado número de leitores e de amostras de otólitos, permitindo também incorporar facilmente novas análises exploratórias.

Palavras-chave: análises de intercâmbios de idades, estatística de dados de idade, R script

ABSTRACT

Title: R toolbox guidelines for age reading analyses. Fish otolith age calibration and exchanges are carried out periodically to improve the quality of age data used in age-based stock assessments. These calibrations use online tools for age reading and the statistical analysis are frequently done on Eltink 2000 spreadsheet. With the replacement of this software and Eltink limitations, statistical evaluation was performed using R code. This change has shown clear advantages as the R script runs automatically and much faster with multiple age readers and of otolith samples, also allowing for easy incorporation of other exploratory data analyses.

Keywords: age exchange analysis, statistic age data, R script

REFERÊNCIA BIBLIOGRÁFICA

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INTRODUCTION

Fish age determination underlies the estimation of fish life-history parameters such as growth rates, lifespan, age at recruitment as well as catch at age, which are important for the study of population demographic structure and age-based stock assessment (Panfili *et al.* 2002). The method of determining fish age structure frequently relied on otoliths observation through a stereoscopic microscope. This is a difficult task since age reading strongly depends on the correct identification of otolith's growth zones *e.g.* annual growth zones could vary among age readers leading towards biased aging estimations between and within readers over time (Campana 2001, Eltink *et al.* 2000). The International Council for the Exploration of the Sea (ICES - <https://www.ices.dk/>) is an intergovernmental marine science organization that is responsible, among others, to ensure age readings consistency between all age reading laboratories (Vitale *et al.* 2019).

ICES age calibration and exchanges are held to evaluate the quality of age data of the different age reading laboratories using selections of otoliths and/or images circulated and discussed among age readers (Appelberg *et al.* 2005; Vitale *et al.* 2019). In these reunions, age experts and coordinators get together to revise precision and bias in age estimations. The exchanges provide more objective estimations since readers use their equipment and are not subject to a schedule (criteria not applicable in a Workshop) (Vitale *et al.* 2019). The statistical guidelines and methods for inter-reader comparisons have for a long time been calculated based on Eltink's spreadsheet (Eltink, 2000) (<http://www.efan.no>, RIVO). The most common statistical measures are the Percentage of Agreement (PA), which is the percentage of readers estimates agreeing with modal age (age given by most readers), the Coefficient of Variation (CV), which is an index of precision (how close individual measurements on a given structure are to each other, *i.e.* reproducibility) and the Absolute Bias (AB) which is the age estimation error related to accuracy (*i.e.* the proximity of the age estimate to the true value), and represents the systematic over or underestimation of age relative to the true age (Eltink *et al.* 2000). In the Eltink, (2000) spreadsheet, the Relative Bias (RB) is used instead since the age estimation is related to modal age. The CV is a statistically robust measure despite a method-related decrease in value with age while PA is strongly influenced by the number of age readers and the age of the fish (Campana, 2001).

A web tool usually used for otolith age readings exchanges and workshops for many years was WebGR (Web Service for support of Growth and Reproduction studies) which was developed in 2008 by a consortium of research institutes and software developers

(<http://webgr.azti.es/ce/search/myce>). But due to many security problems, this software was replaced by SmartDots (Vitale *et al.* 2019). Like WebGR, SmartDots is an open-source software for age estimations based on otoliths images but allows the management of all ICES databases related to the age readings workshops and exchanges and also age readers' annotations in the otoliths images (ICES, 2020; Vitale *et al.* 2019). Other advantages of SmartDots are that it will allow an automatic result output of the exchange/workshop data analyses based on R-scripts (R Core Team, 2020) not depending on the Eltink's spreadsheet. More recently the Working Group on SmartDots Governance (ICES 2020b) was created to oversee and advise on the improvements needed to make SmartDots a fully functional tool for age reading statistical analysis. These outputs are still in development and the age readings analyses in various cases are still using the Eltink's spreadsheet.

In the specific case of the data analyses of the 2019 sardine exchange (ICES 2019a), it was not possible to import to Eltink spreadsheet the complete age readings data list from WebGR, where it was uploaded, presumably due to the high numbers of readers and otoliths of the exchange. Meanwhile, WebGr was deactivated during this process, due to the aforementioned issues, turning it impossible to get access to the exchange readers' readings results already saved in the system, including the otoliths images with the growth zones individually identified. The complete data could still be rebuilt on an Excel spreadsheet based on the information sent by the age readers by email. However, given the volume of data, the analyses on the Eltink's spreadsheet were still complicated and time-consuming. Due to this difficulty, it was decided to make the analyses with R scripts and R Markdown (Xie *et al.* 2018) using the Eltink's spreadsheet formulae as a reference. The goal was to have an R Markdown document that could be used in any otolith age reading exercise providing an automatic output of the main statistic measures. Therefore, this code was developed to be used as a guideline for data analyses in any hypothetical age reading exercise.

METHODS

R script description

The scripts were designed to make the analyses by areas and by readings expertise in one single step. The script is divided into i) tables with the data description (table of participants, overview of samples), ii) exploratory analysis to detect problems with readers' age readings and take a first look at the age data and iii) age comparisons analysis following Eltink 2000 spreadsheet.

A hypothetical fish exchange was created to test the script. This exchange includes 147 otolith samples, 20 readers (from 1 to 20) with expert and trainee readers' level, from 2 areas (area A and area B). The analysis was made by a) all readers by areas, b) expert readers by areas, c) trainee readers by areas. Since the script for the expert and trainee readers analyses are the same as for all readers, we will only incorporate all readers by areas in this report.

Along the script, it is possible to select which type of analysis could be included in the final report using the chunk options (see R Markdown help files).

Three files are needed to start:

1. participant file list (`participant_list.csv` file) with columns names: "name of readers", "expertise level", and "reader code".
2. age reading data (see `AgeReadingData.csv` file) with columns names: "SampleID", "catch date", "length of fish", "area of fish", and "readers". The date of catch should be in the format: day-month-year, *e.g.* "01-09-2018".
3. `FunctionsExchange.RData`

All these files must be saved in the same folder.

The `participant_list.csv`, `AgeReadingData.csv` and `FunctionsExchange.RData` files are available at: <https://github.com/AvSil/R-Toolbox-guidelines-for-age-reading-analysis>

The `exchangeFuncions.RData` file includes the following functions:

- **moda**: Function to calculate the modal age *e.g.*, most frequent age given by readers.
- **perc.agr**: Percentage of agreement (PA) calculated as:

$$PA = 100 * \frac{X_i}{R} \quad [Equation 1]$$

where X_i is the number of readers agreeing with modal age and R is the number of times the fish is aged.

- **cv**: Coefficient of variation calculated as 100x (standard deviation of age readings/mean of age readings). The equation according to Chang (1982) can be written as:

$$CV_j = 100 * \frac{\sqrt{\sum_{i=1}^R (X_{ij} - X_j)^2}}{X_j} \quad [Equation 2]$$

where CV_j is the age precision estimate for the j^{th} fish, x_{ij} is the i^{th} age determination of the j^{th} fish and X_j is the mean age estimate of the j^{th} fish

- **ape***: determinate the Average Percentage Error (APE) with modal age. According to Beamish and Fournier (1981) was defined as:

$$APE = \frac{1}{R} \sum_{i=1}^R \frac{|x_{ij} - x_j|}{X_j} \quad [Equation 3]$$

where x_{ij} is the i^{th} age determination of the j^{th} fish, X_j is the mean age estimate of the j^{th} fish, and R is the number of times each fish is aged.

- **age.cv**: calculate the CV by readers, modal age, and age group using the equation 2. Also, the weighted mean CV's by age reader is calculated and age readers are ranked according to the CV achieved (in the situation of a tie between the two weighted means, the lowest rank will be assigned to all elements. This procedure was applied for all ties methods when assigning ranks).
- **age.pa**: calculate the PA by readers and age group using equation 1. The age readers are ranked from the lowest to the highest relative bias and the weighted mean percentage agreement to the modal age is determined.
- **age.bias**: calculate the relative bias (age group – mean age) by readers and age group. Also, the weighted mean of the relative bias over all age groups by age reader is determined and age readers are ranked from the lowest to the highest relative bias.
- **age.red**: calculate the age composition (*e.g.* number of readings) by reader and age group.
- **age.sd**: calculate the Standard Deviation (SD) by reader and age group.

- **age.mean**: calculate the mean age by reader.
- **testWIL.fun2***: Interbias test and percentage of agreement between readers. This function performs a one-sample Wilcoxon signed rank test (Zar 1984) to test the absence of bias between two readers or between a reader and the modal age. Also, the PA is calculated by pairs of readers. Moreover, the combined weighted mean and a rank value were added per reader, where the readers were assigned with a rank according to the weighted mean.
- **abplot**: function to prepare data for the age bias plots.
- **ageBias.graph**: function to make age bias plots. The mean and 95% confidence interval for each reader's age is plotted against the modal age. A 1:1 line that represents the agreement between the two age estimates is included. Confidence intervals that do not capture this "agreement line" suggest a difference in the two age estimates at modal age (Campana *et al.* 1995).

APE and the Percentage of Agreement between pairs of readers functions (assigned with *) are new analyses that are not included in the Eltink 2000 spreadsheet. For more information on other functions see Eltink *et al.* 2000.

The output tables and figures like the ones in the Eltink 2000 spreadsheet are included in the annex of this manuscript and new tables and figures are included inline.

RESULTS

The following lines of code import the packages needed to run the script and load the `FuncionsExchange.RData` file (Note: include the pathway to the `FuncionsExchange.RData`).

```
rm(list=ls())

# Packages
library(reshape2)
library(FSA)
library(ggplot2)
library(ggpubr)
library(ggthemes)
library(RColorBrewer)
library(knitr)
library(lubridate)
library(dplyr)
library(tidyverse)
library(kableExtra)

# load functions - include the pathway here
load("~/FuncionsExchange.RData")
```

The second chunk imports the table of participants and the age readings matrix. After the new improvement of SmartDots, the age readings matrix aggregates readers in one column (see `AgeReadingsData.csv` file). Since this script was based on the Eltink spreadsheet the age readings matrix and the column names need to be transformed. To change the age readings matrix it is important to check if the readings were correctly transformed. Sometimes during this process age with blanks (non-readings) are filled with zeros. To avoid this, the fill argument should be `fill = NA_integer_`.

```
#Participants list
#####

#Need to have the following columns: Participant code and Expertise level
part<-read.csv(file="participants_list.csv",header=T,sep=",")

#Import Age Readings Matrix
df<-read.csv(file="AgeReadingsData.csv",header=T,sep=",")

#Set catch_date as Date (dates should be in the form has day-month-year;
month as numeric and year with 4 digits e.g 01-03-2015)
df$date<-as.Date(df$catch_date,"%d-%m-%Y")

#Set area as factor
df$area<-as.factor(df$area)
```

```
#change to a column per each read
df<-dcast(data = df, formula =
SampleID+catch_date+length+area~reader, fun.aggregate = sum,
fill=NA_integer_, value.var = "age")
## fill NA_integer_ put NAs in inexisiting readings, if we not specify fill
it will put 0 (zeros)
```

The next field needed to be manually changed for each otolith exercise. The columns names and numbers should correspond to:

- columns with info: “Sample ID”, “sex”, “length”, “date of catch”;
- Columns with readers: “Reader.01”, “Reader.02” “Reader.20”;
- Columns with readers and modal age: columns “Reader.01”, “Reader.02” “Reader.20” and “modal age”.
- columns with length, readers and modal age: “length”, “Reader.01”, “Reader.02” “Reader.20” and “modal age”.
- maximum age of the sample data: select “Reader.01”, “Reader.02” “Reader.20” columns.

In the case of this simulated exchange the correspondence is:

```
#Name of readers
readers<-as.vector(colnames(df[,5:24]))

#columns with info
col.info<-1:4

#columns with readers
col.read<-5:24

#columns with readers and modal age
col.mod<-5:25

#columns with length, readers and modal age
col.len<-c(3,5:25)

# maximum age
age.max<-max(df[,5:24], na.rm=T)
```

The following chunk makes a list of readings per area. In this example, there are 2 areas, so it will create a list with areas A and B and a list with areas A plus B. Also, the PA, CV, and APE are calculated.

Sometimes the CV results exceed 100%. This occurs due to a known issue of the CV calculation formula which is unable to generate correct values when the modal age is 0 and when there are ages 0 assigned by some readers. Also, whenever PA is 100% and modal age is 0, the CV logically must be considered as 0. Concerning this, a small function was created to transform CV to 0% when PA is 100%.

```
## make list
a<-list()
#
# Make a table per area
for (i in levels(as.factor(df$area))){
  a[[i]]<-subset(df,area==i)
}

##Add a list with all areas
a[["all"]] <- df

# Add Modal Age
a.allr<-mapply(cbind, a, "modal.age"=lapply(lapply(a, "[", col.read), moda),
SIMPLIFY=F)

#Determine Percentage of Agreement
a.allr<-mapply(cbind, a.allr, "pa"=lapply(lapply(a.allr, "[", c(col.read,
max(col.read+1))),perc.agr), SIMPLIFY=F)

#Calculate CV
a.allr<-mapply(cbind, a.allr, "cv"=lapply(lapply(a.allr, "[", c(col.read,
max(col.read+1))),cv), SIMPLIFY=F)

#Add APE
a.allr<-mapply(cbind, a.allr,
"ape"=lapply(lapply(a.allr, "[", col.read),ape), SIMPLIFY=F)

#Function to transform CV=0% when PA=100%
func<-function(x){
  x[,"cv"][x[,"pa"]==100]<-0
  x[,"ape"][x[,"pa"]==100]<-0
  return(x)
}

a.allr<-lapply(a.allr,func)
```

The following chunks do not need to be changed and the report output starts from here.

