Stock Assessment Form

Pagellus erythrinus (PAC)

Reference year: 2017

Reporting year: 2018

Pagellus erythrinus is a valuable species for demersal fisheries in Cyprus waters (GSA25). The stock is exploited from all fleet segments and by recreational fishery too. The lack of data from the last segment is one of the major reasons of postponing the assessment of this species. In 2017 a pilot study on recreational fishery (RF) provided the first preliminary quantities of catches derived from this activity. Data from Cyprus official statistics were compiled into a surplus production model in continuous time (SPiCT) under the R language environment. Abundance index derived from effort of Trawl fleet which is believed to be more consistent and reliable than other fishery dependent information. As an auxiliary validation the model was compared with LiME (LB-SPR), CMSY and an Environmental indicator derived from the length trend of the 95th percentile of the larger individuals of PAC in MEDITS data series. MEDITS biomass index was also compared externally with the abundance index used in SPiCT (with similar trends) although a further work is needed to incorporate that index into the code. Results show that the stock is in sustainable exploitation with biomass above optimum levels.

Stock Assessment Form version 1.0 (January 2014)

Uploader: *Ioannis Thasitis*

Stock assessment form

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Pagellus erythrinus	Common Pandora	PAC
1st Geographical sub-area:	2nd Geographical sub-area:	3rd Geographical sub-area:
[GSA_25]		
4th Geographical sub-area:	5th Geographical sub-area:	6th Geographical sub-area:
1st Country	2nd Country	3rd Country
Cyprus		
4th Country	5th Country	6th Country
Stock assessment method: (direct, indirect, combined, none)		
SPiCT Indirect Biomass Model compared to LiME (LBSPR), CMSY		
Authors:		
Ioannis Thasitis, Charis Charilaou		
Affiliation:		
Department of Fisheries and Marine Research, Cyprus		

The ISSCAAP code is assigned according to the FAO 'International Standard Statistical Classification for Aquatic Animals and Plants' (ISSCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. This can be provided by the GFCM secretariat if needed. A list of groups can be found here:

http://www.fao.org/fishery/collection/asfis/en

Direct methods (you can choose more than one):

- Acoustics survey
- Egg production survey
- Trawl survey
- SURBA
- Other (please specify)

Indirect method (you can choose more than one):

- ICA
- VPA
- LCA
- AMCI
- XSA
- Biomass models
- Length based models
- Other (please specify)

Combined method: you can choose both a direct and an indirect method and the name of the combined method (please specify)

2 Stock identification and biological information

The assessment is considered to cover the area under the effective control of Cyprus Republic; it is assumed that the stock limits of the assessed *Pagellus erythrinus* are in agreement with the limits of GSA 25.

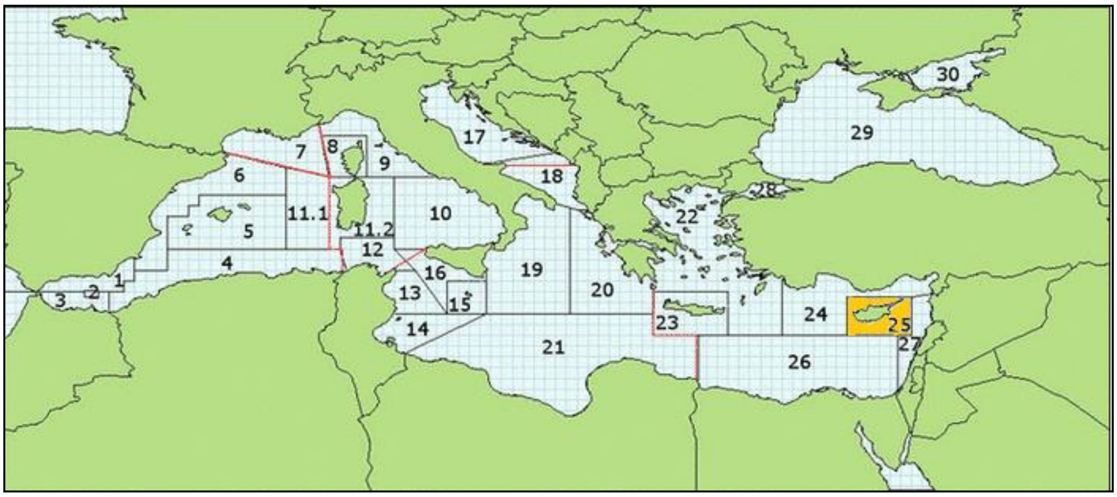


Figure 2.1-1: Geographical location of GSA25.

2.1 Stock unit

2.2 Growth and maturity

The following tables provide growth and maturity information on the stock, based on combined data from commercial catches and fisheries-independent survey. All information is based on data collected under the Cyprus National Data Collection Programme.

Table 2.2-1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LT, LC, etc)				Units	cm
Sex	Fem	Mal	Combined	Reproduction season	
Maximum size observed			30	Recruitment season	
Size at first maturity	14		14	Spawning area	Shelf
Recruitment size to the fishery				Nursery area	Shelf

Table 2-2.2: M vector and proportion of matures by size or age (Males)

Size/Age	Natural mortality	Proportion of matures
…	…	…

Table 2-2.3: M vector and proportion of matures by size or age (Females)

Size/Age	Natural mortality	Proportion of matures
…	…	…

Table 2-3: Growth and length weight model parameters (in case of LiME)

			Sex			
		Units	**female**	**male**	**Combined**	**Years**
Growth model	**L_∞**				30	
	K				0.203	
	t_0				-1.623	
	Data source					
Length weight relationship	**a**				2.355	
	b				2.818	
	M (scalar)				0.45	
	sex ratio (% females/total)					

3 Fisheries information

3.1 Description of the fleet

As indicated in Table 3.1-1, the stock is exploited by different Operational Units, polyvalent vessels operating with passive gears with length basically below 12m and the trawlers .

The small scale polyvalent fleet operates mainly with bottom set nets and bottom longlines, targeting. Vessels under this fleet represent the large majority of the fishing vessels in the Cyprus Fleet Register (96%). Most vessels have length 6-<12m and are allowed to operate every day all year round, with a number of restriction measures on the use of fishing gears and minimum landing sizes, according to the national and community law (see Section 3.3). During 2016 there were 325 licenses (28 with length 0-<6m, 297 with length 6-<12m).

Polyvalent vessels fishing with passive gears over 12m are mainly involved in the large pelagic fishery, but may also target PAC using nets and bottom longlines.

For the trawlers fishing in territorial waters an extended closed season is employed. Since 2012 the trawlers operating in territorial waters are limited to two. Further information on the restrictions applied on this fleet is provided in Section 3.3.

As shown in Table 3.1-2, *Pagellus erythrinus* in GSA25 is exploited with a number of other demersal species for all operational units.

Table 3-1: Description of operational units exploiting the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1	CYP	GSA25	C-Polyvalent small-scale vessels with engine (6-12 metres)	07 – Gillnets, Entangling Nets, Long-lines	33 – Demersal shelf species	*Pagellus erythrinus (PAC)*
Operational Unit 2	CYP	GSA25	B – Polyvalent small-scale vessels with engine (<6 metres)	07 – Gillnets, Entangling Nets, Long-lines	33 – Demersal shelf species	*Pagellus erythrinus (PAC)*
Operational Unit 3	CYP	GSA25	M – Polyvalent vessels (>12 metres)	07 – Gillnets and Entangling Nets	33 – Demersal shelf species	*Pagellus erythrinus (PAC)*
Operational Unit 4	CYP	GSA25	Recreational Fisheries	07 – Hand line and Long-lines	33 – Demersal shelf species	*Pagellus erythrinus (PAC)*
Operational Unit 5	CYP	GSA25	F – Trawlers (>24 metres)	03 - Trawls	33 – Demersal shelf species	*Pagellus erythrinus (PAC)*

Table 3.1-2: Catch, bycatch, discards and effort by operational unit in the reference year

