48.3 Assessment Summary

Tim Earl

# Abstract

*The following document was submitted to the Stock Assessment Review process to outline the source of current model data and parameters, and to summarise the development of the model. Section 1 summarises the development of the model, this is documented in more detail in Section 18, with a comprehensive reference list of papers related to the development of the model. Sections 2-16 describe the input files used in the most recent (2017) assessment, indicating the source of externally estimated parameters, and the data used in fitting the model.* *Section 17 outlines the data weighting approach used in fitting the model to multiple sources of data.*

48.3 Assessment Summary

Tim Earl

# Development history

See detail of all relevant papers at the end of this document for further details

|  |  |
| --- | --- |
| **Year** | **Changes from previous assessment** |
| 1985 | Start of catch time series |
| 1997 | Observers on all vessels |
| 2006 | First CASAL assessment (Hillary *et al.* 2006) |
| 2009 | Catch at age data included. Total catch corrected for depredation |
| 2011 | Inclusion of 0.006377 tag loss factor, depredation corrected CPUE included. Sensitivity testing of 2 vs 3 fleet model |
| 2013 | Investigation of 2 fleet vs 3 fleet representation of catch data. Use of two fleet model was preferred. |
| 2015 | Francis weighting introduced. |
| 2017 | No changes except for two additional years of data |

In the associated bundle:

* Input files after Francis weighting
* Output diagnostics
* All papers referred to in this document (FSA-17-53 is the most recent assessment). These are referenced in full in Table 1.

**Current assessment:**

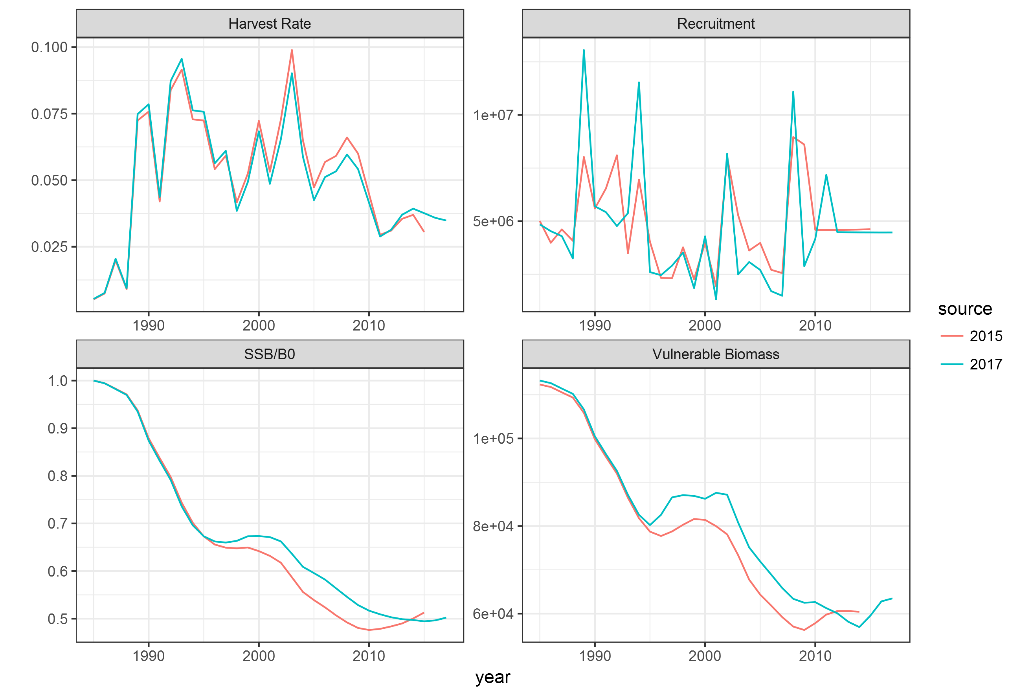


Figure 1: Stock summary MPD runs; Red: Assessment presented at FSA 2015, Turquoise: 2017 assessment using all currently available data.

# Model setup

## Values

Age range: 1-50+

Year range 1985-present[[1]](#footnote-1)

Single area, single stock with no separate sex/maturity partition

Annual cycle:

* Period 1 (Dec-Feb, 0.25 years) Recruitment
* Period 2 (Mar-Jun, 0.33 years) Spawning\_time (partial mortality 0.5), fishery
* Period 3 (Jul-Nov, 0.42 years) Recruitment
* Period 4 (instantaneous) Aging

## Model representation

Population.csl

@size\_based False

@min\_age 1

@max\_age 50

@plus\_group True

@sex\_partition False

@mature\_partition False

@n\_areas 1

@n\_stocks 1

@n\_tags 14

@tag\_names 2003Tags ... 2016Tags

@initial 1985

@current 2017

@final 2052

@annual\_cycle

time\_steps 4

recruitment\_time 1

spawning\_time 2

spawning\_part\_mort 0.5

spawning\_ps 1.0

aging\_time 4

M\_props 0.4166667 0.3333333 0.25 0.0

growth\_props 0.4166667 0.75 1.0 0.0

baranov False

fishery\_names FSG1 FSGS2

fishery\_times 2 2

@y\_enter 1

@n\_quant 15

# Optimiser settings

## Model representation

Estimation.csl

@estimator Bayes

@max\_iters 1000

@max\_evals 4000

@grad\_tol 0.002

@MCMC

start 0

length 1300000

keep 1000

adaptive\_stepsize True

adapt\_at 100000 200000

burn\_in 3000

proposal\_t True

df 4

@profile

parameter initialization.B0

n 11

l 40000

u 140000

@q\_method nuisance

@ageing\_error

type normal

c 0.1

## Notes

Profile range changed 2018 to increase range and resolution. Burn in changed to remove the period with stepsize changing.