Report Output: Data description

Participant table

The participant table indicates the readers involved in the analysis, its level of expertise and the code that will be used along the following analysis (Table 1).

```
kable(part, "pandoc", caption="Participants List")
```

Table 1 – Participant list
Tabela 1 – Lista de participantes

Name	Institute	Expertise Level	Participant Code
AA	Alpha	Advanced	Reader.01
AB	Beta	Advanced	Reader.02
BB	Gama	Advanced	Reader.03
BC	Delta	Advanced	Reader.04
CC	Epsilon	Advanced	Reader.05
CD	Epsilon	Advanced	Reader.06
DD	Theta	Advanced	Reader.07
DE	Theta	Advanced	Reader.08
DF	Lambda	Advanced	Reader.09
GA	Lambda	Advanced	Reader.10
GB	Alpha	Trainee	Reader.11
GC	Alpha	Trainee	Reader.12
FA	Beta	Trainee	Reader.13
FB	Beta	Trainee	Reader.14
FC	Gama	Trainee	Reader.15
FD	Gama	Trainee	Reader.16
FE	Delta	Trainee	Reader.17
FF	Delta	Trainee	Reader.18
HC	Theta	Trainee	Reader.19
HB	Lambda	Trainee	Reader.20

Sample Overview

The sample overview table (Table 2) resumes the number of otoliths per semester, area, and length range.

```

# Overview of samples
samp<-df[,col.info]
samp$semester<-semester(df$catch_date)

sa<-aggregate( length~area+semester,samp,range)
pl<-data.frame(table(samp$area,samp$semester))

colnames(pl)<-c("area","semester","n.samples")
overv<-merge(sa,pl,by=c("area","semester"))

kable(cbind(overv[,c(1:2,4)],"Min Length"=(overv$length[,1]),"Max
Length"=(overv$length[,2])), "pandoc",caption = "Sample Overview")

```

Table 2 – Sample Overview

Tabela 2 – Resumo das amostras

Area	Semester	Number Samples	Minimum Length	Maximum Length
A	1	35	170	237
A	2	44	109	236
B	1	31	104	220
B	2	37	85	211

Exploratory Analysis

The following lines of code make the first look at the data, the length distribution of the samples and the mean length at age by reader.

```

#Distribution length
options(digits=4)
df1<-df
df1$tl_class<-floor(df1$length*.1) # length class

#Length distribution - Basic plot
a1<-ggplot(df1, aes(fill=area, x=tl_class)) +
  geom_bar(position = "stack") #

# Length distribution
fig1<-a1+theme(plot.title=element_text(size=18,face="bold"),
  axis.text.y = element_text(size=12),
  axis.text.x = element_text(size=12),
  axis.title.x = element_text(size=16),
  axis.title.y = element_text(size=16))+
  theme(legend.title = element_blank(),legend.position="top")+
  scale_x_continuous("Total length, cm")+
  scale_y_continuous("Number")

```

```

#Mean length at age
df.m1<-lapply(lapply(a, "[", c(col.read[1]-2, col.read)), me.Len)

df.m2<-melt(df.m1)
  colourCount = length(unique(df.m2$Var1))
  getPalette = colorRampPalette(brewer.pal(9, "Set1"))
order.area<-c("A", "B", "all") # order areas by appearance you want
df.m2$L1<-ordered(df.m2$L1, levels=order.area)

# Mean Length at Age plot
fig2<- ggline(df.m2, x="Var2", y="value", color = "Var1", size = 1, palette
=getPalette(colourCount), ylab="Total Length,mm", xlab="Mean
Age")+theme(legend.title=element_blank(), legend.position="top", legend.box
= "horizontal")+guides(fill=guide_legend(nrow=2, byrow =
T))+facet_wrap(~L1)

```

Total length distribution by areas

Figure 1 presents the fish total length distribution by area.

fig1

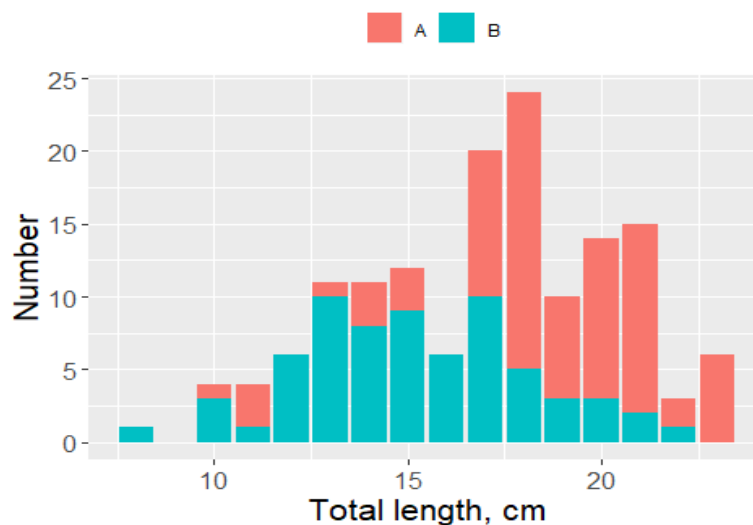


Figure 1 - Total length distribution by areas

Figura 1 – Distribuição de comprimento por área

Mean Length at Age

Figure 2 shows the fish mean length at age by individual reader. This type of analysis allows to check if all readers show the same fish ageing trend.

fig2

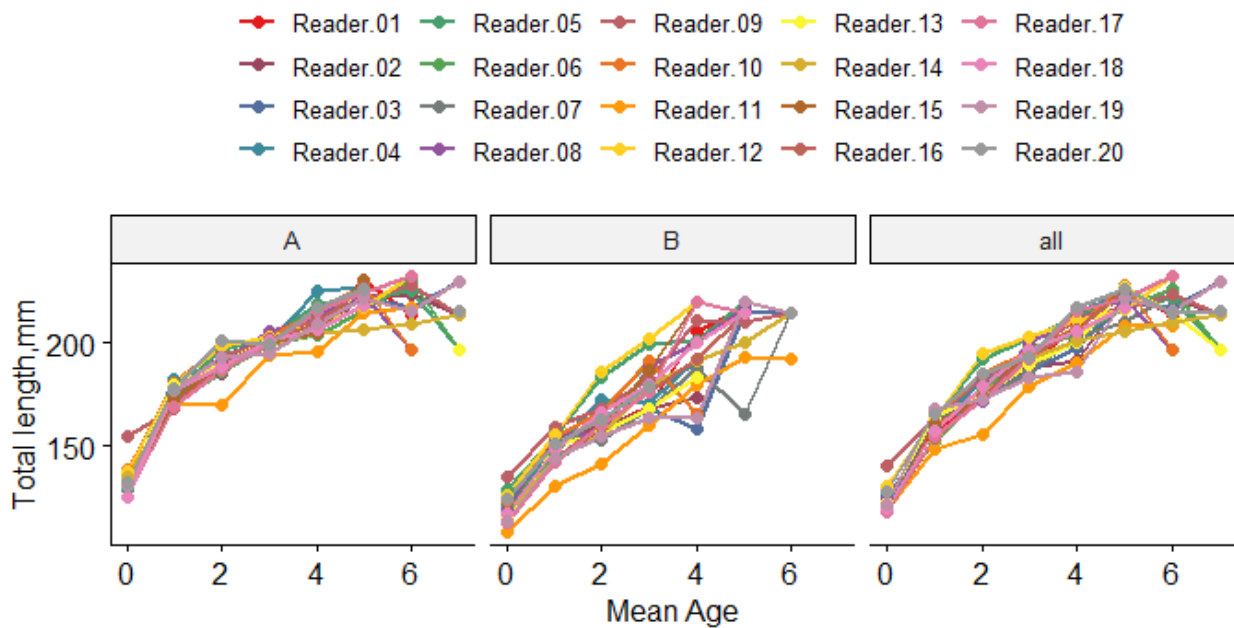


Figure 2 - Mean fish total length by area and readers. A – Area A; B – Area B; all – Area A + Area B
 Figura 2 – Comprimento médio à idade por área e leitores. A – Área A; B – Área B; all – Área A + Área B

REPORT OUTPUT: ALL READERS ANALYSIS

The next lines calculate the PA, CV and APE by areas and readers, following the same approach described in the Eltink spreadsheet.

```
#table with cv and PA by areas
pa_cv_areas<-
sapply(lapply(a.allr,"[",c(max(col.read)+2):ncol(a.allr[[1]])), function
(x) lapply(lapply(x, mean, na.rm=TRUE),round,1))

# Number of otolith readied by reader and age group
#####
age.reding<-lapply(lapply(a.allr,"[",col.mod),age.red)

# Coefficient of variation by reader and age
#####
cv.age.reader<-lapply(lapply(a.allr,"[",
c(readers,"modal.age","cv")),age.cv)

# Percentage of agreement by reader and age
#####
agree<-lapply(lapply(a.allr,"[",col.mod),age.pa)
```

```

# Relative Bias by reader and modal age
#####
rel.bias<-lapply(lapply(a.allr,"[",col.mod),age.bias)

# Age Composition
#####
age.comp<-lapply(lapply(a.allr,"[",col.mod),age.red)

# 2x Standard Deviation
#####
stand<-lapply(lapply(a.allr,"[",col.mod),age.sd)

# Mean Age
#####
me<-lapply(lapply(a.allr,"[",col.mod),age.mean)

#Mean Length at age
#####
me.age.len<-lapply(lapply(a.allr,"[",col.Len),me.Len)

# Interbias and and percentage of agreement between readers
#####
bias<-lapply(lapply(a.allr,"[", col.mod),testWIL.fun2)
#Age Bias Plots
#####
li.all<-mapply(abplot,me,stand,SIMPLIFY = F)

```

Percentage of agreement, Coefficient of variation and Average percentage error

The following code produces table 3 which summarises of the PA, CV and APE by areas.

```

kable(t(pa_cv_areas),"pandoc",caption = "Percentage of agreement
(PA),coefficient of variation (CV) and Average Percent Error (APE) for all
readers analysis")

```

Table 3 - Percentage of agreement (PA), Coefficient of Variation (CV) and Average Percent Error (APE) for all readers' analysis by area

Tabela 3 – Percentagem de concordância (PA), Coeficiente de Variação (CV) e Percentagem de Erro médio (APE) para a análise de todos os leitores por área

Area	PA	CV	APE
A	73.5	49.2	25.9
B	67.3	63.7	38.3
all	70.7	55.9	31.6

Data input by otolith sample

This table corresponds to table 1 in the Eltink spreadsheet. It presents the input data with modal age, PA, CV, APE by otolith sample (see annex, Table A1).

```
kable(a.allr$all, "pandoc", caption = "Percentage of agreement (PA), coefficient of variation (CV) and Average Percent Error (APE) for all readers analysis")
```

Number of samples by reader and age group

The number of age readings by readers and modal age for areas A, B and combined areas is presented in tables A2, A3 and A4 in the annex. These tables correspond to table 2 from the Eltink spreadsheet.

```
for(i in names(age.reading)) {  
  print(kable(x = age.reading[i], "pandoc", caption = paste("Age Readings table for the", i, "area by age", sep=" ")))  
}
```

CV by reader and age

The CV by modal age, age group, readers, and all readers combined for areas A (Table A5), B (Table A6) and both areas (Table A7) are in the annex and correspond to table 2 from the Eltink spreadsheet. Weighted mean CV and ranking are also presented.

```
options(knitr.kable.NA = "")  
for(i in names(cv.age.reader)) {  
  print(kable(cv.age.reader[i], "pandoc", caption = paste("Coeficiente of variation (CV) for", i, "area", sep=" ")))  
}
```

PA by reader and age

Tables A8, A9 and A10 in the annex show the PA for each reader in areas A, B and both areas. Also, the modal age over age groups is presented. The readers are ranked according to their achievement in the PA weighted mean.

```
options(knitr.kable.NA = "")  
for(i in names(agree)) {  
  print(kable(agree[i], "pandoc", caption = paste("Percentage of Agreement (PA) for", i, "area", sep=" ")))  
}
```

Relative bias by reader and age

Tables A11, A12 and A13 in the annex show the relative bias for each and combined area. The age readers are ranked from the lowest to the highest relative bias.

```
options(knitr.kable.NA = "")
for(i in names(rel.bias)) {
  print(kable(rel.bias[i], "pandoc", caption = paste("Relative bias
for", i, "area", sep=" ")))
}
```

Age composition

Tables A14, A15 and A16 in annex 2 show the age composition obtained by each reader and all readers combined for areas A, B and both, respectively.

```
for(i in names(age.comp)) {
  print(kable(age.comp[i], "pandoc", caption = paste("Age Composition
for", i, "area", sep=" ")))
}
```

2x Standard deviation

Tables A17, A18, and A19 from the annex show the 2-standard deviation for areas A, B and both combined. These tables with mean age are used to draw the age bias plots.

```
for (i in names(stand)){
print(kable(stand[i], "pandoc",caption = paste("2x Standart Deviation
for", i, "area", sep=" ")))
}
```

Mean age

Tables A20, A21 and A22 in annex 2 show the mean age by each reader and modal age for each area and their combination.

```
for (i in names(me)){
print(kable(me[i], "pandoc",caption = paste("Mean Age by reader
for", i, "area", sep=" ")))
}
```

Mean Length at Age

Tables A23 to A25 in the annex show the mean length at age obtained by each reader and all readers combined. These tables were also used to get Figure 2.

```
for (i in names(me.age.len)){
print(kable(me.age.len[i], "pandoc",caption = paste("Mean Length at age
```

```
for", i, "area", sep=" ")
}
```

PA, CV and SD vs Modal Age

The coefficient of variation (CV%), percent agreement (PA) and the standard deviation (SD) are plotted against modal age (Fig. A1 in Annex) (Eltink *et al.* 2000).

```
options(digits=1)
b<-
rbind(do.call(cbind,lapply(cv.age.reader, "[", i="ALL", j=1:(age.max+1))), do.
call(cbind,lapply(agree, "[", i="all", j=1:(age.max+1))), do.call(cbind,lapply
(stand, "[", i="All Readers", j=1:(age.max+1)))

met<-rep(c("CV", "PA", "SD"), each=(age.max+1), times=1)
b<-sapply(as.data.frame(b, row.names = F), as.numeric)
b<-melt(b)
b$age<-rep(0:age.max, times=3)
b$var<-met
colnames(b)[2]<-"variable"

fig3<-ggplot(b, aes(x=age, color=
var))+geom_line(data=subset(b, var=="PA"), aes(y=value, color=var), size=1.2)+
geom_line(data=subset(b, var=="CV"), aes(y=value, color=var), size=1.2)+
geom_line(data=subset(b, var=="SD"), aes(y=value*10, color=var), size=1.2)+geo
m_point(data=subset(b, var=="PA"), aes(y=value, color=var), size=2)+
geom_point(data=subset(b, var=="CV"), aes(y=value, color=var), size=2)+
geom_point(data=subset(b, var=="SD"), aes(y=value*10, color=var), size=2)+
theme_bw()+facet_wrap(~variable)+ylab("Percentage,
%")+scale_y_continuous(sec.axis = sec_axis(~./10, name = "Standart
deviation, %"))+theme(legend.title = element_blank())

fig3
```

Age Bias Plots

To draw the age bias plots, the inter-calibration name and the type of readers expertise of the analysis i.e, “all readers,” “Advanced readers” or “Trainee readers” needed to be included in the *ageBias.graph* function (see Figure A2 to A4 in Annex).

```
ageBias.graph(li.all, "Simulated Exchange", "all readers")
```

Inter readers test and agreement between readers pairs

The differences between reader and modal age and/or between readers pairs are tested with a one-sample Wilcoxon signed-rank test (Eltink *et al.* 2000) (Tables A26 to A28 in Annex).

```
for (i in names(bias)){
  print(kable(bias[i], "pandoc", caption = paste("InterBias test and reader
  against modal age bias for", i, "area. (-:no sign of bias ( $p > 0.05$ ); *:
  possibility of bias ( $0.01 < p < 0.05$ ); **: certainty of bias ( $p < 0.01$ ). Age
  readings percentage agreement (PA) between each two readers (above
  diagonal).", sep=" "))%>%
    kable_styling(latex_options="scale_down"))
  cat("\n")
}
```

EXTRA ANALYSIS

Resume of Percentage of Agreement, Coefficient of Variation and bias for all areas by age group

To summarize tables with PA, CV and bias by areas and age group (table 4) the following code was created.

```
options(digits=1)
ab<-
as.data.frame(cbind("PA"=agree$all["all", 1:(age.max+1)], "CV"=cv.age.reader
$all["ALL", 1:(age.max+1)],
"bias"=rel.bias$all["all", 1:(age.max+1)]))

az<-rbind(do.call(cbind,
lapply(agree, "[", i="all", j=1:(age.max+1))), do.call(cbind,
lapply(cv.age.reader, "[", i="ALL", j=1:(age.max+1))), do.call(cbind,
lapply(rel.bias, "[", i="all", j=1:(age.max+1))))

kable(az, "pandoc", caption="Percentage of agreement (PA), coefficient of
variation (CV) and bias by areas and age group")
```

Table 4 – Percentage of agreement (PA), coefficient of variation (CV) and bias by areas and age group

Tabela 4 – Percentagem de concordância (PA), Coeficiente de Variação (CV) e Viés por áreas e grupo de idade

		Age								
		Area	0	1	2	3	4	5	6	7
PA	A	95.6	74.3	77.9	71.5	65.8	73.3			
	B	88.5	65.5	64.7	59.6	39.4	40			
	all	91.2	69.4	71	67.7	61.1	65			
CV	A	302.5	44.5	22.8	19.9	13.8	10.8	12.4	17.1	
	B	182.3	52.5	32.7	28.7	34.2	19.4	9		
	all	226.6	49.1	28	22.8	17.9	13	10.7	17.1	
BIAS	A	0.1	0.2	0.1	-0.1	0	0	-0.5	-0.9	
	B	0.2	0.2	-0.1	-0.3	-0.7	-0.8	-0.4		
	all	0.1	0.2	0	-0.1	-0.1	-0.2	-0.5	-0.9	

Mean length at age by individual readers

To have a look at the mean length at age of individual readers, figure 3 is created using the initial data set. It is a similar plot from figure 2.

```
# Mean Length at Age - Plot (EXTRA)

#Total Length column
df1 <-lapply(a, "[",c("length",readers))
mean.df1<-lapply(df1,me.Len)

mean.df1<-melt(mean.df1)
colourCount = length(unique(mean.df1$L1))
getPalette = colorRampPalette(brewer.pal(9, "Set1"))

mean.df1$Var1<-ordered(mean.df1$Var1, Levels=readers)

ggline(mean.adv,x="Var2",y="value",color = "L1",size = 1,ylab="Total
length,mm", palette =getPalette(colourCount), xlab="Mean Age")+
theme(legend.title=element_blank()+facet_wrap(~Var1)
```