Operational Units*	Fleet (n° of boats)*	Catch (T or kg of the species assessed)	Other species caught (names and weight)	Discards (species assessed)	Discards (other species caught)	Effort (units)
Polyvalent small-scale vessels (6-12 metres)	297		*Boobs boops , Mullus barbatus, Pagellus erythrinus , Sparisoma cretense , Pagellus acarne, Siganus rivulatus, Spicara maena, Serranus cabrilla, Diplodus sargus, Spicara smaris, Octopus vulgaris, Sepia officinalis, Loligo vulgaris*	No discards	*Lagocephalus* spp.	37674 (days)
Polyvalent small-scale vessels (0-6m)	28		*Boobs boops , Mullus barbatus, Pagellus erythrinus , Sparisoma cretense , Pagellus acarne, Siganus rivulatus, Spicara maena, Serranus cabrilla, Diplodus sargus, Spicara smaris, Octopus vulgaris, Sepia officinalis, Loligo vulgaris*	No discards	*Lagocephalus* spp.	3528 (days)
Polyvalent vessels (>12 metres)	26		*Boobs boops, Mullus barbatus, Spicara smaris*	No discards	*Lagocephalus* spp.	711
Recreational Fisheries	2500		*Pagellus erythrinus*	No discards		
Trawlers	2		*Boobs boops , Mullus barbatus, Pagellus erythrinus , Sparisoma cretense , Pagellus*	No discards	*Boops boops, Mullus barbatus, Pagellus erythrinus, P. acarne,*	204

			acarne, Siganus rivulatus, Spicara maena, Serranus cabrilla, Diplodus sargus, Spicara smaris, Octopus vulgaris, Sepia officinalis, Loligo vulgaris		*Spicara smaris, Serranus cabrilla, Merluccius merluccius*	
Total						

3.2 Historical trends

Data set starts in 1975 with the historically highest landing value of the data series (Figure 3.2.1). A variable cyclic effect with periodically high catches is observed up until 2009. From 2006 onwards a series of management decisions were applied with considerable effects on vessel numbers, gear characteristics, depth and distance from shore prohibitions. A graphical representations of these actions is presented in Figure 3.2.2.

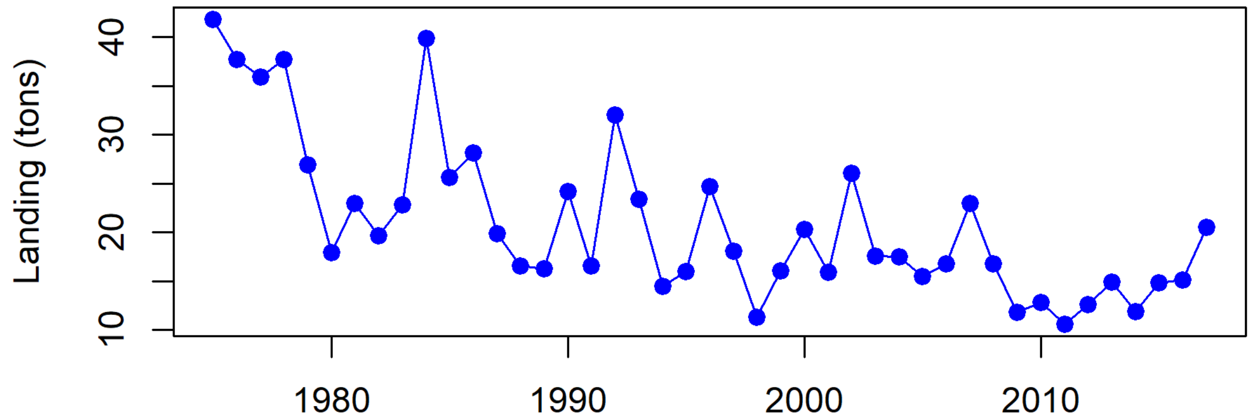


Figure 3.2.1: *Pagellus erythrinus* landings

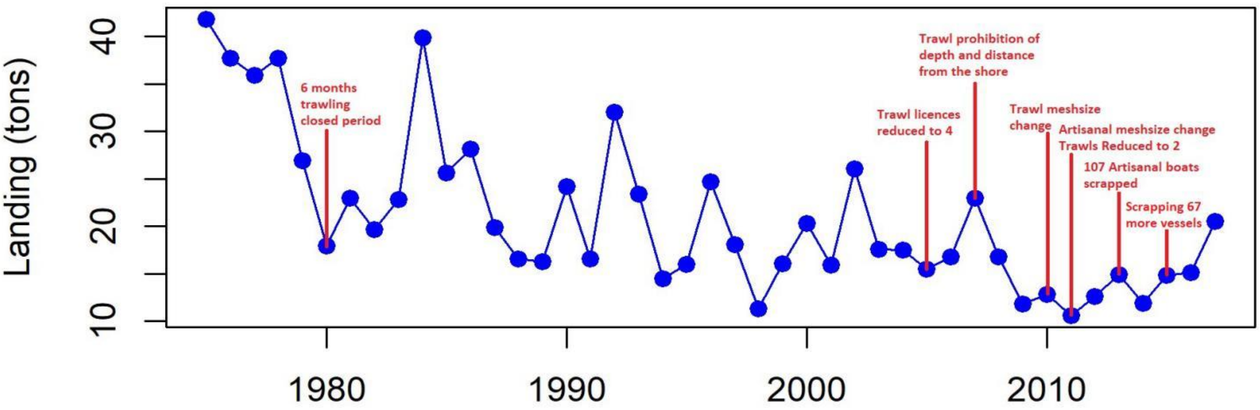


Figure 3.2.2: *Pagellus erythrinus* landings with presentation of management regulations.

3.3 Management regulations

Current and past management regulations:

1. Polyvalent small-scale vessels (0-6m, 6-12m)

- Restriction of the maximum number of licenses.

  Small scale inshore vessel licenses (Category A&B) are restricted to 500 by legislation; however, the maximum number is further reduced in accordance with the number of vessels that are permanently removed from the fleet through adjustment schemes.

  During 2013, 107 vessels were scrapped with public aid, in accordance with an effort adjustment plan based on Article 21 (a) of Regulation (EC) 1198/2006 on the *European Fisheries Fund* –EFF. In 2014 the maximum number of licenses was reduced accordingly to 393 licenses. During 2015 additional 66 vessels were scrapped with public aid, under the Operational Programme 2014-2020 of the European Marine and Fisheries Fund. Therefore, from 2016 the maximum number of licenses has been reduced to 327 licenses.

- Restrictions on the use of fishing gears depending on the fishing license category.

  Until March 2011 minimum mesh size of nets was set at 32mm (open mesh size). From March 2011 minimum mesh size of nets is set at 38mm (open mesh size).
  Maximum length of nets: For boats with license A is 5000m, for boats with license B is 3000m.
  Maximum height of nets: 4m.
  Restrictions on the time and duration of fishing, depending on mesh sizes.
  Additional restrictions on the use of monofilament nets (mesh sizes, length of nets).

2. Bottom Trawlers in territorial waters

- Restriction of the maximum number of licenses. Before 2006 the maximum number of licenses was restricted to 8, while from 2006 until 2011 the maximum number was reduced to 4. From November 2011 maximum number of licenses is restricted to 2.
- Minimum mesh size: From June 2010 the 40mm diamond shape trawl net has been replaced

by a diamond meshed net of 50mm at the cod-end. From November 2011 minimum mesh size of 50mm diamond in any part of the net.

- Depth and distance from the cost restrictions: Prohibition of bottom trawling at depths less than 50m and at distances less than 0.7 nautical miles off the coast.
- Seasonal and Area restrictions:
  - Closed trawling period in territorial waters from 1st of June until the 7th of November (in force since the mid '80s).
  - Prohibition of bottom trawling in the Zygi coastal area, at a distance of 3 nautical miles from the coast.
  - Restriction of 2 areas from fishing with trawl nets, on a rotational basis (northwest part of Cyprus from 8 November – 15 February, southeastern part from 16 February – 31 May every year). Applied from November 2011.

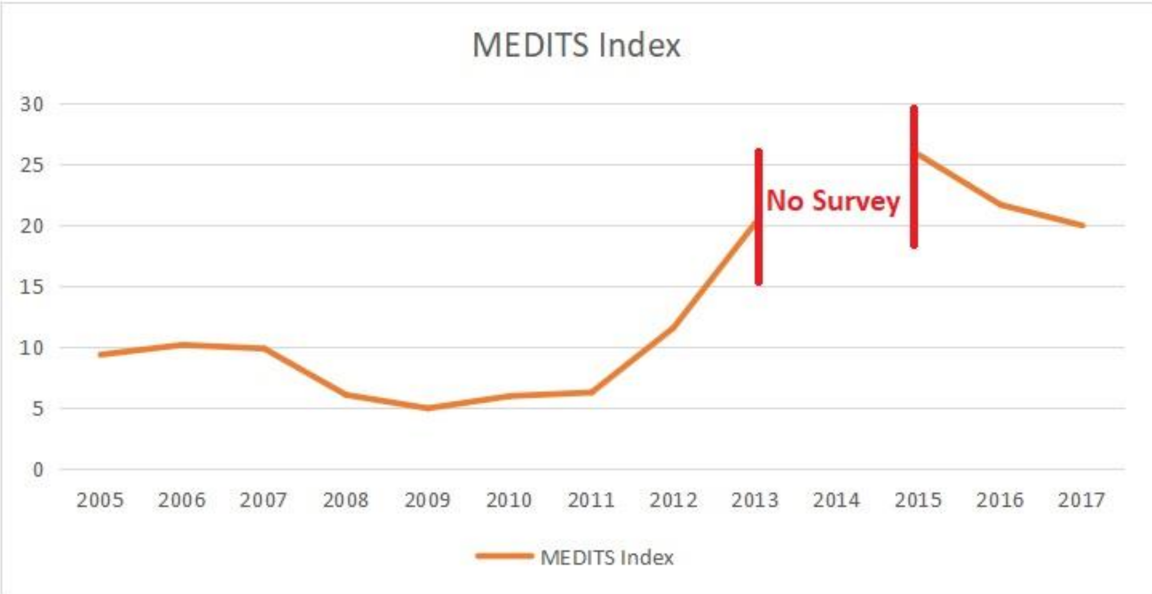
3.4 Reference points

Table 3.3-1: List of reference points and empirical reference values previously agreed (if any)

Indicator	Limit Reference point/empirical reference value	Value	Target Reference point/empirical reference value	Value	Comments
B					
SSB					
F					
Y					
CPUE					
Index of Biomass at sea					

4 Fisheries independent information

Fisheries independent information on *Pagellus erythrinus* have not been used directly for final assessment runs due to short time series compared with length of landing series. Trials were attempted to fit the model with MEDITS biomass index alone but the diagnostics were all showing an unstable model. Further trials of incorporating the MEDITS data as an additional index must be attempted in future runs. However the MEDITS biomass index was compared with Trawl LPUE used which presented similar trends.



5 Ecological information

5.1 Protected species potentially affected by the fisheries

The protected species that are potentially affected by the fisheries are the two turtle species (*Chelonia mydas*, *Caretta caretta)* encountered in Cyprus waters, and cetaceans (*Tursiops truncatus).* The interaction of the net fisheries with cetaceans involves mostly the damage of fishing gear and caught fish eaten by the dolphins.

5.2 *In general, the catch of protected species (shark species, turtles, monk seal, cetaceans) is prohibited in accordance with international obligations (including relevant GFCM recommendations), and data on incidental catches are collected.* Environmental indexes

No environmental indices are used in the assessment.

6 Stock Assessment

In this section there will be one subsection for each different model used, and also different model assumptions runs should be documented when all are presented as alternative assessment options.

6.1 Surplus Production Model in Continues Time (SPiCT)

SPiCT package (Pedersen MW and CW Berg (2017) A stochastic surplus production model in continuous time. Fish and Fisheries, 18: 226–243) was used as the major platform to contact the assessment in R environment (R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/). The model applies a state-space implementation of the Pella-Tomlinson surplus production model in continuous time. It assumes that both the removals (process equation) and survey index equation (observation equation) are subject to errors. Additional error is assumes at the catch equation too.

6.1.1 Model assumptions

The model assumes that total biomass changes are a function of the net biomass of the population processes of recruitment, growth and natural mortality (surplus production) and the biomass harvested through fishing.

The surplus production is the result of a constant density-independent growth rate, r and a density-dependent restriction that reduces the rate of growth when the biomass approaches the carrying capacity, K. The catch removals assumed to be proportional to the instantaneous biomass, B, and the fishing mortality, F. A second equation correlates the survey abundance index time series with the biomass equation, assuming a constant coefficient q that represents the catchability.