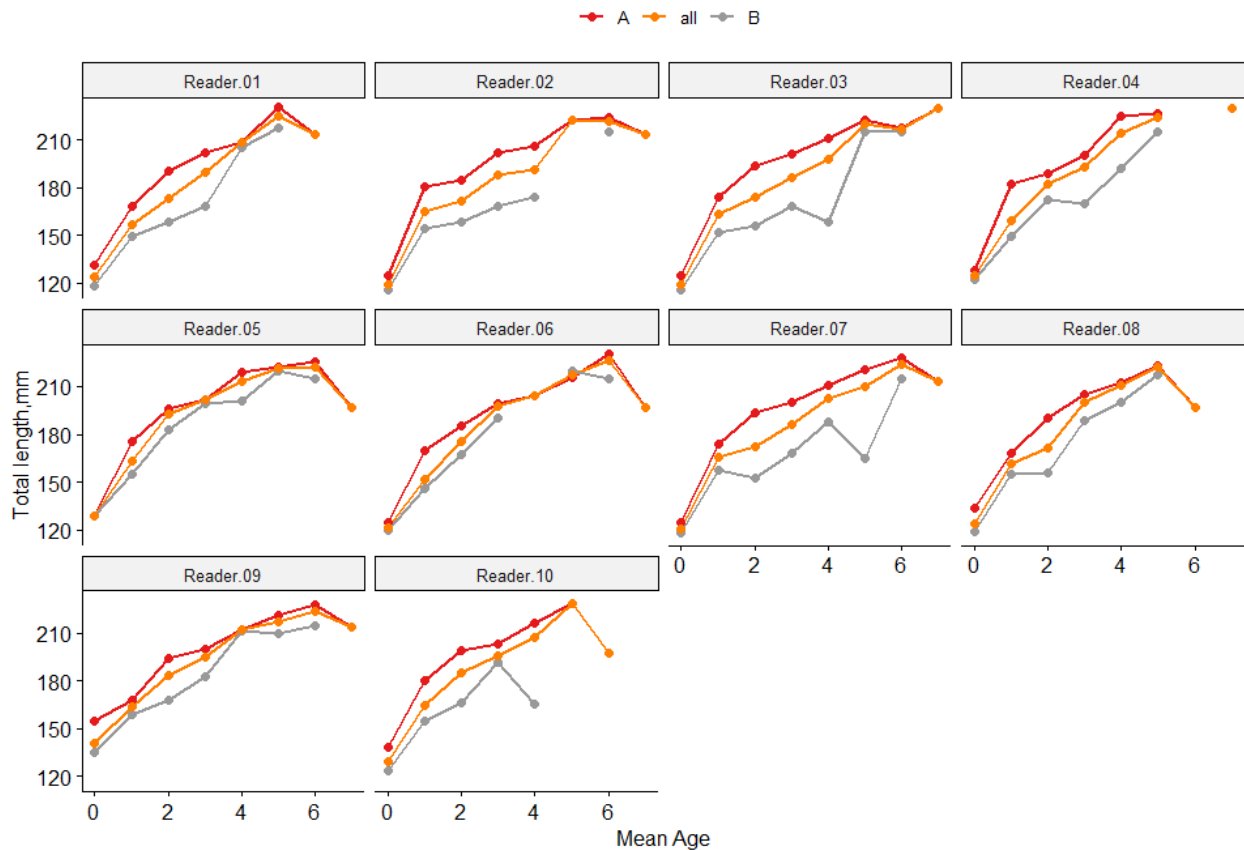


Figure 3 – Fish total length at mean age by reader and area. A- Area A, B- Area B, all – Area A + Area B

Figura 3 – Comprimento total do peixe à idade média. A – Área A, B – Área B, all – Área A + Área B

Growth Analysis

Figure 4 represents the growth pattern obtained by each reader.

```
wkcav<-melt(a.allr$all[1:24], id=(c("SampleID", "catch_date",
"length", "area")))

#column names
colnames(wkcav)[5]<-"readers"
colnames(wkcav)[6]<-"age"

#Order
wkcav$age <- ordered(wkcav$age, Levels = c("0", "1", "2", "3",
"4", "5", "6", "7", "NA"))

fig4<-ggplot(subset(wkcav, !wkcav$age=="NA"), aes(age, length, fill=area)) +
geom_boxplot() +
xlab("Age, years")+ ylab("Length, cm") +
facet_wrap(~readers, nrow = 2)+theme_bw() +
theme(strip.text.y = element_text()) +
```

```

theme(axis.text.x = element_text(size=10),
      plot.title=element_text(size=10,face="bold"),
      axis.text.y = element_text(size=10),
      axis.title.x = element_text(size=10),
      axis.title.y = element_text(size=10),
      strip.text.x = element_text(size = 10))

```

fig4

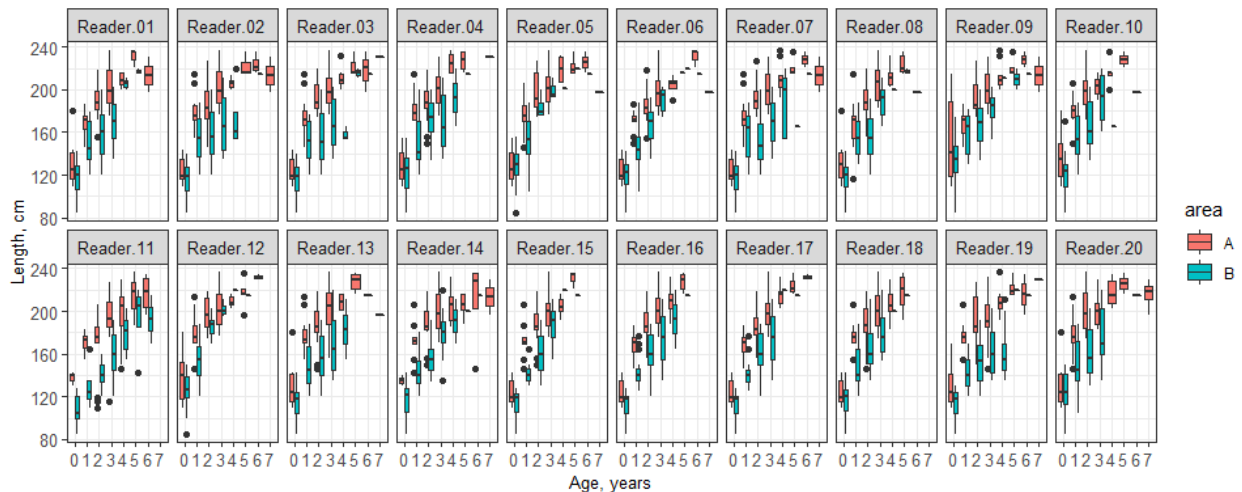


Figure 4 - Growth pattern obtained by each reader by area.

Figure 4 – Padrão de crescimento para cada leitor, por área.

For the analysis using only expert or trainee readers, we will select from the main age matrix the readers by expertise and re-run the code lines described above.

REPORT OUTPUT: ADVANCED READERS ANALYSIS

The following code lines refer to the analysis using only Advanced readers.

The participants' file is used to select the advanced readers. Afterward, the code to retrieve the output is similar to one described in all reader's analyses.

```

adv<-dropLevels(subset(part,ExpertiseLevel=="Advanced"))
adv<-Levels(adv$ParticipantCode)

# Select Readers by expertise level
df.adv <-lapply(a, "[", c(colnames(a$aLL)[col.info],adv))

```

```

#Add Modal Age
df.adv <- mapply(cbind, df.adv,
"modal.age"=lapply(lapply(df.adv, "[", adv), moda), SIMPLIFY=F)

#Add PA
df.adv<- mapply(cbind, df.adv,
"pa"=lapply(lapply(df.adv, "[", c(adv, "modal.age")), perc.agr), SIMPLIFY=F)

#Add cv
df.adv<-mapply(cbind, df.adv,
"cv"=lapply(lapply(df.adv, "[", c(adv, "modal.age")), cv), SIMPLIFY=F)

###Add APE
df.adv<-mapply(cbind, df.adv, "ape"=lapply(lapply(df.adv, "[", adv), ape),
SIMPLIFY=F)

#For modal age 0 and PA 100%, change CV to 0%
df.adv<-lapply(df.adv, func)

##OUTPUT
#Mean PA, CV and APE

pa_cv.adv<-sapply(lapply(df.adv, "[", c("pa", "cv", "ape")), function (x)
lapply(lapply(x, mean, na.rm=TRUE), round, 1))

#Other tables

age.reding.adv<-lapply(lapply(df.adv, "[", c(adv, "modal.age")), age.red)
agree.adv<-lapply(lapply(df.adv, "[", c(adv, "modal.age")), age.pa)
cv.adv<-lapply(lapply(df.adv, "[", c(adv, "modal.age", "cv")), age.cv)
bias.adv<-lapply(lapply(df.adv, "[", c(adv, "modal.age")), age.bias)
stand.adv<-lapply(lapply(df.adv, "[", c(adv, "modal.age")), age.sd)
me.adv<-lapply(lapply(df.adv, "[", c(adv, "modal.age")), age.mean)
IntBias.adv<-lapply(lapply(df.adv, "[", c(adv, "modal.age")), testWIL.fun2)

me.age.Len.adv<-
lapply(lapply(df.adv, "[", c("Length", adv, "modal.age")), me.Len)

```

REPORT OUTPUT: TRAINEE READERS ANALYSIS

The following lines of code refer to the analysis using only trainee readers.

The participant's file is used to select the trainee readers. Afterward, the code to retrieve the output is similar to one described in all readers analyses.

```

bas<-dropLevels(subset(part, ExpertiseLevel=="Trainee"))
bas<-Levels(bas$ParticipantCode)

```



```

# Select Rs by expertise level
df.bas <- lapply(a, "[", c(colnames(a$all)[col.info], bas))

#Add Modal Age
df.bas<- mapply(cbind, df.bas,
"modal.age"=lapply(lapply(df.bas, "[", bas), moda), SIMPLIFY=F)

#Add PA
df.bas<- mapply(cbind, df.bas,
"pa"=lapply(lapply(df.bas, "[", c(bas, "modal.age")), perc.agr), SIMPLIFY=F)

#Add cv
df.bas<-mapply(cbind, df.bas,
"cv"=lapply(lapply(df.bas, "[", c(bas, "modal.age")), cv), SIMPLIFY=F)

##Add APE
df.bas<-mapply(cbind, df.bas, "ape"=lapply(lapply(df.bas, "[", bas), ape),
SIMPLIFY=F)

df.bas<-lapply(df.bas, func)

##OUTPUT
#Mean PA, CV and APE

pa_cv.bas<-sapply(lapply(df.bas, "[", c("pa", "cv", "ape")), function (x)
lapply(lapply(x, mean, na.rm=TRUE), round, 1))

#Other tables
age.reding.bas<-lapply(lapply(df.bas, "[", c(bas, "modal.age")), age.red)
agree.bas<-lapply(lapply(df.bas, "[", c(bas, "modal.age")), age.pa)
cv.bas<-lapply(lapply(df.bas, "[", c(bas, "modal.age", "cv")), age.cv)
bias.bas<-lapply(lapply(df.bas, "[", c(bas, "modal.age")), age.bias)
stand.bas<-lapply(lapply(df.bas, "[", c(bas, "modal.age")), age.sd)
me.bas<-lapply(lapply(df.bas, "[", c(bas, "modal.age")), age.mean)
IntBias.bas<-lapply(lapply(df.bas, "[", c(bas, "modal.age")), testWIL.fun2)

me.age.Len.bas<-
lapply(lapply(df.bas, "[", c("Length", bas, "modal.age")), me.Len)

```

SESSION SOFTWARE INFORMATION

This script was tested using the following R and packages versions:

```
sessionInfo()

## R version 4.0.3 (2020-10-10)
## Platform: x86_64-w64-mingw32/x64 (64-bit)
## Running under: Windows 10 x64 (build 19043)
##
## Matrix products: default
##
## locale:
## [1] LC_COLLATE=Portuguese_Portugal.1252
LC_CTYPE=Portuguese_Portugal.1252
## [3] LC_MONETARY=Portuguese_Portugal.1252 LC_NUMERIC=C
## [5] LC_TIME=Portuguese_Portugal.1252
##
## attached base packages:
## [1] stats      graphics  grDevices  utils      datasets  methods   base
##
## other attached packages:
## [1] kableExtra_1.3.4   forcats_0.5.1     stringr_1.4.0
purrr_0.3.4
## [5] readr_2.1.1       tidyr_1.1.4      tibble_3.1.6
tidyverse_1.3.1
## [9] dplyr_1.0.7       lubridate_1.8.0   knitr_1.37
RColorBrewer_1.1-2
## [13] ggthemes_4.2.4    ggpubr_0.4.0     ggplot2_3.3.5    FSA_0.9.1
## [17] reshape2_1.4.4
##
```

DISCUSSION

This document describes the development of an R script routine that allows making the analyses of an age reading exercise following the same approach used in the Eltink's Excel spreadsheet (Eltink, 2000; Eltink *et al.* 2000). This R routine showed to be a preferred option in relation to the Excel spreadsheet since it performs quite well with a high number of age readers and/or otolith's samples, incorporating new analyses involving indexes calculations like the APE and the PA between pairs of readers. It also includes a first analysis of the age reading data, which is useful to have a first look on the otolith's age reading general trend.

This work also gave the opportunity to revisit some situations that raise difficulties in data analysis in the Eltink's spreadsheet. For example, in case it was not possible to calculate a modal age in the spreadsheet due to multimodality (e.g., a sample with two or more ages given by an equal number of readers), the mean age was considered the "true age". This might not be the most adequate solution as it implies a systematic underestimation of the modal age, causing discrepancies in the estimation of the growth curves, as well as bias in the calculation of the PA and the Age Error Matrix (AEM) (ICES 2019b).

WGSMART (ICES 2020b) is currently developing a multi-stage approach to the selection of the modal age. With this approach, two different weight score scales, based on the age reader's experience for a given species and area, are assigned to each reader: one weight score linearly decreasing with the experience and the other decreasing with a negative exponential shape. A stepwise procedure to decide the final modal age consists in i) primarily using the obtained traditional modal age (most common age), ii) for samples with multimodality, using the linear weighted mode (weights based on experience scores of readers), and iii) if there are still samples with the same number of readers for more than one age, applying the negative exponential weighted mode (ICES 2020c).

Nevertheless, WGSMART (ICES 2020b) indicated that this is a partial solution for this problem as it may still have an impact in the calculated PA and in the AEM since both depend on the modal age. According to ICES (2019b), the consequence of this influence still needs to be assessed.

Other advantages in using the R script are the possibility to incorporate new types of analyses in age reading exercises, like an AEM. The AEM is a matrix that shows the probabilities of age classes being wrongly assigned to the "true age" class (Candy *et al.* 2012). The "true age" in our example is the modal age. Procedures for including AEM have been developed (Dorval *et al.* 2013; Punt *et al.* 2008) and most models used for stock assessment of European

fish stocks, i.e. Stock Synthesis and State-space Assessment Model (SAM) (Methot and Wetzel, 2013) are capable of incorporating error matrices. Nevertheless, age estimation error is not usually implemented in a single stock assessment.

In conclusion, the R script for age readings analyses showed to have multiple advantages in comparison with the Eltink Spreadsheet. The R script proved to be efficient with a large number of readers and otoliths samples and allowed the inclusion of new statistics which could be useful for fish stock assessment. This script will surely be in constant development and should be amended whenever SmartDots criteria are revised. The code and data example presented in this manuscript are available at: <https://github.com/AvSil/R-Toolbox-guidelines-for-age-reading-analysis>. The R script being opened to all users in a GitHub page is also expected to contribute for a dynamic improvement of the performance of the script, as anyone can share and discuss issues and solutions among coworkers and improve their skills on the matter.