6.1.2 Script Used

```
#################################################################
# Run SPiCT in continuous time with Pella-Tomlinson model
#################################################################
rm(list=ls())
library(TMB)
library(spict)
library(ggplot2)
library(gridExtra)
```

```
species     <- "PACRec"  # Species
usePrior    <- F         # use prior information?
FixParam    <- F         # fix parameters? (e.g. n=2 for Schaefer model)
retro       <- T         # do retrospective analysis?
manage      <- T         # forecast managment scenarios?
interpolate <- T         # fill the gaps of the abund. index series with
smooth      <- F         # smooth the abund. index timeseries using loess
robust      <- T         # check robustness to initial values
######################################################################
#         Load the data of the selected species
######################################################################
Data <- read.table(file=paste(species,"_data.txt",sep = ""),
                   sep = "\t",
                   header = T)
Data <- as.list(Data)
######################################################################
#         Interpolate the abundance index time series?
######################################################################
if (interpolate){
  library(imputeTS)
  Data$obsI <- na.interpolation(Data$obsI, option="stine")
}
######################################################################
#         Smooth the abundance index time series?
######################################################################
if (smooth){
  Ismooth <- loess(Data$obsI ~ Data$timeI, span=0.4, degree=2)
  Ipredict <- predict(Ismooth, Data$timeI)
  Data$obsI <- Ipredict
}
######################################################################
#     Check the data and input parameters and plot
######################################################################
inp <- check.inp(Data)      # contains all parameters needed to run SPiCT
```

```
inp$dtc                 # the time interval between observations
inp$dteuler              # the time step for the solver, use dteuler=1 for discrete time
inp$catchunit <- "tones"    # set the measurement unit of catch
inp$getJointPrecision <- T   # to calculate covariance of all parameters
par(mfrow=c(2,1),mar=c(2,4,2,2)) #mar=c(bottom,left,top,right))
plot(Data$timeC, Data$obsC, type="o",
    xlab="", ylab="Landing (tons)",
    pch=19, col="blue")
plot(Data$timeI, Data$obsI, type="o",
    xlab="year", ylab="Abund. index (kg/day)",
    pch=19, col="green")
dev.copy(png,file=paste(species,"Data.png", sep="_"),
       width=16, height=12, units="cm", res=300)
dev.off()
plotspict.ci(Data)      # alternative way to plot the input data series
####################################################################
#              Run SPiCT and plot results
####################################################################
# Note: the command fit.spict(Data) runs SPiCT in continuous time
# with default parameters. Parameters can be changed using inp$...<-... .
# In that case, to run the model with the new parameters call fit.spict(inp)
res <- fit.spict(inp, dbg=0) # run the model, dbg (set to 1
# or 2 to show debbuging information)
names(res)               # the names of output parameters
capture.output(summary(res)) # summary of results
plot(res)              # plot results
par(mfrow=c(3,2), mar=c(4, 4, 3, 3.3))
plotspict.bbmsy(res, qlegend=F, stamp="")
plotspict.ffmsy(res, qlegend=F, stamp="")
plotspict.catch(res, qlegend=F, stamp="")
plotspict.fb(res, stamp="")
plotspict.production(res, stamp="")
plotspict.priors(res, do.plot=1, stamp="")
dev.copy(png, file=paste(species,"Results.png", sep="_"),
```

```
        width=15, height=19, units="cm", res=300)
dev.off()
par(mfrow=c(2,3), mar=c(5, 4, 3, 3))
plotspict.priors(res, do.plot=10)
dev.copy(png,file=paste(species,"Priors.png",sep="_"),
        width=19, height=16, units="cm", res=300)
dev.off()
##########################################################################
#       Estimate and plot convergence diagnostics
##########################################################################
resd <- calc.osa.resid(res)
par(mfrow=c(1,1), mar=c(5, 4.1, 3, 4))
plotspict.diagnostic(resd,stamp="")
dev.copy(png,file=paste(species,"diagnostics.png",sep="_"),
        width=19, height=19, units="cm", res=300)
dev.off()
##########################################################################
#               Show summary of results
##########################################################################
capture.output(summary(res))       # show summary of results
get.par('logBmsy', res, exp=TRUE)   # get a parameter value
cov <- res$cov.fixed               # covariance matrix of parameters
cov1 <- cov2cor(get.cov(res,"logB_2010","logF_2010"))
##########################################################################
#           Perform retrospective analysis
##########################################################################
if (retro){
  rep <- retro(res, nretroyear=3)
  plotspict.retro(rep,stamp="")    # use default plot retro function
  path <- getwd()
  source(paste(path,"/plot_retro.R",sep=""))
  plot_retro(rep,res,inp,stamp="")  # use my own plot retro function
  dev.copy(png,file=paste(species,"retro.png", sep="_"),
         width=19, height=9.5, units="cm", res=300)
```

```
  dev.off()
}
######################################################################
#          Forecast management scenarios
######################################################################
if (manage){
  res1 <- manage(res)
  df1  <- mansummary(res1)
  head(df1)
  p1   <-tableGrob(head(df1))
  grid.arrange(p1)
  dev.copy(png,file=paste(species,"ManagmentForecast.png",sep="_"),
         width=20, height=10, units="cm", res=300)
  dev.off()
}
par(mfrow=c(2, 2), mar=c(4, 4.5, 3, 3.5))
plotspict.bbmsy(res1)
plotspict.ffmsy(res1, qlegend=FALSE)
plotspict.catch(res1, qlegend=FALSE)
plotspict.fb(res1, man.legend=FALSE)
dev.copy(png,file=paste(species,"Forecast.png",sep="_"),
        width=19, height=16, units="cm", res=300)
dev.off()
######################################################################
#          Check robustness to initial values
######################################################################
if (robust) {
  set.seed(1234)
  check.ini(Data, ntrials=50)   # do minimum 50 runs with different initial values
}
#####################################################################
#       Create Table with estimated parameters
#####################################################################
m      <- get.par('logm', res, exp=F)
```

```
n       <- get.par('logn', res, exp=F)
q       <- get.par('logq', res, exp=F)
Bmsy    <- get.par('logBmsy', res, exp=F)
Fmsy    <- get.par('logFmsy', res, exp=F)
K       <- get.par('logK', res, exp=F)
r       <- get.par('logr', res, exp=F)
MSY     <- get.par('logMSY', res, exp=F)
B       <- get.par('logB', res, exp=F)
Fm      <- get.par('logF', res, exp=F)
FFmsy   <- get.par('logFFmsy', res, exp=F)
BBmsy   <- get.par('logBBmsy', res, exp=F)
Fmsyll  <- Fmsy[1]
Fmsyul  <- Fmsy[3]
Bmsyll  <- Bmsy[1]
Bmsyul  <- Bmsy[3]
FFmsyll <- FFmsy[which(row.names(FFmsy)=="2016"), 1]
FFmsyul <- FFmsy[which(row.names(FFmsy)=="2016"), 3]
BBmsyll <- BBmsy[which(row.names(BBmsy)=="2016"), 1]
BBmsyul <- BBmsy[which(row.names(BBmsy)=="2016"), 3]
sdb     <- get.par('logsdb', res, exp=T)
sdc     <- get.par('logsdc', res, exp=T)
sdi     <- get.par('logsdi', res, exp=T)

df <- data.frame(K=format(round(exp(K[,2]), 0), nsmall = 0),
        r=format(round(exp(r[,2]), 3), nsmall = 3),
        MSY=format(round(exp(MSY[,2]), 0), nsmall = 0),
        Bmsy=format(round(exp(Bmsy[,2]), 0), nsmall = 0),
        Fmsy=format(round(exp(Fmsy[,2]), 2), nsmall = 2),
        BBmsy=format(
         round(exp(BBmsy[which(row.names(BBmsy)=="2016"),2]), 2),
         nsmall = 2),
        FFmsy=format(
         round(exp(FFmsy[which(row.names(FFmsy)=="2016"),2]), 2),
         nsmall = 2)
```

```
)
p <- tableGrob(df,rows = NULL)
grid.arrange(p)
dev.copy(png, file=paste(species,"Parameters.png",sep="_"),
       width=12, height=3, units="cm", res=300)
dev.off()
######################################################################
#         Save output to file
######################################################################
x <- list(m = m,
        n = n,
        q = q ,
        r = r,
        K =K ,
        MSY = MSY,
        Bmsy = Bmsy,
        Fmsy = Fmsy,
        B = B,
        Fm = Fm,
        BBmsy = BBmsy,
        FFmsy = FFmsy,
        cov = cov,
        sdb = sdb,
        sdc = sdc,
        sdi = sdi)
save(file=paste(species,".RData",sep=""), x)
```

6.1.3 Input data and Parameters

Data are presented in the exact form that they were called in the script to formulate the objects and analysis.

obsC	timeC	obsI	timeI
41.84	1975	16.4	1975
37.74	1976	15.7	1976
35.94	1977	12.2	1977
37.75	1978	12.6	1978
26.95	1979	9.8	1979
17.95	1980	4.8	1980
22.95	1981	6.9	1981
19.65	1982	7.4	1982
22.85	1983	7.7	1983
39.85	1984	7.3	1984
25.65	1985	6.9	1985
28.15	1986	4.6	1986
19.85	1987	4.2	1987
16.56	1988	3.8	1988
16.26	1989	3.7	1989
24.16	1990	3.7	1990
16.56	1991	5.2	1991
32.06	1992	5.2	1992
23.36	1993	5.8	1993
14.46	1994	5.8	1994
15.96	1995	3.6	1995
24.66	1996	4.2	1996
18.06	1997	3.9	1997
11.28	1998	2.7	1998
16.08	1999	2.7	1999

20.28	2000	2.2	2000
15.88	2001	3.8	2001
26.08	2002	6.3	2002
17.58	2003	2.4	2003
17.48	2004	5.3	2004
15.48	2005	5.3	2005
16.78	2006	7.6	2006
22.98	2007	8.9	2007
16.8	2008	7.5	2008
11.8	2009	6.6	2009
12.8	2010	7.1	2010
10.6	2011	6.1	2011
12.6	2012	8.9	2012
14.9	2013	7.6	2013
11.9	2014	7.6	2014
14.8	2015	12.5	2015
15.1	2016	13.63	2016
20.5	2017		2017

6.1.4 Results

The assessment indicates that *Pagellus erythrinus* is fished at sustainable levels, and current (2017) biomass is above B_{msy}. Current F is bellow F_{msy} since 2008 (Table 6.1.4-1 and Fig. 6.1.4-2). As the catch is increasing and F has a slight increasing trend the scientific advise is to retain the current framework and monitor the progress of the stock as new data become available.

Table 6.1.4-1. Estimates of model parameters. The last two columns indicate relative biomass and fishing mortality levels in 2017.