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Annex – Tables based on Eltink (2000) spreadsheet.

Table A1 – Readings for Reader 01, Reader 02 until Reader 20 (R01, R02 R20) and modal age, Percentage of Agreement (PA), Coefficient of Variation (CV), and Average Percentage Error (APE) for each otolith sample (SampleID).

Tabela A1 – Leituras do leitor 1, leitor 2 até ao leitor 20 (R01, R02 R20) e idade modal, Percentagem de Concordância (PA), Coeficiente de Variação (CV) e Percentagem de Erro Médio (APE) para cada otólito (SampleID).

SampleID	catch_date	Length (mm)	Area	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	Modal Age	PA	CV	APE
05 2015 ^a 16901	01/05/2015	183	A	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	90.0	15.8	9.5
05 2015 ^a 16902	01/05/2015	216	A	4	6	4	4	5	5	5	5	5	4	5	4	4	5		4	4	4	4	7	4	52.6	17.8	13.6
05 2015 ^a 16903	01/05/2015	183	A	2	2	2	2	2	2	2	2	1	3	2	2	2	2	2	2	2	3	2	2	2	85.0	18.8	9.3
05 2015 ^a 16904	01/05/2015	185	A	3	3	3	3	3	3	3	3	3	2	3	3	3	4	3	3	3	3	3	3	3	90.0	10.5	3.3
05 2015 ^a 16905	01/05/2015	202	A	4	4	4	3	3	4	4	4	4		4	4	4	5	4	4	4	4	4	4	4	84.2	10.0	4.8
05 2015 ^a 16906	01/05/2015	216	A	4	5	5	4	5	5	5	4	5	4	4	5	4	5	4	4	4	4	5	5	4	50.0	11.4	11.1
05 2015 ^a 16907	01/05/2015	174	A	2	2	2	2	2	2	2	2	2	1	2	2	2	3	2	2	2	3	2	2	2	85.0	18.8	9.3
05 2015 ^a 16908	01/05/2015	197	A	6	7	6		7	7	7	6	7	6	6	5	7	7		4		5	6	7	7	47.1	14.3	9.8
05 2015 ^a 16909	01/05/2015	187	A	3	3	3	3	3	3	3	3	3	2	4	3	3	3	3	3	3	3	3	3	3	90.0	10.5	3.3
05 2015 ^a 16922	01/05/2015	208	A	4	3	4	3	3	4	4	3	4		4	3	3	3	3	3	3	3	4	3	3	63.2	14.6	13.1
05 2015 ^a 16929	01/05/2015	205	A	4	3	3	2	3	3	3	3	4	4	2	4	3	3	3	3	3	4	3	3	3	65.0	18.2	13.5
05 2015 ^a 16930	01/05/2015	193	A	2	3	2	2	2	2	2	3	2	1	3	2	2	2	2	3	3	4	3	2	2	60.0	28.2	23.6
05 2015 ^a 16931	01/05/2015	188	A	2			2			2	2	0		3	1						2	3	1	2	50.0	48.1	18.9
05 2015 ^a 16932	01/05/2015	208	A	3		3	2	3	3	3	3	3	2	5	2	3	3	3	3	3	2	3	3	3	73.7	22.1	12.4
05 2015 ^a 16933	01/05/2015	189	A	3		3	2	1		2	2	0		4	1		4		3	3	2	3	1	3	33.3	49.2	31.5
05 2015 ^a 16934	01/05/2015	206	A	4	4	4		4	4	4	4	4		6	4		5	4	4	4	4	4	4	4	88.2	12.3	6.3
06 2014B 16873	01/06/2014	104	B	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	85.0	251.0	170.0
06 2015 ^a 16914	01/06/2015	198	A	2	2	2	2	1	2	2	2	3	1	2	2	2	2	2	2	3	2	3	2	2	75.0	24.3	13.9
06 2015B 16854	01/06/2015	120	B	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	80.0	211.2	160.0
06 2015B 16884	01/06/2015	165	B	2	2	2	2	1	2	2	2	1		4	1	2	2	2	2	2	2	2	1	2	73.7	33.7	18.9
07 2015 ^a 16843	01/07/2015	198	A	2	3	3	2	2	3	3	2	3	2	3	2	2	4	3	3	3	2	3	1	3	50.0	26.3	23.3
07 2015 ^a 16844	01/07/2015	214	A	3	3	4	3	3		3	1	3	2	4	3	2	3		3	3	3	3	2	3	66.7	24.2	15.3
07 2015 ^a 16846	01/07/2015	217	A	2	2	3	2	2		3	2	2	2	3	2	2	3	2	3	3	2	2	2	2	68.4	20.4	17.7
07 2015 ^a 16848	01/07/2015	230	A	6	7	7	7	4		7	3	7		6	6	5	7		5	6	5	7	7	7	47.1	20.0	13.3
07 2015 ^a 16852	01/07/2015	180	A	0	1	1	1		1	1	0	1	0		0	0			2		2	1	0	1	46.7	91.1	60.0
07 2015 ^a 16915	01/07/2015	116	A	0	0	0	0	0	0	0	1	0		2	0	0			0	0	0	0	0	0	88.9	317.6	160.0
07 2015 ^a 16916	01/07/2015	109	A	0	0	0	0	0	0	0	0	0	0	2	0	0			0	0	0	0	0	0	94.7	447.2	180.0
07 2015 ^a 16917	01/07/2015	119	A	0	0	0	0	0	0	0	0	0	0	2	0	0			0	0	0	0	0	0	94.7	447.2	180.0
07 2015 ^a 16918	01/07/2015	116	A	0	0	0	0	0	0	0	0	0	0	3	0	0			0	0	0	0	0	0	94.7	447.2	180.0
07 2015 ^a 16919	01/07/2015	146	A	1	2	1		1		1	1	1		4	1	2	6	1	1	1	2	3	1	1	64.7	79.2	47.7
07 2015 ^a 16920	01/07/2015	150	A	1	2	1	2	1	1	1	1	1	1	4	0	2	2	2	1	1	2	2	1	1	55.0	56.7	44.1
07 2015 ^a 16921	01/07/2015	156	A	2	2	1	2	1	1	1	1	2	1		4	0	3	2	2	2	2	3		2	50.0	48.8	32.7
07 2015 ^a 16923	01/07/2015	186	A	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	95.0	20.8	9.0
07 2015B 16809	01/07/2015	85	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.0	0.0	0.0
07 2015B 16810	01/07/2015	100	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.0	0.0	0.0
07 2015B 16811	01/07/2015	150	B	2	2	3	1	1	1	3	2	0	2	2	0	2	1	2	2	2	2	3	0	2	50.0	54.8	45.8
07 2015B 16812	01/07/2015	135	B	1	2	2	0	0	1	2	2	0		2	0				1		1	3	1	1	31.2	83.0	55.6
07 2015B 16813	01/07/2015	160	B	2	3	3	2	1	1	3	2	0	2	2	1	2	3	2	2	2	2	2		2	57.9	38.9	24.6
07 2015B 16849	01/07/2015	140	B	1	1	1	1	0	1	1	1	1	1	3	0	1	1	1	1	1	1	1	0	1	80.0	61.9	30.0
07 2015B 16863	01/07/2015	211	B	4	3	5	3	3		4	3	4	3	5	3	4	4	3	3	3	2	4	3	3	52.6	22.0	17.9
08 2015 ^a 16818	01/08/2015	143	A	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	95.0	458.3	190.0
08 2015B 16855	01/08/2015	142	B	0	1	1	0	0	0	0	0	0	0	5	0	0	0	1	1			3	0	0	68.4	212.2	130.0
08 2015B 16857	01/08/2015	182	B	2	2		1	1	1	1	2	1	1	4	1	2	3	3	2	2	1	2	1	1	47.4	50.9	38.2

SampleID	catch_date	Length (mm)	Area	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	Modal Age	PA	CV	APE		
09 2014B 16867	01/09/2014	150	B	1	1	1	1	0	1	1	1	1	2	2	0	2	1	1	1	1	1	2	0	1	65.0	56.3	36.2		
09 2014B 16868	01/09/2014	128	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.0	0.0	0.0		
09 2015 ^a 16823	01/09/2015	210	A	3	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	90.0	14.4	8.6	
09 2015 ^a 16824	01/09/2015	219	A	3	3	2	3	2	3	3	2	3	3	3	2	2	3	2	3	3	2	3	2	3	3	57.9	19.3	18.0	
09 2015 ^a 16825	01/09/2015	218	A	2	2	2		2	2	2	2	2	2	3	2	2	2		2	2	2	2	2	2	2	94.4	11.2	4.6	
09 2015 ^a 16826	01/09/2015	227	A	3	2	3		2	3	2	3	2	3	3	3	3	3	3	3	4	3	2	2	3	3	61.1	20.5	15.9	
09 2015 ^a 16827	01/09/2015	218	A	3	3	3	3	3	3	3	3	3	3	5	3	3	3		3	3	3	3	3	3	3	94.4	14.8	6.1	
09 2015 ^a 16828	01/09/2015	206	A	2	1	1	1	1	1	1	3	0	1	2	1	1	1	1	3		1	1	1	1	1	72.2	58.1	38.3	
09 2015 ^a 16829	01/09/2015	214	A	2	1	1	1			1	5	0	4	1	1	2		2		2	2	2	1	1	1	46.7	74.1	39.6	
09 2015 ^a 16830	01/09/2015	218	A	3		2	2	2		2	3	3	3	2	2	2	2	2	2	2	3	2	2	2	2	70.6	20.2	15.4	
09 2015 ^a 16831	01/09/2015	232	A	3	3	4	4	4		4	4	4	5	3	3	4		4	4	3	3	4	4	4	58.8	15.4	11.4		
09 2015 ^a 16832	01/09/2015	219	A	3	3	2		3		3	5	3	5	2	3	4		4	4	3	3		3	3	53.3	26.4	16.0		
09 2015B 16833	01/09/2015	124	B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	95.0	458.3	190.0		
09 2015B 16859	01/09/2015	191	B	2	2	3	2	2	2	3	2	3	2	3	2	2	2	2	3	3	2	2	2	2	2	70.0	20.3	18.3	
10 2009B 16887	01/10/2009	180	B	3	3	3			2	2	2	3		3	1	2	1	2	2	2	2	3		2	50.0	29.7	20.0		
10 2014 ^a 16802	01/10/2014	185	A	2	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2	2	1	2	84.2	19.8	13.7		
10 2014 ^a 16803	01/10/2014	185	A	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	89.5	16.2	5.0	
10 2014 ^a 16874	01/10/2014	170	A	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	94.7	21.3	9.0	
10 2014 ^a 16875	01/10/2014	155	A	1	1	1	0	0	2	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	78.9	49.7	30.0	
10 2014 ^a 16876	01/10/2014	175	A	1	1	1	1	2	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	85.0	31.4	22.2	
10 2014 ^a 16877	01/10/2014	180	A	2	2	2	1	1	3	2	2	2	1	2	1	2	2	2	2	2	1	2	1	2	1	2	65.0	30.6	25.7
10 2014 ^a 16878	01/10/2014	140	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.0	0.0	0.0	
10 2014 ^a 16879	01/10/2014	175	A	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100.0	0.0	0.0	
10 2014 ^a 16880	01/10/2014	130	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.0	0.0	0.0	
10 2014 ^a 16881	01/10/2014	200	A	2	2	2	2	2	3	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	90.0	14.4	8.6	
10 2014B 16869	01/10/2014	156	B	2	2	2	2	0	1	2	1	2	1	2	1	1	1	2	2	2	1	2	1	2	2	55.0	39.5	36.7	
10 2014B 16874	01/10/2014	170	B	1	1	1	1	1	2	1	1	1	1	1										1	90.0	27.6	8.2		
10 2014B 16875	01/10/2014	155	B	1	1	1	0	0	2	1	1	0	1	1	0									1	60.0	73.7	30.0		
10 2014B 16876	01/10/2014	175	B	1	1	1	1	2	2	1	2	1	1	1										1	70.0	36.7	16.2		
10 2014B 16877	01/10/2014	180	B	2	2	2	1	1	3	2	2	1	2											2	60.0	33.2	13.3		
10 2014B 16878	01/10/2014	140	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.0	0.0	0.0	
10 2014B 16879	01/10/2014	175	B	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100.0	0.0	0.0	
10 2014B 16880	01/10/2014	130	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.0	0.0	0.0	
10 2014B 16881	01/10/2014	200	B	2	2	2	2	2	3	2	3	2	2	2										2	80.0	18.5	7.3		
10 2014B 16895	01/10/2014	145	B	1		3	1	1	1	2	2	0	2	3	0	1	1	2	1	1	1	4	1	1	1	52.6	68.9	52.1	
10 2014B 16896	01/10/2014	160	B	2	3	3	2			3	2	0	3	3	1	2	1	2	3	3	2	3		3	47.1	39.3	27.4		
10 2014B 16897	01/10/2014	165	B	3	4	4	4			5	3	0	4	4	1	3	2	2	4		2	4	3	4	41.2	41.1	27.9		
10 2014B 16898	01/10/2014	125	B	1	1	1	1	0	1	1	0	0	1	3	0	1	0	0	1	1	1	2	1	1	1	60.0	84.8	60.0	
10 2014B 16899	01/10/2014	135	B	1	1	1	1	0	1	1	2	1	1	1	0	1	1	1	1	1	1	2	1	1	1	80.0	44.7	20.0	
10 2015A 16796	01/10/2015	190	A	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	95.0	7.2	3.1	
10 2015A 16797	01/10/2015	185	A	3	3	2	2	2	3	3	2	3	2	3	1	2	2	2	2	3	2	3	2	2	2	55.0	24.7	22.1	
10 2015A 16798	01/10/2015	236	A	5	5	5	5	5	6	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	90.0	5.9	3.5	
10 2015A 16799	01/10/2015	221	A	5	6	6	5	5	6	6	5	6	5	5	5	5	6	5	5	5	5	5	7	5	5	65.0	11.0	9.6	
10 2015A 16800	01/10/2015	213	A	4	4	4	3	3	4	4	3	4	4	4	3	4	4	4	4	3	4	4	4	4	4	75.0	11.6	10.0	
10 2015A 16910	01/10/2015	172	A	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	95.0	20.8	9.0	
10 2015A 16911	01/10/2015	171	A	2	2	1	1	1	1	1	1	1	1	2	2	1	2	3	1	2	2	2	2	1	1	50.0	39.5	35.5	
10 2015A 16912	01/10/2015	171	A	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	95.0	20.8	9.0	
10 2015A 16913	01/10/2015	189	A	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	95.0	11.2	4.9	
10 2015B 16845	01/10/2015	118	B	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	95.0	458.3	190.0	
10 2015B 16856	01/10/2015	177	B	2	1	1	1	1	1	1	2	1	1	4	1	1	1	2	1	1	1	2	1	1	1	75.0	54.8	38.9	
11 2012B 16864	01/11/2012	134	B	2	2	2	2	0	1	2	2	2	2	2	0	2	2	1	2	2	1	2	2	2	2	75.0	39.5	31.8	
11 2012B 16865	01/11/2012	174	B	2	2	2	2	1	3	3	2	0	2	3	1	2	3	2	2	2	2	3	1	2	2	55.0	38.7	25.0	
11 2015A 16801	01/11/2015	200	A	4	4	4	3	3	4	4	3	4	4	4	3	4	5	4	3	3	3	4	3	4	4	55.0	15.7	14.2	
11 2015B 16816	01/11/2015	109	B	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	95.0	458.3	190.0	

SampleID	catch_date	Length (mm)	Area	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	Modal Age	PA	CV	APE	
11 2015B 16817	01/11/2015	188	B	3	1	2	2	1	1	1	1	2	1	3	1	1	3	2	2	2	1	2	1	1	50.0	45.7	39.4	
11 2015B 16889	01/11/2015	160	B	2	2	2	2		2	2	2	2	2	3	1	2	2	2	2	2	2	2	2	2	2	89.5	16.2	5.0
12 2015B 16822	01/12/2015	164	B	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	95.0	20.8	9.0
12 2015B 16885	01/12/2015	120	B	1	1	1	1	0	0	1	0	0		3	0	1	1	0	0	0	0	0	1	0	0	52.6	138.0	100.0