K	r	MSY	Bmsy	Fmsy	BBmsy	FFmsy
171	0.264	21	45	0.47	1.68	0.45

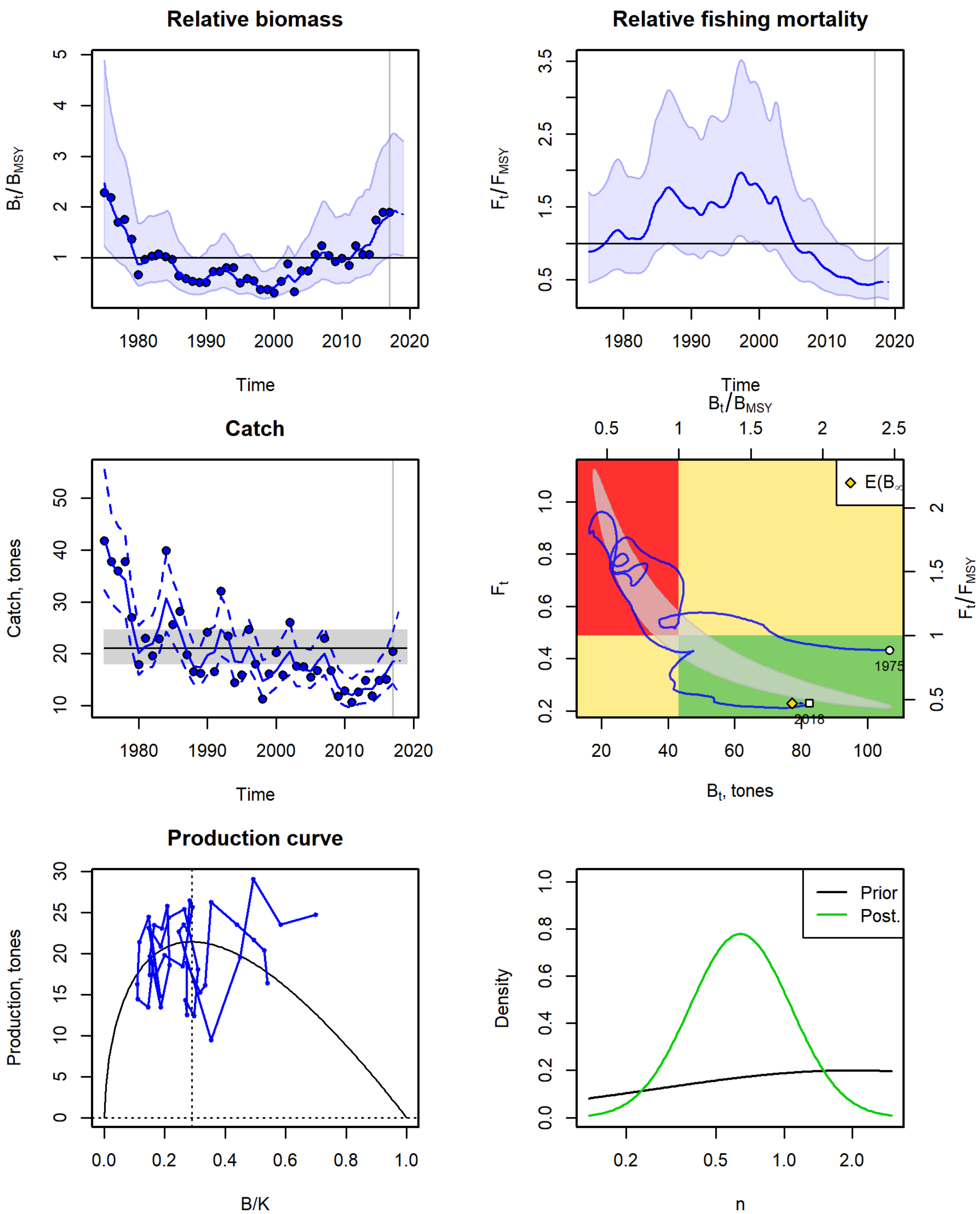


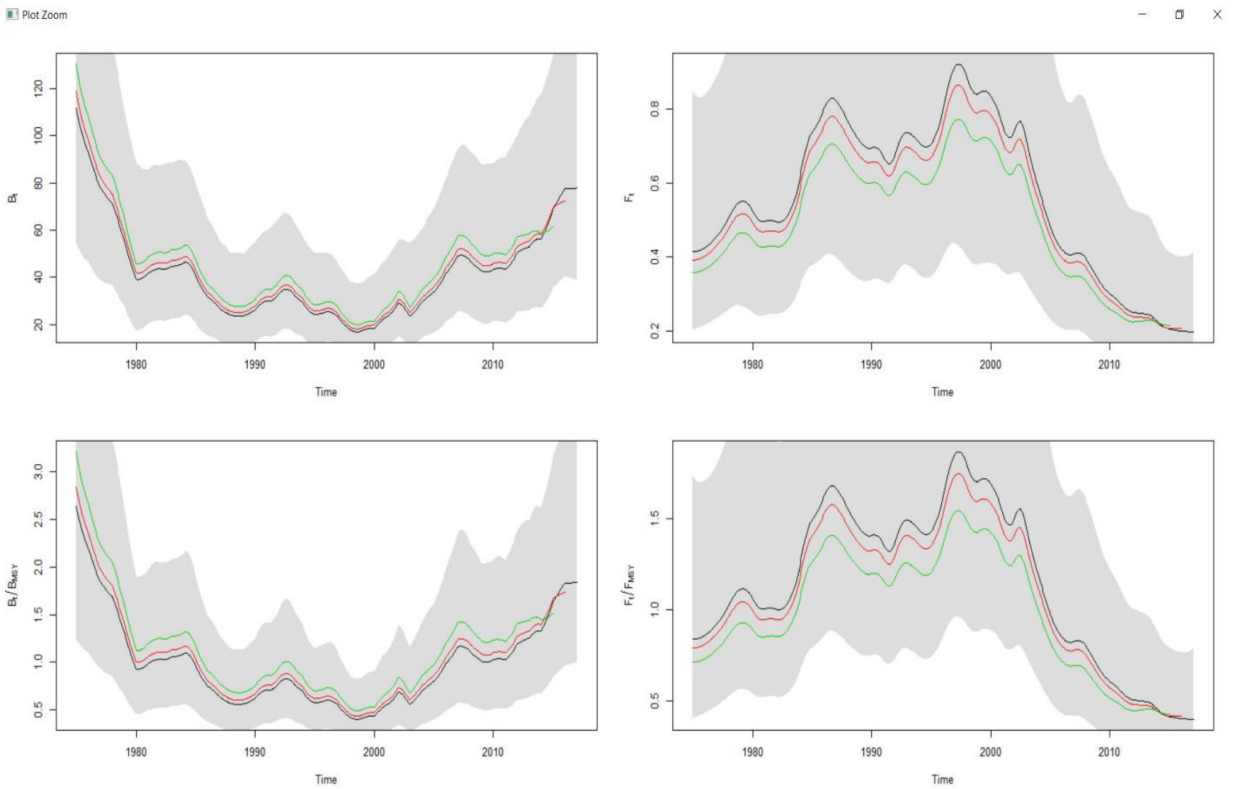
Fig. 6.1.4-2. Stock assessment results for Pagellus erythrinus in GSA-25. Upper row: Median (blue solid line) of relative biomass and relative fishing mortality with 95% CI (blue shaded area). Middle row: Observed (blue points) and estimated catch with 95% CIs (left) and Kobe plot of relative fishing mortality versus

relative biomass (right). Bottom row: Production curve (left) and comparison of prior and posterior distributions of the n parameter, which determines the shape of the production curve in the Pella-Tomlinson model (right).