Table A2 – Number of otoliths readings by reader and age group for area A

Tabela A2 – Número de otólitos lidos por leitor e grupo de idade para a área A

	0	1	2	3	4	5	6	7	Total
Reader.01	8	11	19	26	10	3	2		79
Reader.02	7	11	20	22	5	3	3	2	73
Reader.03	7	16	19	20	9	3	3	1	78
Reader.04	8	12	25	18	4	4		1	72
Reader.05	8	17	18	22	4	4	2	1	76
Reader.06	7	9	15	21	8	3	3	1	67
Reader.07	7	16	19	20	9	4	2	2	79
Reader.08	7	13	26	20	6	6	1		79
Reader.09	12	14	15	21	9	4	2	2	79
Reader.10	8	14	24	2	5	2	1		56
Reader.11	3	4	17	22	17	11	4		78
Reader.12	11	17	20	19	5	5	2		79
Reader.13	8	10	25	22	4	5		1	75
Reader.14	2	9	17	22	9	7	4	2	72
Reader.15	7	11	21	19	6	3			67
Reader.16	7	11	19	26	10	5			78
Reader.17	7	11	15	27	9	3	2		74
Reader.18	7	9	24	24	8	7			79
Reader.19	8	9	17	29	9	4	2	1	79
Reader.20	8	21	19	16	6	2		4	76

Table A3 – Number of otoliths readings by reader and age group for area B

Tabela A3 – Número de otólitos lidos por leitor e grupo de idade para a área B

	0	1	2	3	4	5	6	Total
Reader.01	11	17	21	15	2	2		68
Reader.02	10	15	21	16	4		1	67
Reader.03	10	14	21	16	3	2	1	67
Reader.04	12	27	17	6	2	1		65
Reader.05	20	25	7	3	2	1	1	59
Reader.06	10	30	17	5		1	1	64
Reader.07	11	15	20	15	5	1	1	68
Reader.08	13	13	30	9	1	2		68
Reader.09	31	15	10	8	1	2	1	68
Reader.10	13	22	18	4	1			58
Reader.11	5	5	17	18	9	4	2	60
Reader.12	18	31	6	3	1	1		60
Reader.13	9	11	22	13	2		1	58
Reader.14	10	19	13	12	3	1	1	59
Reader.15	10	7	25	9	1	1		53
Reader.16	9	16	19	13	2	1		60
Reader.17	9	13	18	13	1	1		55
Reader.18	11	21	19	7	1	1		60
Reader.19	9	3	20	17	9	1	1	60
Reader.20	11	19	14	7			1	52

Table A4 – Number of otoliths readings by reader and age group for all area

Tabela A4 – Número de otólitos lidos por leitor e grupo de idade para todas as áreas

	0	1	2	3	4	5	6	7	Total
Reader.01	19	28	40	41	12	5	2		147
Reader.02	17	26	41	38	9	3	4	2	140
Reader.03	17	30	40	36	12	5	4	1	145
Reader.04	20	39	42	24	6	5		1	137
Reader.05	28	42	25	25	6	5	3	1	135
Reader.06	17	39	32	26	8	4	4	1	131
Reader.07	18	31	39	35	14	5	3	2	147
Reader.08	20	26	56	29	7	8	1		147
Reader.09	43	29	25	29	10	6	3	2	147
Reader.10	21	36	42	6	6	2	1		114
Reader.11	8	9	34	40	26	15	6		138
Reader.12	29	48	26	22	6	6	2		139
Reader.13	17	21	47	35	6	5	1	1	133
Reader.14	12	28	30	34	12	8	5	2	131
Reader.15	17	18	46	28	7	4			120
Reader.16	16	27	38	39	12	6			138
Reader.17	16	24	33	40	10	4	2		129
Reader.18	18	30	43	31	9	8			139
Reader.19	17	12	37	46	18	5	3	1	139
Reader.20	19	40	33	23	6	2	1	4	128

Table A5 - Coefficient of variation (CV) for area A

Tabela A5 – Coeficiente de Variação por leitor e grupo de idade para a área A

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.01	346.4	49.7	19.2	14.2	20.2				84.5	19
Reader.02	233.5	43.6	18.7	12.3	20.2				62.6	8
Reader.03	233.5	47.3	18.7	19.5	20.2				64.9	9
Reader.04	233.5	41.5	30.4	19.9	84.9				70.4	13
Reader.05	346.4	81.6	54.1	46.7					119.2	20
Reader.06	233.5	34.2	45.2	33.3					73.8	14
Reader.07	346.4	43.5	19.7	13.9	15.7				82.6	18
Reader.08		43.5	22.9	20.9	20.2				23.8	3
Reader.09		73.3	83.1	89.6	141.4				66.0	10
Reader.10		48.5	34.4	20.6					28.4	4
Reader.11	151.2	47.9	26.7	23.2	15.7				51.1	6
Reader.12		80.0	51.1	50.1	70.7				49.0	5
Reader.13	316.2	48.5	12.1	16.7					74.3	15
Reader.14	210.8	69.8	42.9	33.1	60.6				75.3	16
Reader.15	316.2	50.5	12.5	15.9	28.3				79.8	17
Reader.16	316.2	30.4	17.1	9.9	20.2				68.6	12

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.17		31.8	17.1	0.0					13.7	1
Reader.18		26.7	29.1	20.9	47.1				21.6	2
Reader.19	241.5	48.2	21.0	15.1					62.4	7
Reader.20	210.8	40.6	39.5	20.6					67.2	11
ALL	182.3	52.5	32.7	28.7	34.2				236.0	

Table A6 - Coefficient of variation (CV) for area B

Tabela A6 – Coeficiente de Variação por leitor e grupo de idade para a área B

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.01	346.4	49.7	19.2	14.2	20.2				84.5	19
Reader.02	233.5	43.6	18.7	12.3	20.2				62.6	8
Reader.03	233.5	47.3	18.7	19.5	20.2				64.9	9
Reader.04	233.5	41.5	30.4	19.9	84.9				70.4	13
Reader.05	346.4	81.6	54.1	46.7					119.2	20
Reader.06	233.5	34.2	45.2	33.3					73.8	14
Reader.07	346.4	43.5	19.7	13.9	15.7				82.6	18
Reader.08		43.5	22.9	20.9	20.2				23.8	3
Reader.09		73.3	83.1	89.6	141.4				66.0	10
Reader.10		48.5	34.4	20.6					28.4	4
Reader.11	151.2	47.9	26.7	23.2	15.7				51.1	6
Reader.12		80.0	51.1	50.1	70.7				49.0	5
Reader.13	316.2	48.5	12.1	16.7					74.3	15
Reader.14	210.8	69.8	42.9	33.1	60.6				75.3	16
Reader.15	316.2	50.5	12.5	15.9	28.3				79.8	17
Reader.16	316.2	30.4	17.1	9.9	20.2				68.6	12
Reader.17		31.8	17.1	0.0					13.7	1
Reader.18		26.7	29.1	20.9	47.1				21.6	2
Reader.19	241.5	48.2	21.0	15.1					62.4	7
Reader.20	210.8	40.6	39.5	20.6					67.2	11
ALL	182.3	52.5	32.7	28.7	34.2				236.0	

Table A7 - Coefficient of variation (CV) for all areas

Tabela A7 – Coeficiente de Variação por leitor e grupo de idade para todas as áreas

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.01	435.9	48.6	18.4	12.3	11.1	10.5			76.8	17
Reader.02	299.5	40.4	17.4	11.8	21.4	16.3			59.7	8
Reader.03	299.5	44.9	18.7	18.8	11.8	9.5		10.9	60.6	9
Reader.04	299.5	44.6	25.1	19.9	30.2	10.5			66.1	12
Reader.05	435.9	64.5	42.5	26.4	20.1	9.5		38.6	96.3	20
Reader.06	299.5	34.7	38.1	26.8	11.4	10.5			69.3	14
Reader.07	435.9	39.4	20.2	17.2	11.2	16.3			76.5	16
Reader.08	435.9	62.9	21.4	27.5	18.2	10.5		47.1	85.9	19
Reader.09		62.0	59.5	53.0	37.2	9.5			46.3	6
Reader.10		52.7	34.3	16.6	22.3	28.9			27.9	2

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.11	124.8	49.7	25.4	23.2	15.7	10.5		0.0	40.5	5
Reader.12		65.0	46.4	36.9	30.9	10.5	12.9	12.9	39.2	4
Reader.13	412.3	48.9	12.1	16.3	15.3	22.2	12.9	23.6	73.3	15
Reader.14	190.0	78.2	31.3	23.0	22.0	28.3			53.0	7
Reader.15	412.3	46.7	8.8	15.1	21.6	22.5			76.9	18
Reader.16	412.3	40.6	16.4	11.1	11.1	10.5		15.7	68.4	13
Reader.17		29.2	19.1	9.6	11.7	10.5	12.9		15.1	1
Reader.18		54.2	31.5	22.8	20.6	22.2			28.4	3
Reader.19	319.8	55.4	20.6	14.5	11.8	0.0		10.9	61.7	10
Reader.20	282.3	33.9	31.7	26.9	30.9	36.0	28.3		63.8	11
ALL	226.6	49.1	28.0	22.8	17.9	13.0	10.7	17.1	190.0	

Table A8 – Percentage of agreement (PA) by reader and age group for area A

Tabela A8 – Percentagem de concordância (PA) por leitor e grupo de idade para área A

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.01	100.0	70.0	80.0	90.0	90.0	70.0	0	0	80.6	7
Reader.02	100.0	70.0	90.0	90.0	60.0	70.0	100	100	83.2	5
Reader.03	100.0	100.0	90.0	80.0	90.0	70.0	100	50	87.9	2
Reader.04	100.0	70.0	90.0	60.0	40.0	100.0	0	100	72.4	14
Reader.05	100.0	80.0	70.0	80.0	40.0	70.0	100	50	74.5	13
Reader.06	100.0	70.0	70.0	80.0	70.0	30.0	100	100	75.5	12
Reader.07	100.0	100.0	80.0	70.0	80.0	70.0	100	100	82.8	6
Reader.08	90.0	70.0	80.0	50.0	50.0	70.0	0	0	63.0	18
Reader.09	100.0	80.0	70.0	70.0	80.0	70.0	100	100	76.7	9
Reader.10	100.0	70.0	50.0	10.0	80.0	70.0	0	0	48.8	19
Reader.11	40.0	30.0	40.0	50.0	60.0	70.0	100	0	44.4	20
Reader.12	100.0	80.0	80.0	70.0	60.0	100.0	100	0	75.6	11
Reader.13	100.0	70.0	90.0	80.0	60.0	100.0	0	50	79.2	8
Reader.14	70.0	60.0	90.0	70.0	40.0	30.0	100	100	69.2	16
Reader.15	100.0	80.0	100.0	80.0	80.0	70.0	0		85.2	3
Reader.16	100.0	70.0	90.0	90.0	90.0	100.0	0	0	84.0	4
Reader.17	100.0	90.0	80.0	90.0	90.0	100.0	100	0	88.0	1
Reader.18	100.0	50.0	80.0	70.0	50.0	100.0	0	0	67.6	17
Reader.19	100.0	60.0	70.0	80.0	80.0	100.0	100	50	75.9	10
Reader.20	100.0	90.0	80.0	60.0	50.0	30.0	0	100	72.1	15
All	95.6	74.3	77.9	71.5	65.8	73.3			74.6	

Table A9 – Percentage of agreement (PA) by reader and age group for area A

Tabela A9 – Percentagem de concordância (PA) por leitor e grupo de idade para área A

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.01	90.0	80.0	80.0	80.0	50.0	100	0		80.0	3
Reader.02	80.0	70.0	80.0	80.0	50.0	0	100		75.4	6
Reader.03	80.0	60.0	80.0	80.0	50.0	100	100		74.0	7

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.04	80.0	80.0	60.0	60.0	50.0	0	0		67.7	12
Reader.05	90.0	60.0	30.0	40.0	100.0	100	100		57.1	15
Reader.06	80.0	80.0	30.0	20.0		100	100		55.6	16
Reader.07	90.0	70.0	80.0	80.0	50.0	0	100		77.1	5
Reader.08	100.0	60.0	80.0	50.0	50.0	100	0		70.6	10
Reader.09	100.0	70.0	40.0	50.0	0.0	100	100		61.8	14
Reader.10	100.0	80.0	50.0	30.0	100.0	0			65.0	13
Reader.11	50.0	10.0	50.0	50.0	50.0	100	100		41.0	20
Reader.12	100.0	60.0	20.0	20.0	0.0	0	0		42.7	19
Reader.13	90.0	60.0	90.0	80.0	0.0	0	100		77.2	4
Reader.14	80.0	60.0	40.0	40.0	0.0	0	100		50.8	18
Reader.15	90.0	40.0	90.0	80.0	0.0	0	0		69.2	11
Reader.16	90.0	90.0	90.0	90.0	50.0	0	0		85.7	2
Reader.17	100.0	90.0	90.0	100.0	0.0	0	0		88.7	1
Reader.18	100.0	90.0	70.0	50.0	50.0	0	0		73.3	9
Reader.19	80.0	10.0	60.0	60.0	100.0	100	100		52.7	17
Reader.20	80.0	90.0	70.0	60.0	0.0	0	100		73.8	8
All	88.5	65.5	64.7	59.6	39.4	40			67.0	

Table A10 – Percentage of agreement (PA) by reader and age group for all areas

Tabela A20 – Percentagem de concordância (PA) por leitor e grupo de idade para todas as áreas

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.01	90.0	70.0	80	90.0	80.0	80	0	0	79.3	5
Reader.02	90.0	70.0	80	90.0	60.0	50	100	100	79.6	4
Reader.03	90.0	80.0	80	80.0	80.0	80	100	50	81.2	3
Reader.04	90.0	80.0	80	60.0	40.0	80	0	100	73.1	9
Reader.05	90.0	70.0	50	70.0	40.0	80	100	50	66.2	15
Reader.06	90.0	80.0	50	60.0	70.0	50	100	100	67.6	14
Reader.07	90.0	80.0	80	70.0	70.0	50	100	100	77.8	7
Reader.08	90.0	60.0	80	50.0	50.0	80	0	0	64.8	16
Reader.09	100.0	70.0	60	60.0	60.0	80	100	100	69.2	11
Reader.10	100.0	80.0	50	10.0	80.0	50	0	0	55.7	19
Reader.11	50.0	20.0	40	50.0	60.0	80	100	0	42.5	20
Reader.12	100.0	70.0	50	50.0	50.0	80	50	0	60.7	17
Reader.13	90.0	60.0	90	80.0	50.0	80	50	50	76.7	8
Reader.14	80.0	60.0	60	60.0	30.0	20	100	100	59.7	18
Reader.15	90.0	60.0	100	80.0	60.0	50	0		78.9	6
Reader.16	90.0	80.0	90	90.0	80.0	80	0	0	84.1	2
Reader.17	100.0	90.0	80	90.0	80.0	80	50	0	86.2	1
Reader.18	100.0	70.0	70	60.0	50.0	80	0	0	67.8	12
Reader.19	90.0	40.0	60	80.0	80.0	100	100	50	67.6	14
Reader.20	90.0	90.0	70	60.0	40.0	20	50	100	71.3	10
all	91.2	69.4	71	67.7	61.1	65			70.6	

Table A11– Relative bias by reader and age group for area A

Tabela A11 – Viés por leitor e grupo de idade para a área A

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.01	0.00	0.13	0.17	0.04	-0.12	-0.33	-1.0	-1.0	0.01	12
Reader.02	0.00	0.27	0.12	-0.10	0.25	0.33	0.0	0.0	0.09	16
Reader.03	0.00	0.00	0.00	-0.08	0.12	0.33	0.0	-0.5	-0.01	10
Reader.04	0.00	0.14	-0.12	-0.27	-0.57	0.00	-1.0	0.0	-0.15	5
Reader.05	0.00	0.00	-0.29	-0.28	-0.12	0.33	0.0	-1.5	-0.20	4
Reader.06	0.00	0.27	0.20	0.05	0.29	0.67	0.0	0.0	0.17	18
Reader.07	0.00	0.00	0.06	-0.04	0.25	0.33	0.0	0.0	0.04	14
Reader.08	0.14	0.47	0.06	-0.32	-0.25	-0.33	-1.0	-2.5	-0.10	6
Reader.09	0.00	-0.07	0.00	-0.24	0.25	0.33	0.0	0.0	-0.05	9
Reader.10	0.00	-0.10	-0.54	-0.94	-0.40	-0.67	-2.0	-1.0	-0.55	1
Reader.11	1.29	1.14	0.72	0.80	0.50	-0.33	0.0	-1.0	0.76	20
Reader.12	0.00	-0.20	-0.28	-0.40	-0.12	0.00	0.0	-1.5	-0.28	2
Reader.13	0.00	0.20	0.06	-0.22	-0.43	0.00	-1.0	-1.0	-0.09	7
Reader.14	0.33	0.85	0.12	0.32	0.62	0.67	0.0	0.0	0.40	19
Reader.15	0.00	0.15	0.00	-0.10	-0.17	-0.67	-1.0		-0.06	8
Reader.16	0.00	0.33	0.12	0.04	-0.12	0.00	-1.0	-2.5	0.01	12
Reader.17	0.00	0.08	0.24	0.04	-0.12	0.00	0.0	-1.0	0.06	15
Reader.18	0.00	0.60	0.17	0.00	-0.50	0.00	-1.0	-2.0	0.04	14
Reader.19	0.00	0.33	0.33	0.08	0.00	0.00	0.0	-0.5	0.15	17
Reader.20	0.00	-0.07	-0.24	-0.52	0.25	0.33	-2.0	0.0	-0.21	3
all	0.10	0.20	0.10	-0.10	0.00	0.00	-0.5	-0.9	0.00	

Table A12 – Relative bias by reader and age group for area B

Tabela A12 – Viés por leitor e grupo de idade para a área B

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.01	0.08	0.35	0.05	0.00	-0.5	0.0	-1.0		0.10	14
Reader.02	0.17	0.37	0.20	0.17	-0.5	-1.0	0.0		0.20	16
Reader.03	0.17	0.47	0.20	0.33	-0.5	0.0	0.0		0.27	18
Reader.04	0.17	-0.05	-0.37	-0.40	-1.5	-1.0	-1.0		-0.23	7
Reader.05	0.08	-0.30	-0.82	-0.57	0.0	0.0	0.0		-0.39	3
Reader.06	0.17	0.20	-0.35	-1.00		0.0	0.0		-0.17	8
Reader.07	0.08	0.35	0.25	0.25	0.5	-1.0	0.0		0.23	17
Reader.08	0.00	0.35	0.00	-0.50	-0.5	0.0	-1.0		-0.01	12
Reader.09	0.00	-0.25	-0.70	-1.17	-1.5	0.0	0.0		-0.53	2
Reader.10	0.00	0.00	-0.50	-0.73	0.0	-2.0			-0.31	4
Reader.11	1.10	1.62	0.61	0.42	0.5	0.0	0.0		0.90	20
Reader.12	0.00	-0.38	-0.94	-1.42	-2.0	-1.0	-1.0		-0.77	1
Reader.13	0.10	0.53	-0.06	0.08	-1.0	-2.0	0.0		0.10	14
Reader.14	0.20	0.27	-0.17	-0.17	-0.5	-2.0	0.0		-0.03	9
Reader.15	0.10	0.54	-0.06	-0.22	-1.5	-1.0	-1.0		0.00	13
Reader.16	0.10	0.12	0.00	-0.08	-0.5	-1.0	-1.0		-0.02	10

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.17	0.00	0.14	0.00	0.00	-1.0	-1.0	-1.0		-0.02	10
Reader.18	0.00	-0.06	-0.33	-0.50	-1.0	-2.0	-1.0		-0.30	5
Reader.19	0.40	1.12	0.39	0.42	0.0	0.0	0.0		0.57	19
Reader.20	0.20	-0.13	-0.40	-0.44	-1.0	-2.0	0.0		-0.25	6
all	0.20	0.20	-0.10	-0.30	-0.7	-0.8	-0.4		0.00	

Table A13 – Relative bias by reader and age group for all areas

Tabela A13 – Viés por leitor e grupo de idade para todas as áreas

	0	1	2	3	4	5	6	7	w.mean	ranking
Reader.01	0.05	0.26	0.11	0.03	-0.20	-0.25	-1.0	-1.0	0.06	14
Reader.02	0.11	0.32	0.17	0.00	0.10	0.00	0.0	0.0	0.14	17
Reader.03	0.11	0.26	0.11	0.05	0.00	0.25	0.0	-0.5	0.12	15
Reader.04	0.11	0.03	-0.25	-0.31	-0.78	-0.25	-1.0	0.0	-0.19	6
Reader.05	0.05	-0.18	-0.56	-0.34	-0.11	0.25	0.0	-1.5	-0.28	3
Reader.06	0.11	0.23	-0.11	-0.28	0.29	0.50	0.0	0.0	0.00	12
Reader.07	0.05	0.20	0.16	0.05	0.30	0.00	0.0	0.0	0.13	16
Reader.08	0.05	0.40	0.03	-0.38	-0.30	-0.25	-1.0	-2.5	-0.06	8
Reader.09	0.00	-0.17	-0.37	-0.54	-0.10	0.25	0.0	0.0	-0.27	4
Reader.10	0.00	-0.04	-0.52	-0.86	-0.33	-1.00	-2.0	-1.0	-0.43	2
Reader.11	1.18	1.40	0.67	0.68	0.50	-0.25	0.0	-1.0	0.82	20
Reader.12	0.00	-0.29	-0.61	-0.73	-0.50	-0.25	-0.5	-1.5	-0.49	1
Reader.13	0.06	0.37	0.00	-0.11	-0.50	-0.50	-0.5	-1.0	-0.01	10
Reader.14	0.23	0.54	-0.03	0.16	0.40	0.00	0.0	0.0	0.21	18
Reader.15	0.06	0.35	-0.03	-0.13	-0.50	-0.75	-1.0		-0.03	9
Reader.16	0.06	0.23	0.06	0.00	-0.20	-0.25	-1.0	-2.5	0.00	12
Reader.17	0.00	0.12	0.11	0.03	-0.22	-0.25	-0.5	-1.0	0.02	13
Reader.18	0.00	0.26	-0.08	-0.16	-0.60	-0.50	-1.0	-2.0	-0.11	7
Reader.19	0.24	0.74	0.36	0.19	0.00	0.00	0.0	-0.5	0.33	19
Reader.20	0.12	-0.10	-0.31	-0.50	0.11	-0.25	-1.0	0.0	-0.23	5
all	0.10	0.20	0.00	-0.10	-0.10	-0.20	-0.5	-0.9	0.00	

Table A14 - Age Composition by reader and age group for A area

Tabela A14 – Composição das idades por leitor e grupo de idade para a área A

	0	1	2	3	4	5	6	7	Total
Reader.01	8	11	19	26	10	3	2		79
Reader.02	7	11	20	22	5	3	3	2	73
Reader.03	7	16	19	20	9	3	3	1	78
Reader.04	8	12	25	18	4	4		1	72
Reader.05	8	17	18	22	4	4	2	1	76
Reader.06	7	9	15	21	8	3	3	1	67
Reader.07	7	16	19	20	9	4	2	2	79
Reader.08	7	13	26	20	6	6	1		79
Reader.09	12	14	15	21	9	4	2	2	79

	0	1	2	3	4	5	6	7	Total
Reader.10	8	14	24	2	4	2	1		55
Reader.11	3	4	17	22	17	11	4		78
Reader.12	11	17	20	19	5	5	2		79
Reader.13	8	10	25	22	4	5		1	75
Reader.14	2	9	17	22	9	7	4	2	72
Reader.15	7	11	21	19	4	1			63
Reader.16	7	11	19	26	10	5			78
Reader.17	7	11	15	27	9	3	2		74
Reader.18	7	9	24	24	8	7			79
Reader.19	8	9	17	29	9	4	2	1	79
Reader.20	8	21	19	16	6	2		4	76

Table A15 - Age Composition by reader and age group for B area

Tabela A15 – Composição das idades por leitor e grupo de idade para a área B

	0	1	2	3	4	5	6	Total
Reader.01	11	17	21	15	2	2		68
Reader.02	10	15	21	16	4		1	67
Reader.03	10	14	21	16	3	2	1	67
Reader.04	12	27	17	6	2	1		65
Reader.05	20	25	7	3	2	1	1	59
Reader.06	10	30	17	5		1	1	64
Reader.07	11	15	20	15	5	1	1	68
Reader.08	13	13	30	9	1	2		68
Reader.09	31	15	10	8	1	2	1	68
Reader.10	13	22	18	4	1			58
Reader.11	5	5	17	18	9	4	2	60
Reader.12	18	31	6	3	1	1		60
Reader.13	9	11	22	13	2		1	58
Reader.14	10	19	13	12	3	1	1	59
Reader.15	10	7	25	9	1	1		53
Reader.16	9	16	19	13	2	1		60
Reader.17	9	13	18	13	1	1		55
Reader.18	11	21	19	7	1	1		60
Reader.19	9	3	20	17	9	1	1	60
Reader.20	11	19	14	7			1	52

Table A16 - Age Composition by reader and age group for A and B areas

Tabela A16 – Composição das idades por leitor e grupo de idade para a área A e área B

	0	1	2	3	4	5	6	7	Total
Reader.01	19	28	40	41	12	5	2		147
Reader.02	17	26	41	38	9	3	4	2	140
Reader.03	17	30	40	36	12	5	4	1	145
Reader.04	20	39	42	24	6	5		1	137
Reader.05	28	42	25	25	6	5	3	1	135
Reader.06	17	39	32	26	8	4	4	1	131

	0	1	2	3	4	5	6	7	Total
Reader.07	18	31	39	35	14	5	3	2	147
Reader.08	20	26	56	29	7	8	1		147
Reader.09	43	29	25	29	10	6	3	2	147
Reader.10	21	36	42	6	6	2	1		114
Reader.11	8	9	34	40	26	15	6		138
Reader.12	29	48	26	22	6	6	2		139
Reader.13	17	21	47	35	6	5	1	1	133
Reader.14	12	28	30	34	12	8	5	2	131
Reader.15	17	18	46	28	7	4			120
Reader.16	16	27	38	39	12	6			138
Reader.17	16	24	33	40	10	4	2		129
Reader.18	18	30	43	31	9	8			139
Reader.19	17	12	37	46	18	5	3	1	139
Reader.20	19	40	33	23	6	2	1	4	128

Table A17 – 2x Standard Deviation for A area

Tabela A17 – 2x Desvio Padrão por leitor e grupo de idade para a área A

	0	1	2	3	4	5	6	7
Reader.01	0.0000	1.030	0.770	0.700	0.710	1.15		0.000
Reader.02	0.0000	0.920	0.680	0.600	1.770	1.15		0.000
Reader.03	0.0000	0.000	0.710	0.990	0.710	1.15		1.410
Reader.04	0.0000	1.070	0.660	1.100	1.070	0.00		
Reader.05	0.0000	0.820	0.940	1.080	1.670	1.15		4.240
Reader.06	0.0000	0.930	1.120	0.970	0.980	1.15		
Reader.07	0.0000	0.000	0.830	1.080	0.930	1.15		0.000
Reader.08	0.7600	2.370	0.830	1.600	1.410	1.15		4.240
Reader.09	0.0000	0.920	1.370	2.020	0.930	1.15		0.000
Reader.10	0.0000	1.140	1.040	0.490	2.000	2.31		
Reader.11	2.5100	2.200	1.340	1.730	1.510	1.15		0.000
Reader.12	0.0000	0.830	1.150	1.290	1.280	0.00		1.410
Reader.13	0.0000	1.120	0.490	0.840	1.070	0.00		2.830
Reader.14	1.1500	2.930	0.660	1.110	1.040	1.15		0.000
Reader.15	0.0000	0.750	0.000	0.870	1.000			
Reader.16	0.0000	1.230	0.660	0.700	0.710	0.00		1.410
Reader.17	0.0000	0.580	0.870	0.700	0.710	0.00		
Reader.18	0.0000	1.660	1.240	1.290	1.070	0.00		0.000
Reader.19	0.0000	1.450	0.970	0.800	1.070	0.00		1.410
Reader.20	0.0000	0.520	0.870	1.460	2.560	3.06		0.000
All Readers	0.8123	1.434	1.025	1.304	1.365	1.32		2.133

Table A18 – 2x Standard Deviation for B area

Tabela A18 – 2x Desvio Padrão por leitor e grupo de idade para a área B

	0	1	2	3	4	5	6	7
Reader.01	0.580	1.340	0.79	0.850	1.410			
Reader.02	0.780	1.190	0.82	0.780	1.410			
Reader.03	0.780	1.390	0.82	1.300	1.410			
Reader.04	0.780	0.790	0.99	1.030	4.240			
Reader.05	0.580	1.140	1.27	2.270				
Reader.06	0.780	0.820	1.49	1.330				
Reader.07	0.580	1.170	0.89	0.900	1.410			
Reader.08	0.000	1.170	0.92	1.040	1.410			
Reader.09	0.000	1.100	2.16	3.280	7.070			
Reader.10	0.000	0.970	1.03	0.930				
Reader.11	3.330	2.520	1.40	1.590	1.410			
Reader.12	0.000	1.000	1.08	1.590	2.830			
Reader.13	0.630	1.490	0.47	1.030				
Reader.14	0.840	1.770	1.57	1.870	4.240			
Reader.15	0.630	1.550	0.49	0.880	1.410			
Reader.16	0.630	0.680	0.69	0.580	1.410			
Reader.17	0.000	0.730	0.69	0.000				
Reader.18	0.000	0.500	0.97	1.040	2.830			
Reader.19	1.930	2.050	1.00	1.030	0.000			
Reader.20	0.840	0.700	1.26	1.050				
All Readers	1.052	1.538	1.34	1.681	2.381			

Table A19 – 2x Standard Deviation for all area

Tabela A19 – 2x Desvio Padrão por leitor e grupo de idade para a todas as áreas

	0	1	2	3	4	5	6	7
Reader.01	0.4600	1.220	0.780	0.740	0.840	1.000	0.000	0.000
Reader.02	0.6300	1.070	0.760	0.710	1.750	1.630	0.000	0.000
Reader.03	0.6300	1.130	0.790	1.150	0.940	1.000	0.000	1.410
Reader.04	0.6300	0.920	0.880	1.070	1.940	1.000	0.000	
Reader.05	0.4600	1.060	1.230	1.400	1.560	1.000	0.000	4.240
Reader.06	0.6300	0.850	1.440	1.460	0.980	1.150	0.000	
Reader.07	0.4600	0.950	0.870	1.050	0.970	1.630	0.000	0.000
Reader.08	0.4600	1.760	0.870	1.440	1.350	1.000	0.000	4.240
Reader.09	0.0000	1.030	1.940	2.610	2.900	1.000	0.000	0.000
Reader.10	0.0000	1.020	1.020	0.710	1.630	2.310		
Reader.11	2.9400	2.380	1.350	1.700	1.410	1.000	0.000	0.000
Reader.12	0.0000	0.920	1.290	1.680	2.160	1.000	1.410	1.410
Reader.13	0.4900	1.340	0.490	0.940	1.070	2.000	1.410	2.830
Reader.14	0.8800	2.400	1.240	1.450	1.930	2.830	0.000	0.000
Reader.15	0.4900	1.260	0.350	0.870	1.510	1.910	0.000	
Reader.16	0.4900	0.990	0.680	0.670	0.840	1.000	0.000	1.410
Reader.17	0.0000	0.650	0.810	0.580	0.880	1.000	1.410	

	0	1	2	3	4	5	6	7
Reader.18	0.0000	1.360	1.210	1.290	1.400	2.000	0.000	0.000
Reader.19	1.5000	1.930	0.970	0.920	0.940	0.000	0.000	1.410
Reader.20	0.6600	0.610	1.070	1.340	2.540	3.420	2.830	0.000
All	0.9683	1.492	1.214	1.443	1.656	1.584	1.203	2.133