6.1.5 Robustness analysis

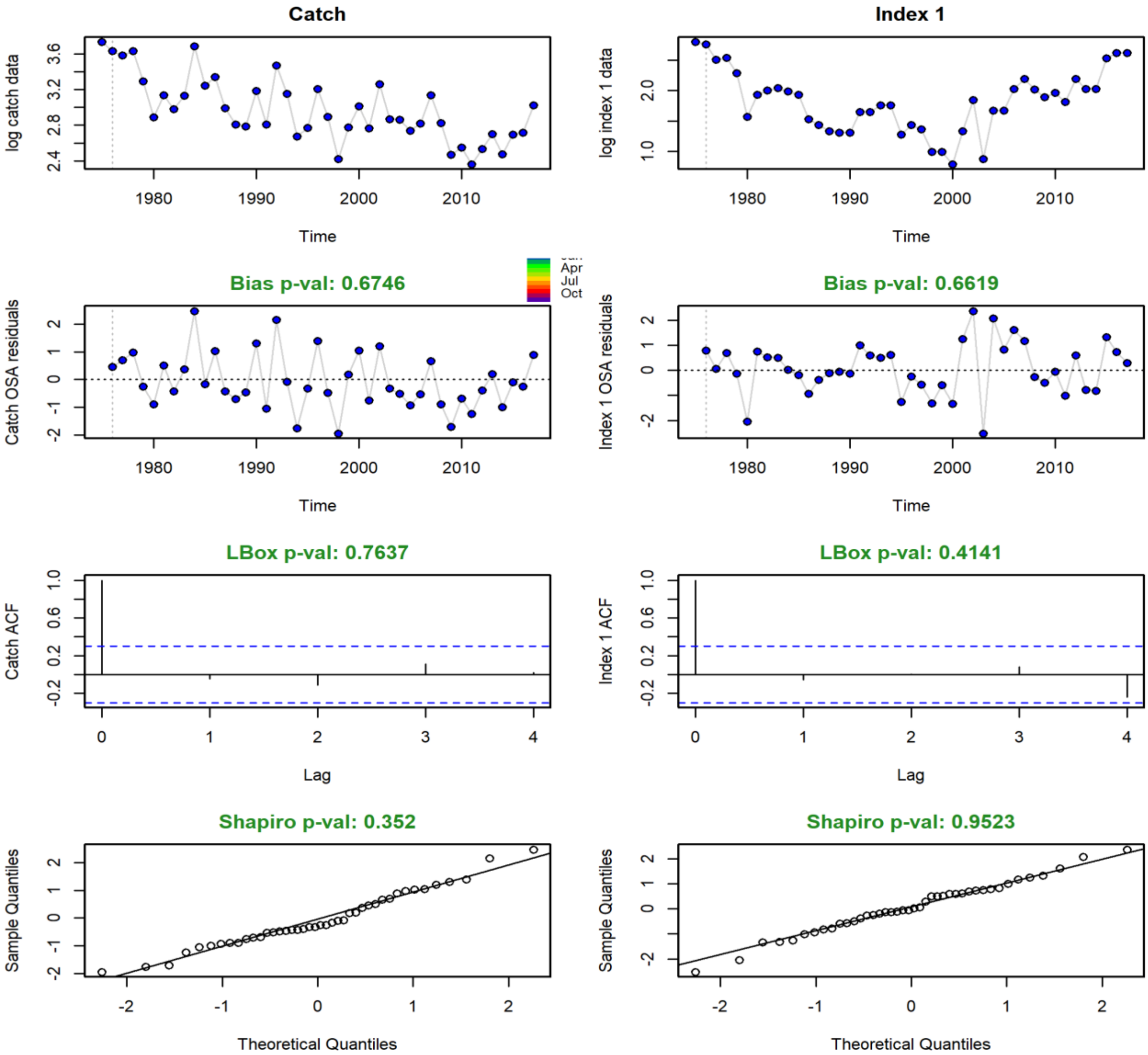
6.1.6 Retrospective analysis, comparison between model runs, sensitivity analysis, etc.

Retrospective analysis show consistent trends among runs. Overall, the retrospective plots don't show any patterns, suggesting model/data consistency and robustness of the results (Fig. 6.1.6-1).



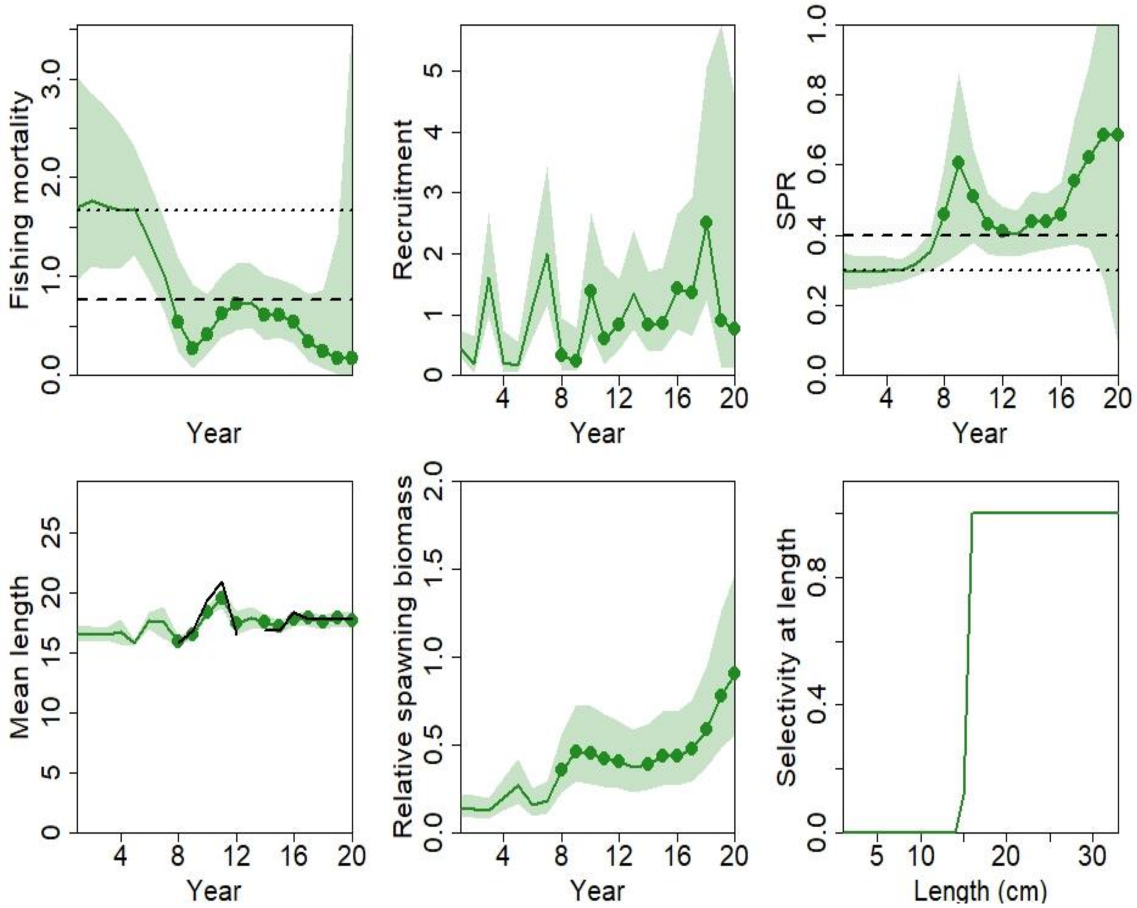
6.1.7 Assessment quality

Residual show no significant deviation from normality with low scores (Fig. 6.1.7-1).

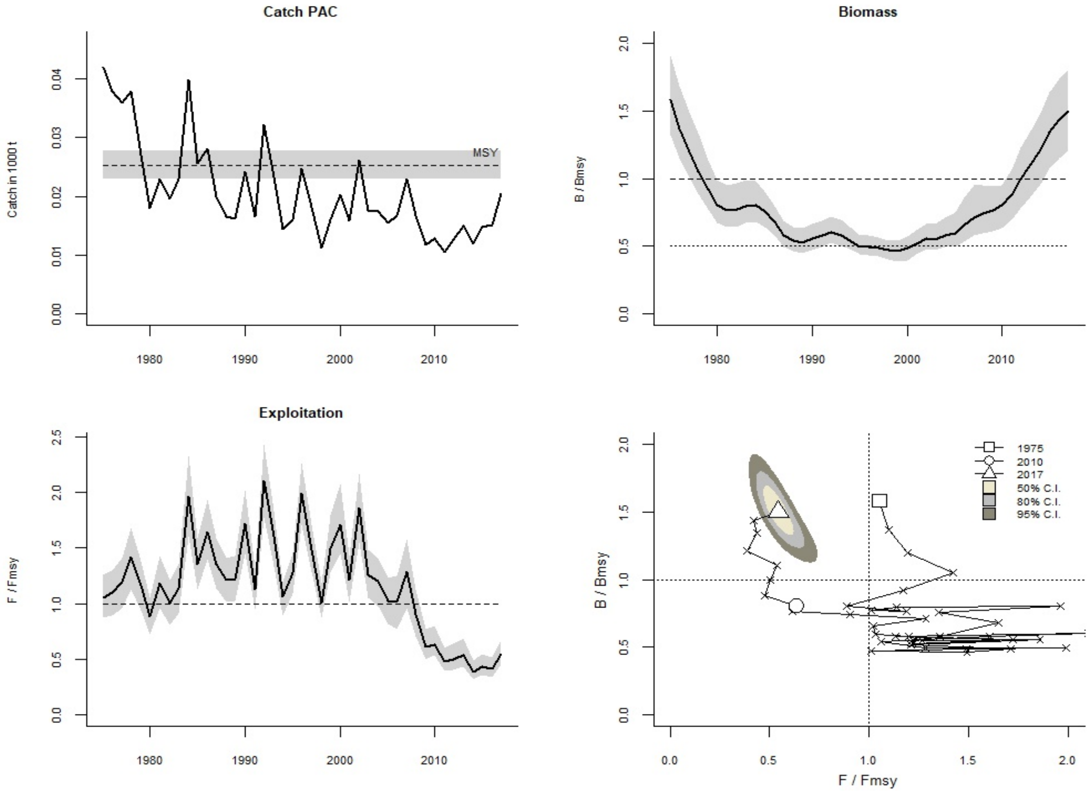

Catch
Index 1
log catch data
log index 1 data
Time
Bias p-val: 0.6746
Bias p-val: 0.6619
Apr
Jul
Oct
Catch OSA residuals
Index 1 OSA residuals
LBox p-val: 0.7637
LBox p-val: 0.4141
Catch ACF
Index 1 ACF
Lag
Shapiro p-val: 0.352
Shapiro p-val: 0.9523
Sample Quantiles
Theoretical Quantiles