Table A20 – Mean Age by reader for A area

Tabela A20 – Idade média por leitor para área A

	0	1	2	3	4	5	6	7
Reader.01	0.00	1.13	2.17	3.04	3.88	4.67	5.0	6.0
Reader.02	0.00	1.27	2.12	2.90	4.25	5.33	6.0	7.0
Reader.03	0.00	1.00	2.00	2.92	4.12	5.33	6.0	6.5
Reader.04	0.00	1.14	1.88	2.73	3.43	5.00	5.0	7.0
Reader.05	0.00	1.00	1.71	2.72	3.88	5.33	6.0	5.5
Reader.06	0.00	1.27	2.20	3.05	4.29	5.67	6.0	7.0
Reader.07	0.00	1.00	2.06	2.96	4.25	5.33	6.0	7.0
Reader.08	0.14	1.47	2.06	2.68	3.75	4.67	5.0	4.5
Reader.09	0.00	0.93	2.00	2.76	4.25	5.33	6.0	7.0
Reader.10	0.00	0.90	1.46	2.06	3.50	4.33	4.0	6.0
Reader.11	1.29	2.14	2.72	3.80	4.50	4.67	6.0	6.0
Reader.12	0.00	0.80	1.72	2.60	3.88	5.00	6.0	5.5
Reader.13	0.00	1.20	2.06	2.78	3.57	5.00	5.0	6.0
Reader.14	0.33	1.85	2.12	3.32	4.62	5.67	6.0	7.0
Reader.15	0.00	1.15	2.00	2.90	3.75	3.00	5.0	
Reader.16	0.00	1.33	2.12	3.04	3.88	5.00	5.0	4.5
Reader.17	0.00	1.08	2.24	3.04	3.88	5.00	6.0	6.0
Reader.18	0.00	1.60	2.17	3.00	3.50	5.00	5.0	5.0
Reader.19	0.00	1.33	2.33	3.08	4.00	5.00	6.0	6.5
Reader.20	0.00	0.93	1.76	2.48	4.25	5.33	4.0	7.0
All Readers	0.10	1.20	2.10	2.90	4.00	5.10	5.5	6.1

Table A21 – Mean Age by reader for B area

Tabela A21 – Idade média por leitor para área B

	0	1	2	3	4	5	6
Reader.01	0.08	1.35	2.05	3.00	3.5	5.0	5.0
Reader.02	0.17	1.37	2.20	3.17	3.5	4.0	6.0
Reader.03	0.17	1.47	2.20	3.33	3.5	5.0	6.0
Reader.04	0.17	0.95	1.63	2.60	2.5	4.0	5.0
Reader.05	0.08	0.70	1.18	2.43	4.0	5.0	6.0
Reader.06	0.17	1.20	1.65	2.00		5.0	6.0
Reader.07	0.08	1.35	2.25	3.25	4.5	4.0	6.0
Reader.08	0.00	1.35	2.00	2.50	3.5	5.0	5.0
Reader.09	0.00	0.75	1.30	1.83	2.5	5.0	6.0
Reader.10	0.00	1.00	1.50	2.27	4.0	3.0	
Reader.11	1.10	2.62	2.61	3.42	4.5	5.0	6.0
Reader.12	0.00	0.62	1.06	1.58	2.0	4.0	5.0

Reader.13	0.10	1.53	1.94	3.08	3.0	3.0	6.0
Reader.14	0.20	1.27	1.83	2.83	3.5	3.0	6.0
Reader.15	0.10	1.54	1.94	2.78	2.5	4.0	5.0
Reader.16	0.10	1.12	2.00	2.92	3.5	4.0	5.0
Reader.17	0.00	1.14	2.00	3.00	3.0	4.0	5.0
Reader.18	0.00	0.94	1.67	2.50	3.0	3.0	5.0
Reader.19	0.40	2.12	2.39	3.42	4.0	5.0	6.0
Reader.20	0.20	0.87	1.60	2.56	3.0	3.0	6.0
All Readers	0.20	1.20	1.90	2.70	3.3	4.2	5.6

Table A22 – Mean Age by reader for all area

Tabela A22 – Idade média por leitor para todas as áreas

	0	1	2	3	4	5	6	7
Reader.01	0.05	1.26	2.11	3.03	3.80	4.75	5.0	6.0
Reader.02	0.11	1.32	2.17	3.00	4.10	5.00	6.0	7.0
Reader.03	0.11	1.26	2.11	3.05	4.00	5.25	6.0	6.5
Reader.04	0.11	1.03	1.75	2.69	3.22	4.75	5.0	7.0
Reader.05	0.05	0.82	1.44	2.66	3.89	5.25	6.0	5.5
Reader.06	0.11	1.23	1.89	2.72	4.29	5.50	6.0	7.0
Reader.07	0.05	1.20	2.16	3.05	4.30	5.00	6.0	7.0
Reader.08	0.05	1.40	2.03	2.62	3.70	4.75	5.0	4.5
Reader.09	0.00	0.83	1.63	2.46	3.90	5.25	6.0	7.0
Reader.10	0.00	0.96	1.48	2.14	3.67	4.00	4.0	6.0
Reader.11	1.18	2.40	2.67	3.68	4.50	4.75	6.0	6.0
Reader.12	0.00	0.71	1.39	2.27	3.50	4.75	5.5	5.5
Reader.13	0.06	1.37	2.00	2.89	3.50	4.50	5.5	6.0
Reader.14	0.23	1.54	1.97	3.16	4.40	5.00	6.0	7.0
Reader.15	0.06	1.35	1.97	2.87	3.50	4.25	5.0	
Reader.16	0.06	1.23	2.06	3.00	3.80	4.75	5.0	4.5
Reader.17	0.00	1.12	2.11	3.03	3.78	4.75	5.5	6.0
Reader.18	0.00	1.26	1.92	2.84	3.40	4.50	5.0	5.0
Reader.19	0.24	1.74	2.36	3.19	4.00	5.00	6.0	6.5
Reader.20	0.12	0.90	1.69	2.50	4.11	4.75	5.0	7.0
All	0.10	1.20	2.00	2.90	3.90	4.80	5.5	6.1

Table A23 – Mean Length at Age by reader for A area

Tabela A23 – Comprimento médio à idade por leitores para a área A

	0	1	2	3	4	5	6	7
Reader.01	0.00	1.13	2.17	3.04	3.88	4.67	5.0	6.0
Reader.02	0.00	1.27	2.12	2.90	4.25	5.33	6.0	7.0
Reader.03	0.00	1.00	2.00	2.92	4.12	5.33	6.0	6.5
Reader.04	0.00	1.14	1.88	2.73	3.43	5.00	5.0	7.0
Reader.05	0.00	1.00	1.71	2.72	3.88	5.33	6.0	5.5
Reader.06	0.00	1.27	2.20	3.05	4.29	5.67	6.0	7.0
Reader.07	0.00	1.00	2.06	2.96	4.25	5.33	6.0	7.0
Reader.08	0.14	1.47	2.06	2.68	3.75	4.67	5.0	4.5

Reader.09	0.00	0.93	2.00	2.76	4.25	5.33	6.0	7.0
Reader.10	0.00	0.90	1.46	2.06	3.50	4.33	4.0	6.0
Reader.11	1.29	2.14	2.72	3.80	4.50	4.67	6.0	6.0
Reader.12	0.00	0.80	1.72	2.60	3.88	5.00	6.0	5.5
Reader.13	0.00	1.20	2.06	2.78	3.57	5.00	5.0	6.0
Reader.14	0.33	1.85	2.12	3.32	4.62	5.67	6.0	7.0
Reader.15	0.00	1.15	2.00	2.90	3.75	3.00	5.0	
Reader.16	0.00	1.33	2.12	3.04	3.88	5.00	5.0	4.5
Reader.17	0.00	1.08	2.24	3.04	3.88	5.00	6.0	6.0
Reader.18	0.00	1.60	2.17	3.00	3.50	5.00	5.0	5.0
Reader.19	0.00	1.33	2.33	3.08	4.00	5.00	6.0	6.5
Reader.20	0.00	0.93	1.76	2.48	4.25	5.33	4.0	7.0
Modal Age	0.10	1.20	2.10	2.90	4.00	5.10	5.5	6.1

Table A24 – Mean Length at Age by reader for B area

Tabela A24 – Comprimento médio à idade por leitores para a área B

	0	1	2	3	4	5	6
Reader.01	118.2	149.9	158.4	168.7	205.5	217.5	
Reader.02	115.8	154.4	158.8	168.1	173.8		215
Reader.03	115.8	152	155.9	168.1	158.3	215.5	215
Reader.04	122.5	149.4	172.8	170.3	192.5	215	
Reader.05	128.8	154.9	183.3	199.3	201	220	215
Reader.06	119.6	146.3	167.4	190.2		220	215
Reader.07	118.2	157.1	152.7	168.1	188.2	165	215
Reader.08	118.8	155.1	155.4	188.3	200	217.5	
Reader.09	134.8	159.1	168	182.4	211	210	215
Reader.10	123.1	154.8	166.2	191.8	165		
Reader.11	107.4	130	140.6	159.7	179.7	193.2	192.5
Reader.12	125.8	155	186.2	202	220	215	
Reader.13	114.4	150	156.7	167.9	183		215
Reader.14	117	143.5	155.7	179	191	200	215
Reader.15	113.3	142.1	159.4	187	220	215	
Reader.16	112	143.3	160.1	175.8	192.5	215	
Reader.17	112	142	160.3	175.8	220	215	
Reader.18	116.4	148.6	165.8	180.1	200	215	
Reader.19	113.1	143.3	154.6	163.6	163.4	220	215
Reader.20	124.2	150.7	162.6	178.7			215
modal.age	118.3	153.3	160.8	170.8	182.5	220	215

Table A25 – Mean Length at Age by reader for all area

Tabela A25 – Comprimento médio à idade por leitores para a todas as áreas

	0	1	2	3	4	5	6	7
Reader.01	123.8	157.2	173.7	190	208.4	225.4	213.5	
Reader.02	119.5	165.5	171.5	187.9	191.6	222.7	221.8	213.5
Reader.03	119.5	163.6	173.9	186.3	197.8	219.8	217	230
Reader.04	124.9	159.5	182.5	192.8	214.3	224.6		230

Reader.05	128.7	163.4	192.7	201.7	213	221.8	222	197
Reader.06	121.7	151.8	175.9	197.3	204.1	217	226.8	197
Reader.07	120.7	165.7	172.4	186.4	202.8	209.8	223.7	213.5
Reader.08	124.1	161.6	171.6	200.1	211	222	197	
Reader.09	140.4	163.4	183.5	195	212.2	217.3	223.7	213.5
Reader.10	128.9	164.8	184.8	195.5	207.5	228.5	197	
Reader.11	118.8	148.1	155.3	178.6	190.5	208.7	208.8	
Reader.12	130.3	163.8	195.3	203.2	210.8	216.8	232.5	
Reader.13	122.5	164	174.4	189.7	200	227.6	215	197
Reader.14	120	152.9	175.1	192.4	201.2	205.5	210.6	213.5
Reader.15	118	160.7	173	196.3	207	226.8		
Reader.16	117.6	153.6	174.4	193.4	206.8	225.5		
Reader.17	117.6	154.1	172.6	192	215.9	222	232.5	
Reader.18	119.6	157	178.5	196.5	205.7	217.8		
Reader.19	121.2	168.3	172.4	183.1	186.3	221.8	215.7	230
Reader.20	127.3	165.2	184.7	193.1	217.3	226	215	216
modal.age	120.7	162.6	175.3	191.2	205.8	223.2	225	213.5

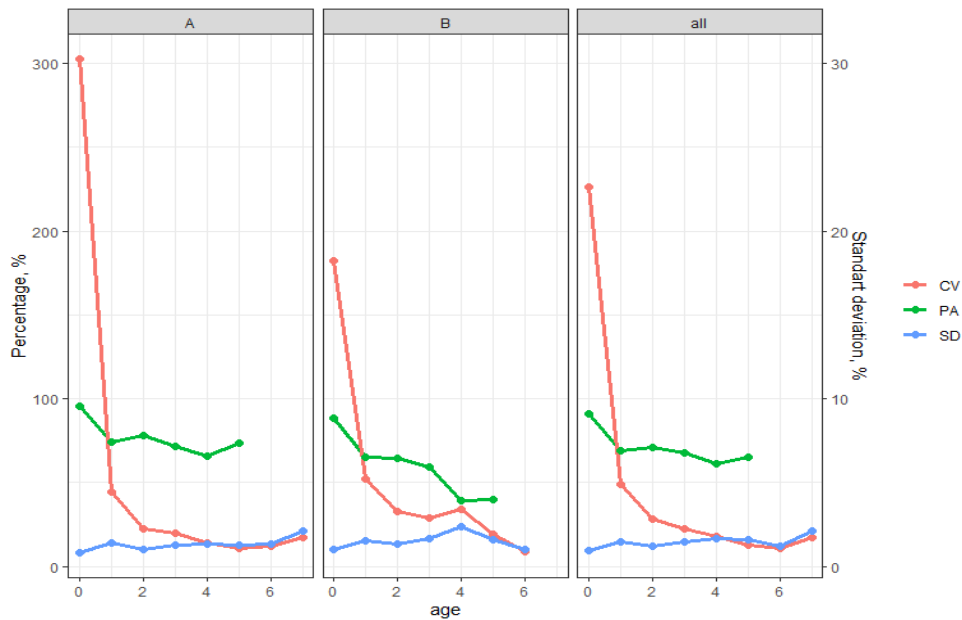


Figure A1 - Coefficient of Variation (CV), Percentage of Agreement (PA) and Standard Deviation (SD) plotted against Modal Age for area A, B and both areas combined (all).

Figura A1 – Coeficiente de Variação (CV), Percentagem de concordância (PA) e desvio padrão (SD) por idade modal para as áreas A, B e a sua combinação (all).

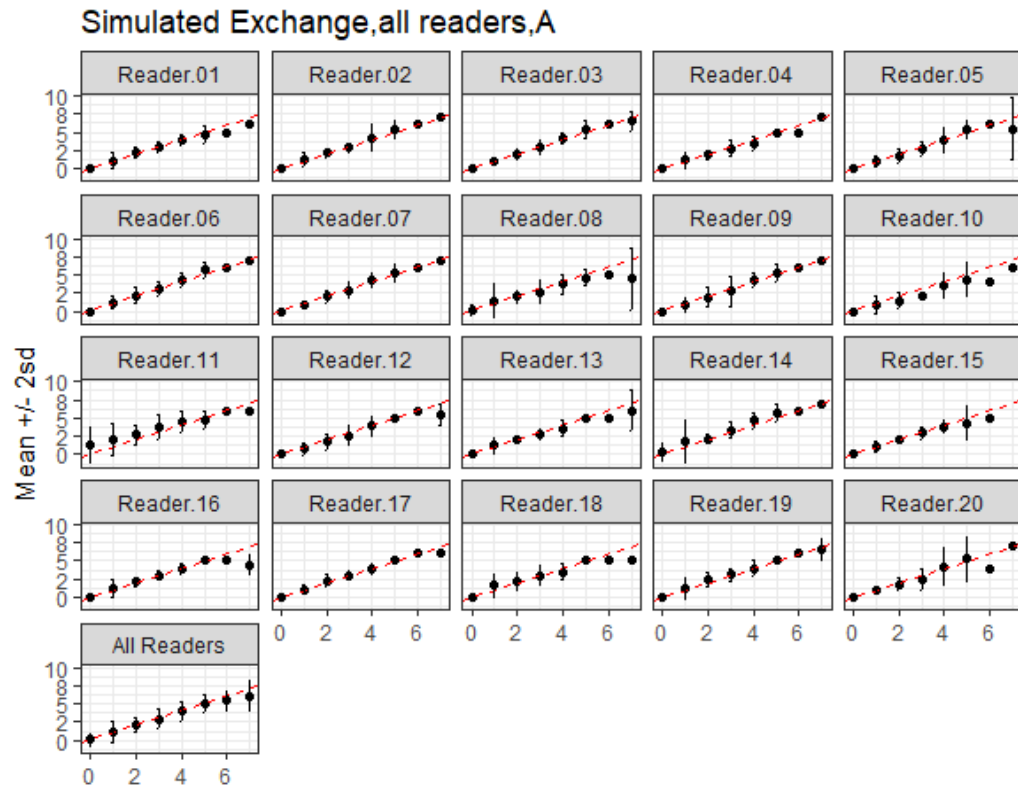


Figure A2 – Age Bias Plot of individual age readers against modal age for the A area.

Figura A2 – Viés da idade entre cada leitor e a idade modal para a área A.

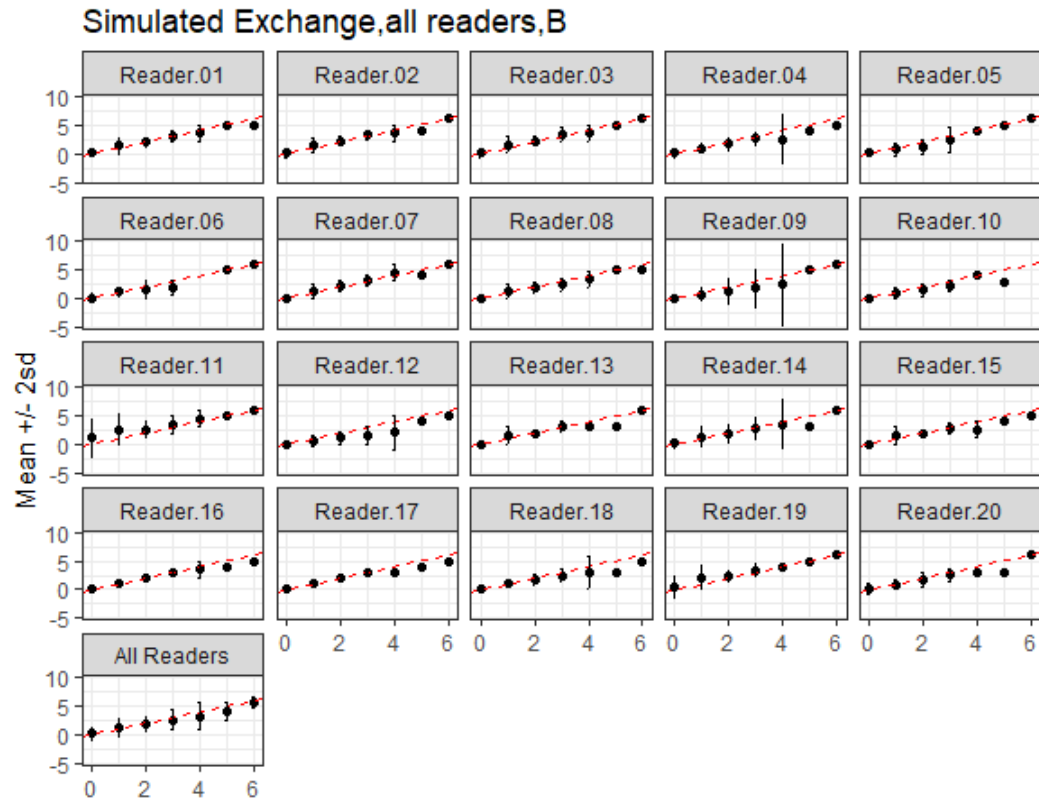


Figure A3 – Age Bias Plot of individual age readers against modal age for the B area.

Figura A3 – Viés da idade entre cada leitor e a idade modal para a área B.

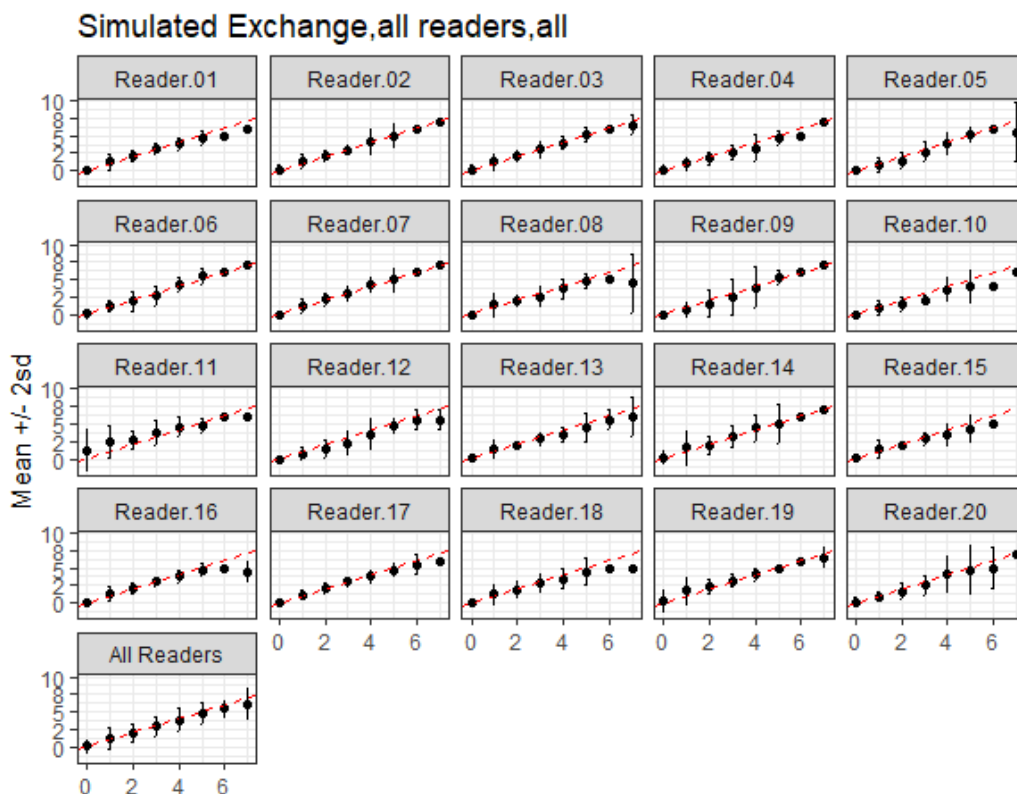


Figure A4 – Age Bias Plot of individual age readers against modal age for the A and B combined areas.

Figura A4 – Viés da idade entre cada leitor e a idade modal para as áreas A e B .

Table 2.26 - Inter-reader bias test and reader against modal age bias test for A Area. (-: no sign of bias ($p>0.05$); *: possibility of bias ($0.01<p<0.05$); **: certainty of bias ($p<0.01$)) (bellow diagonal). Age reading's percentage agreement between each two readers (above diagonal)). R.01: Reader.01; R.02: Reader.02 and so on.

Tabela 2.26 – Teste de viés entre leitores e teste de leitores versus idade modal para a área A. (-: sem viés ($p>0.05$); *: possibilidade de viés ($0.01<p<0.05$); **: certeza de viés($p<0.01$)) (diagonal inferior). Percentagem de concordância entre pares de leitores (diagonal superior). R.01: Reader.01; R.02: Reader.02 e assim por diante.

	R.01	R.02	R.03	R.04	R.05	R.06	R.07	R.08	R.09	R.10	R.11	R.12	R.13	R.14	R.15	R.16	R.17	R.18	R.19	R.20	moda l.age
R.01		67	71	56	59	56	70	66	71	34	53	68	70	51	65	76	75	71	72	58	81
R.02	-		72	57	61	57	77	54	72	29	43	67	70	57	61	67	68	63	75	59	77
R.03	-	-		56	70	66	84	61	76	32	43	75	70	59	68	75	72	57	71	67	85
R.04	-	-	-		57	42	61	58	54	34	28	63	65	47	61	58	54	67	57	56	67
R.05	-	-	-	-		54	68	61	66	33	29	72	63	49	58	62	62	57	57	67	71
R.06	-	-	-	-	-		65	43	65	22	35	54	49	49	51	54	54	42	54	47	63
R.07	-	-	-	-	-	-		57	84	28	42	68	66	61	65	68	71	56	76	70	84
R.08	-	-	-	-	-	-	-		57	37	38	59	66	43	63	66	59	65	49	62	63
R.09	-	-	-	-	-	-	-	-		27	42	63	61	54	59	65	68	54	75	62	77
R.10	**	**	*	-	-	**	*	*	*		16	33	37	19	30	32	30	34	33	35	33

	R.01	R.02	R.03	R.04	R.05	R.06	R.07	R.08	R.09	R.10	R.11	R.12	R.13	R.14	R.15	R.16	R.17	R.18	R.19	R.20	moda Lage
R.11	**	**	**	**	**	**	**	**	**	**		35	35	33	37	43	44	37	46	27	43
R.12	-	-	-	-	-	-	-	-	-	-	**		71	51	66	67	67	66	62	71	75
R.13	-	-	-	-	-	-	-	-	-	*	**	-		52	72	68	62	72	66	65	75
R.14	-	*	*	**	**	-	*	**	*	**	-	**	**		52	59	56	51	56	47	63
R.15	-	-	-	-	-	-	-	-	-	*	**	-	-	**		67	62	62	62	62	73
R.16	-	-	-	-	-	-	-	-	-	**	**	-	-	-	-		86	68	68	62	82
R.17	-	-	-	-	-	-	-	-	-	**	**	-	-	-	-	-		61	72	61	81
R.18	-	-	-	-	-	-	-	-	-	**	**	-	-	-	-	-	-		62	54	68
R.19	-	-	-	-	-	-	-	-	-	**	**	*	-	-	-	-	-	-		56	76
R.20	-	-	-	-	-	-	-	-	-	-	**	-	-	**	-	-	-	-	*		70
moda Lage	-	-	-	-	-	-	-	-	-	*	**	-	-	*	-	-	-	-	-	-	

Table 2.27 - Inter-reader bias test and reader against modal age bias test for B Area. (-: no sign of bias ($p>0.05$); *: possibility of bias ($0.01<p<0.05$); **: certainty of bias ($p<0.01$)) (below diagonal). Age reading's percentage agreement between each two readers (above diagonal). R.01: Reader.01; R.02: Reader.02 and so on.

Tabela 2.27 – Teste de viés entre leitores e teste de leitores *versus* idade modal para a área B. (- : sem viés ($p>0.05$); *: possibilidade de viés ($0.01<p<0.05$); **: certeza de viés($p<0.01$)) (diagonal inferior). Percentagem de concordância entre pares de leitores (diagonal superior). R.01: Reader.01; R.02: Reader.02 e assim por diante.

	R.01	R.02	R.03	R.04	R.05	R.06	R.07	R.08	R.09	R.10	R.11	R.12	R.13	R.14	R.15	R.16	R.17	R.18	R.19	R.20	modal .age
R.01		71	71	60	35	41	72	71	54	46	37	28	68	47	53	63	60	57	51	46	81
R.02	-		87	59	35	40	81	57	54	46	41	29	65	44	54	63	59	44	56	38	75
R.03	-	-		56	32	38	84	54	59	40	46	24	62	43	53	63	59	41	54	37	74
R.04	*	*	**		50	57	54	47	56	56	21	46	49	51	43	60	57	53	35	41	68
R.05	**	**	**	*		56	35	40	47	40	12	56	29	32	25	32	31	41	24	43	50
R.06	*	**	**	-	*		43	47	43	49	15	49	40	47	32	44	40	53	25	47	54
R.07	-	-	-	*	**	**		60	57	43	40	26	65	49	50	57	56	46	54	40	75
R.08	-	-	-	-	**	-	-		47	51	29	35	56	46	57	56	54	59	43	43	69
R.09	**	**	**	*	-	*	**	**		37	28	37	44	43	41	50	49	43	38	40	62
R.10	*	**	**	-	-	-	**	*	-		22	41	37	35	29	40	37	51	26	38	54
R.11	**	**	**	**	**	**	**	**	**	**		9	34	28	29	32	31	24	40	18	37
R.12	**	**	**	*	-	*	**	**	-	-	**		28	37	29	37	35	44	16	46	37
R.13	-	-	-	*	**	**	-	-	**	**	**	**		49	51	60	59	54	51	49	66
R.14	-	-	-	-	**	-	-	-	**	-	**	**	-		38	43	41	49	38	37	44
R.15	-	-	-	*	**	*	-	-	**	*	**	**	-	-		57	56	50	38	34	54
R.16	-	-	-	-	**	*	-	-	**	*	**	**	-	-	-		81	59	43	46	75
R.17	-	-	-	-	**	*	-	-	**	*	**	**	-	-	-	-		56	40	43	71
R.18	-	*	*	-	*	-	*	-	*	-	**	**	-	-	-	-	-		32	49	65
R.19	*	*	-	**	**	**	*	**	**	**	-	**	*	**	**	**	*	**		22	47
R.20	-	*	*	-	-	-	*	-	-	-	**	*	*	-	-	-	-	-	**		54
mod	-	-	-	-	**	-	-	-	**	-	**	**	-	-	-	-	-	-	**	-	

Table 2.28 - Inter-reader bias test and reader against modal age bias test for all Areas. (-: no sign of bias ($p>0.05$); *: possibility of bias ($0.01<p<0.05$); **: certainty of bias ($p<0.01$)) (bellow diagonal). Age reading's percentage agreement between each two readers (above diagonal). R.01: Reader.01; R.02: Reader.02 and so on.

Tabela 2.28 – Teste de viés entre leitores e teste de leitores *versus* idade modal para todas as áreas. (-: sem viés ($p>0.05$); *: possibilidade de viés ($0.01<p<0.05$); **: certeza de viés($p<0.01$)) (diagonal inferior). Percentagem de concordância entre pares de leitores (diagonal superior). R.01: Reader.01; R.02: Reader.02 e assim por diante.

	R.01	R.02	R.03	R.04	R.05	R.06	R.07	R.08	R.09	R.10	R.11	R.12	R.13	R.14	R.15	R.16	R.17	R.18	R.19	R.20	modal.age
R.01		69	71	58	48	49	71	68	63	39	46	50	69	49	59	70	68	65	63	52	81
R.02	-		79	58	49	49	79	56	64	37	42	50	67	51	58	65	64	54	66	50	76
R.03	-	-		56	52	53	84	58	68	35	44	51	66	52	61	69	66	50	63	53	80
R.04	*	*	*		54	49	58	53	55	44	24	55	57	49	52	59	56	61	47	49	67
R.05	**	**	**	-		55	53	51	57	36	21	65	48	41	43	48	48	50	41	56	61
R.06	-	-	-	-	-		54	45	54	34	26	52	45	48	42	50	48	47	41	47	59
R.07	-	-	-	*	**	-		59	71	35	41	49	65	55	58	63	64	51	66	56	80
R.08	-	-	-	-	*	-	-		52	44	34	48	61	44	61	61	57	62	46	53	66
R.09	*	*	*	-	-	-	*	-		31	35	51	53	49	51	58	59	49	58	52	70
R.10	**	**	**	-	-	*	**	**	-		19	37	37	27	30	35	33	42	30	37	43
R.11	**	**	**	**	**	**	**	**	**	**		23	35	31	33	38	38	31	43	22	40
R.12	**	**	**	-	-	*	**	**	-	-	**		51	44	49	53	52	56	41	59	57
R.13	-	-	-	*	*	-	-	-	*	**	**	**		50	63	65	61	64	59	57	71
R.14	-	-	-	**	**	*	-	*	**	**	**	**	-		46	52	49	50	48	42	54
R.15	-	-	-	-	*	-	-	-	-	**	**	**	-	-		63	59	56	51	49	65
R.16	-	-	-	*	**	-	-	-	*	**	**	**	-	-	-		84	64	56	54	79
R.17	-	-	-	*	**	-	-	-	*	**	**	**	-	-	-	-		59	57	52	76
R.18	-	-	-	-	*	-	-	-	-	**	**	**	-	-	-	-	-		48	52	67
R.19	*	*	*	**	**	**	*	**	**	**	**	**	*	-	**	*	-	**		40	63
R.20	*	*	*	-	-	-	*	-	-	-	**	-	*	**	-	*	*	-	**		63
modal.age	-	-	-	-	*	-	-	-	-	**	**	**	-	-	-	-	-	-	**	-	