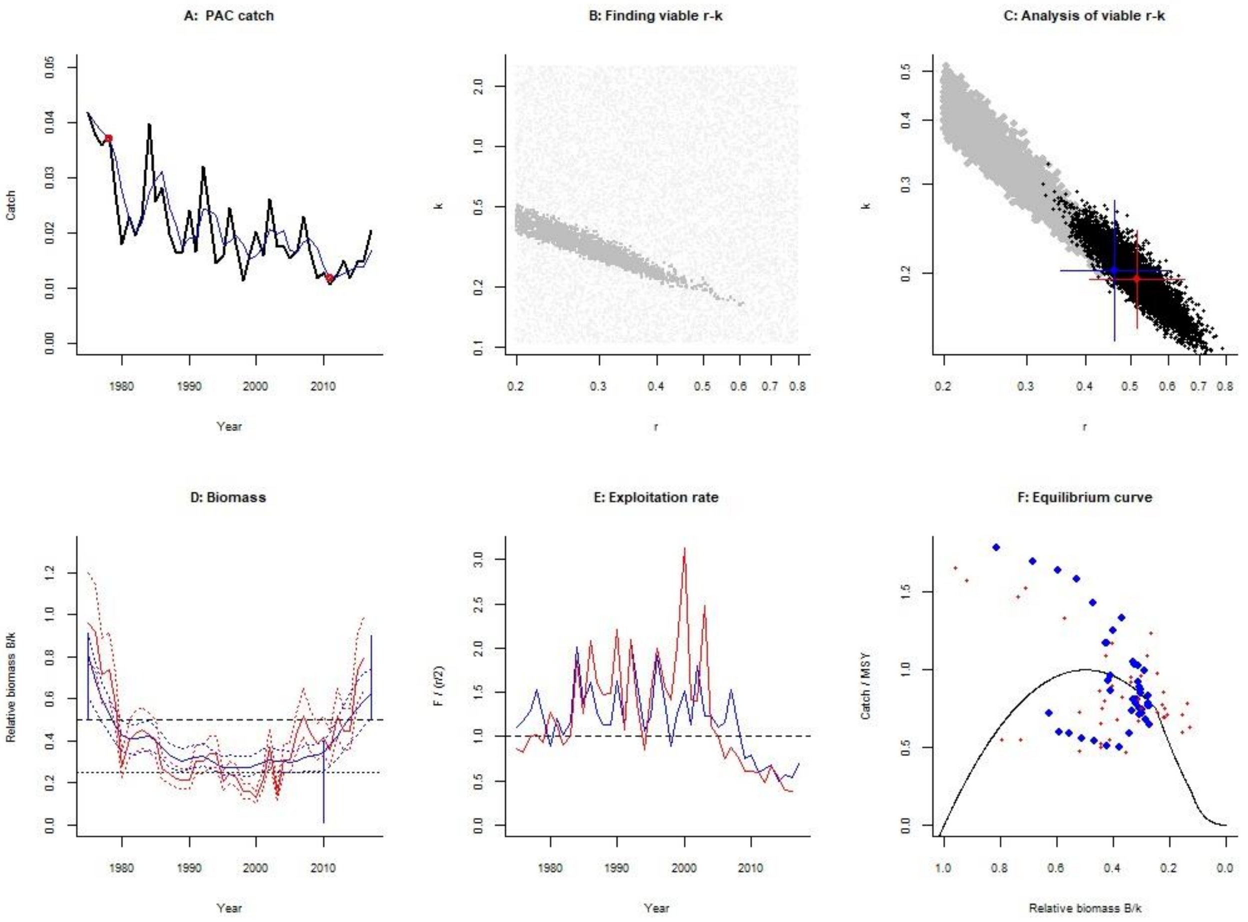
6.1.8 Comparative study with other methods

LiME (LB-SPR) Results

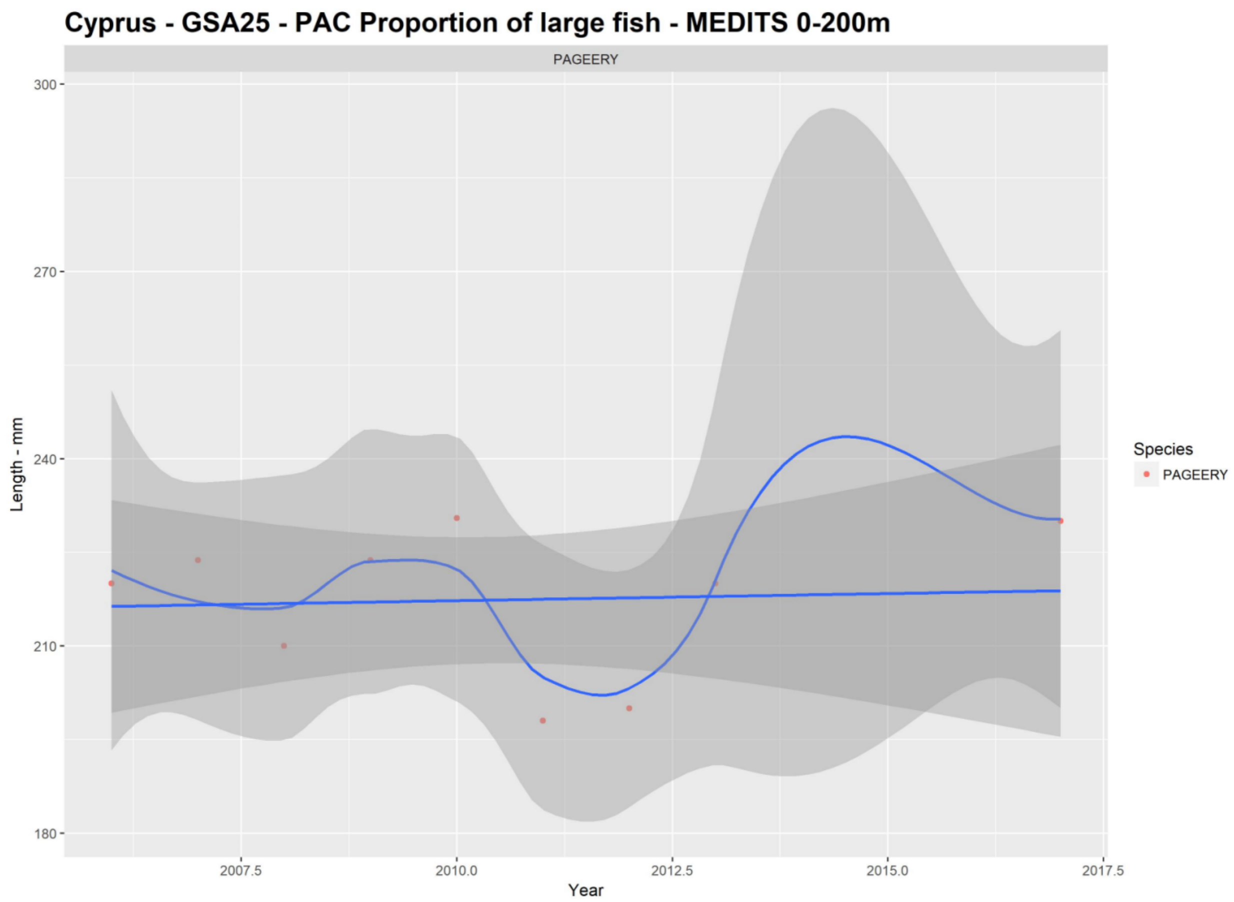


CMSY Results





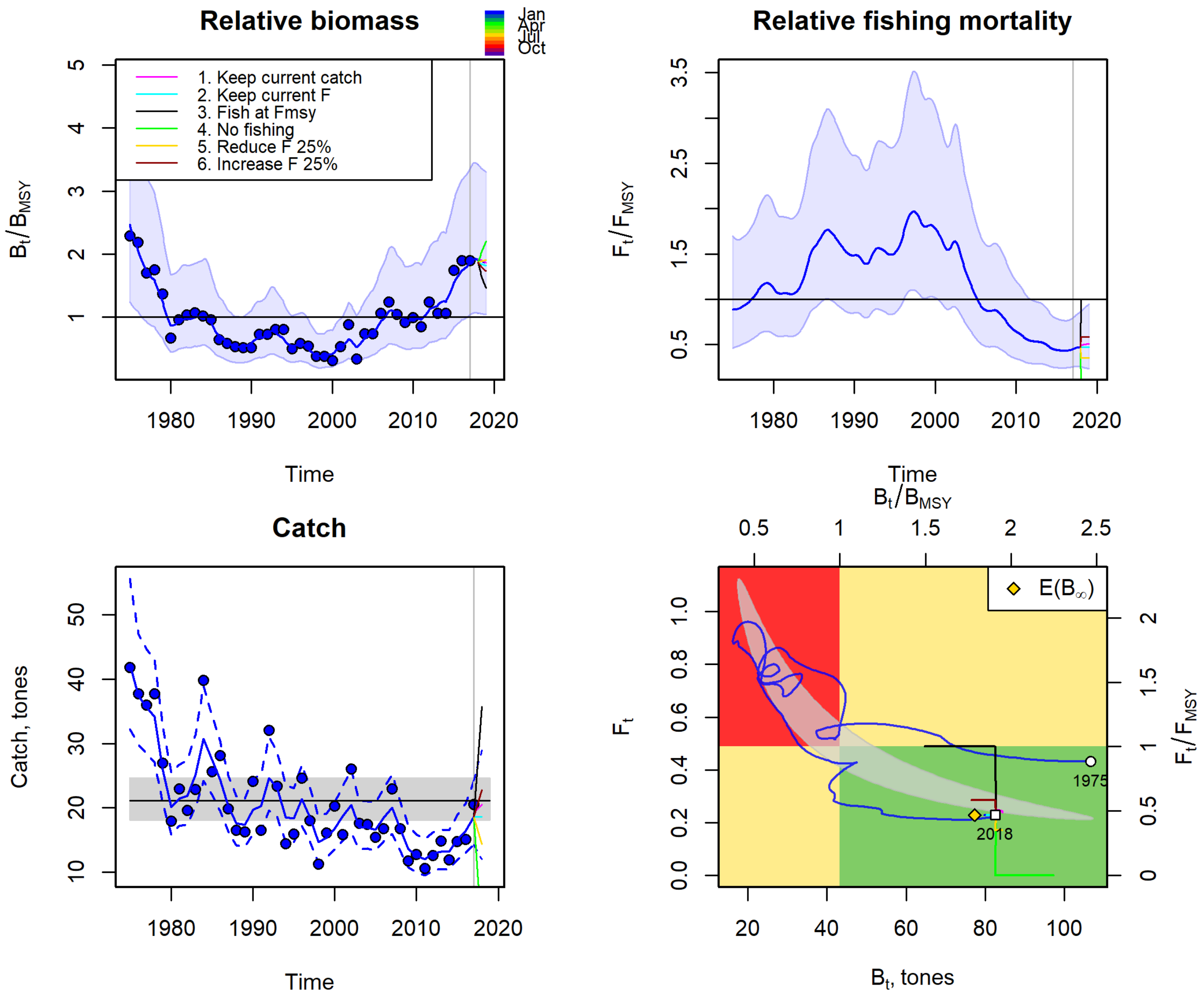
Empirical Environmental Indicator


Cyprus - GSA25 - PAC Proportion of large fish - MEDITS 0-200m
PAGEERY
300
270
240
210
180
Length - mm
2007.5
2010.0
2012.5
2015.0
2017.5
Year
Species
PAGEERY

7 Stock predictions

Forecast code of the model was activated and the results are presented both as table and figure short term predictions.

	C	B	F	B/Bmsy	F/Fmsy	perc.dB	perc.dF
1. Keep current catch	20.5	84.2	0.242	1.828	0.518	0.4	6.8
2. Keep current F	18.8	82.1	0.227	1.783	0.485	-2.1	0
3. Fish at Fmsy	35.1	67	0.467	1.456	1	-20.1	106.2
4. No fishing	0	99.6	0	2.163	0	18.7	-99.9
5. Reduce F 25%	14.5	86.2	0.17	1.871	0.364	2.7	-25
6. Increase F 25%	23	78.3	0.283	1.7	0.606	-6.7	25



Draft scientific advice

Based on	Indicator	Analytic al reference point (name and value)	Current value from the analysis (name and value)	Empirical reference value (name and value)	Trend (time period)	Stock Status
Fishing mortality	Fishing mortality	F/F_{msy} : 0.45			I	S
	Fishing effort				N	
	Catch				I	
Stock abundance	Biomass	B/B_{msy}: 1.68				O_H
Recruitment						
Final Diagnosis		Sustainable Exploitation with stock biomass above optimum				

State the rationale behind that diagnoses, explaining if it is based on analytical or on empirical references

7.1 Explanation of codes

Trend categories

1) N - No trend
2) I - Increasing
3) D – Decreasing
4) C - Cyclic

Stock Status

Based on Fishing mortality related indicators

1) **N - Not known or uncertain** – Not much information is available to make a judgment;
2) **U - undeveloped or new fishery** - Believed to have a significant potential for expansion in total production;
3) **S - Sustainable exploitation**- fishing mortality or effort below an agreed fishing mortality or effort based Reference Point;
4) **IO –In Overfishing status**– fishing mortality or effort above the value of the agreed fishing mortality or effort based Reference Point. An agreed range of overfishing levels is provided;

Range of Overfishing levels based on fishery reference points

In order to assess the level of overfishing status when $F_{0.1}$ from a Y/R model is used as LRP, the following operational approach is proposed:

- If $Fc^*/F_{0.1}$ is below or equal to 1.33 the stock is in **(O_L): Low overfishing**
- If the $Fc/F_{0.1}$ is between 1.33 and 1.66 the stock is in **(O_I): Intermediate overfishing**
- If the $Fc/F_{0.1}$ is equal or above to 1.66 the stock is in **(O_H): High overfishing**

*Fc is current level of F

5) **C- Collapsed**- no or very few catches;

Based on Stock related indicators

1) **N - Not known or uncertain:** Not much information is available to make a judgment
2) **S - Sustainably exploited:** Standing stock above an agreed biomass based Reference Point;
3) **O - Overexploited**: Standing stock below the value of the agreed biomass based Reference Point. An agreed range of overexploited status is provided;

Empirical Reference framework for the relative level of stock biomass index

- **Relative low biomass:** Values lower than or equal to 33rd percentile of biomass index in the time series **(O_L)**
- **Relative intermediate biomass:** Values falling within this limit and 66th percentile **(O_I)**
- **Relative high biomass:** Values higher than the 66th percentile **(O_H)**

4) **D – Depleted**: Standing stock is at lowest historical levels, irrespective of the amount of fishing effort exerted;
5) **R –Recovering:** Biomass are increasing after having been depleted from a previous period;

Agreed definitions as per SAC Glossary

Overfished (or overexploited) *- A stock is considered to be overfished when its abundance is below an agreed biomass based reference target point, like B0.1 or BMSY. To apply this denomination, it should be assumed that the current state of the stock (in biomass) arises from the application of excessive fishing pressure in previous years. This classification is independent of the current level of fishing mortality.*

Stock subjected to overfishing (or overexploitation) *- A stock is subjected to overfishing if the fishing mortality applied to it exceeds the one it can sustainably stand, for a longer period. In other words, the current fishing mortality exceeds the fishing mortality that, if applied during a long period, under stable conditions, would lead the stock abundance to the reference point of the target abundance (either in terms of biomass or numbers)*