Burn in increased in 2018 so that it is larger than adaptive stepsize.

# Initial biomass

## Values

B0 initialised at 70,000 tonnes

Uniform-log prior on 20,000 tonnes to 1,000,000 tonnes

## Model representation

Population.csl

@initialization

B0 70000

Estimation.csl

@estimate

parameter initialization.B0

lower\_bound 20000

upper\_bound 1000000

prior uniform-log

phase 1

# Recruitment

## Source data/Values

Beverton Holt recruitment form, with initial value of steepness set to 0.75.

Free estimates 1985-(current-7)

Year\_range 1992-(current-6)

@randomisation\_method lognormal-empirical

Priors bounded on [0.001,20], lognormally distributed with mu=1, cv=0.8, except first year and last 7 which are fixed to 1.

Model relatively insensitive to changes in steepness (Hillary 2006). Earl (2015, unpublished) showed that steepness values 0.4-0.99 (compared to assessment value of 0.75) made only a minor difference to the perception of the stock status. The effect on projections shows that the sustainable catch is reduced by the steepness lower than 0.75, but remains relatively unchanged for higher values.

## Model representation

Population.csl

@recruitment

YCS\_years 1984 ... 2016

YCS 1 ... 1

SR BH

steepness 0.75

first\_free 1985

last\_free 2010

year\_range 1992 2011

@first\_random\_year 2008

@randomisation\_method lognormal-empirical

@standardise\_YCS True

Estimation.csl

@estimate

parameter recruitment.YCS

lower\_bound 1 0.001 ... 0.001 1 1 1 1 1 1 1

upper\_bound 1 20 ... 20 1 1 1 1 1 1 1

prior lognormal

mu 1 ... 1

cv 0.8 ... 0.8

phase 1

## Notes

Since FSA-13 recruitment post 1992 has been used in projections as a more precautionary assumption, given that recruitment has been lower in this period than previously. See also WG-FSA-13 paragraph 4.21 for recruitment in projections.

# Maturity ogive

## Source data/Values

## Model representation

Population.csl

@maturity\_props

all allvalues\_bounded 1 23 0 0 0 0 0 0.06 0.14 0.22 0.3 0.38 0.46 0.54 0.62 0.658 0.7 0.742 0.784 0.826 0.868 0.91 0.952 0.994 1

## Notes

In Hillary *et al*. 2006 the maturity was given as a length based ogive. In 2011 an age-based ogive was used. The timing and reasoning for this change is not clear, but may be related to the inclusion of catch at age data in 2009.

# Natural mortality

Fixed value for all ages

## Source data/Values

0.13

## Model representation

Population.csl

@natural\_mortality

all 0.13

## Notes

0.165 in Hillary 2006, but the value of 0.13 dates back to WG-FSA-05/18

# Growth

## Source data/Values

Length-weight parameters date back to Hillary *et al.* (2006). Length-weight fitting to the data from different years resulted in little change to the parameter estimates and assessment (Earl, 2015; unpublished).

Von Bertalanffy growth parameters estimated in WG-FSA-11/33-rev-1, and sensitivity testing in Earl (2015; unpublished). The variability between years suggests that the parameters may be poorly estimated, partly due to aging errors, and also affected by changes in sampling (recent seasons have seen samples stratified by length to get a wider spread)

Within the model these parameters affect the fit of early part of the catch composition (no age data, only lengths) and the tag data, where releases and recaptures are measured (obviously hard to age released fish).

## Model representation

Population.csl

@size\_at\_age\_type von\_Bert

@size\_at\_age\_dist normal

@size\_at\_age

k 0.08

t0 -0.7

Linf 126

cv 0.08

@size\_weight

a 2.54e-8

b 2.8

verify\_size\_weight 150 30 50

## Notes

Growth estimated externally in 48.3, internally in 48.4

# Tagging release data

Tagging data is available from 2003 release cohort onwards. Release mortality is estimated externally using a length dependent relationship:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Length class (cm) | 30, 40 | 50 | 60 | 70 | 80 | 90 | 100+ |
| Survival | 0 | 0.96 | 0.95 | 0.95 | 0.94 | 0.83 | 0.80 |

Within the model, no further post-release tagging occurs.

All releases since 2003 are included where the fish length is in the range [30,200) cm, the release area is 48.3 and the release species is recorded as “TOP”.

## Source data/Values

Tag shedding rate 0.006377 based on linear approximation over four years to the observed double tag loss rate.

There is a 0.75 year no growth period – WG-FSA-07/29

## Model representation

Population.csl

@tag\_shedding\_rate 0.006377 0.006377 0.006377 0.006377 0.006377 0.006377 0.006377 0.006377 0.006377 0.006377 0.006377 0.006377 0.006377 0.006377

@tag\_loss\_props 0.4166667 0.3333333 0.25 0.0

@tag\_growth\_loss 2003Tags

nogrowth\_period 0.75

...

@tag\_growth\_loss 2016Tags

nogrowth\_period 0.75

@tag 2003Tags

...

@tag 2016Tags

tag\_name 2016Tags

release\_type deterministic

sex both

year 2016

step 2

mature\_only False

number <Number released corrected for in-year recaptures and instant mortality>

plus\_group False

class\_mins 40 50 60 70 80 90 100 110 120 130 140

props\_all <Proportions at length>

mortality 0.

ogive SelSGS2

## Notes

Instant tag mortality is estimated externally, based on a length-dependent relationship, and so no further tag mortality is applied in the model.

## References

Tag mortality at length described in WG-FSA-07/29

Effect of double tagging: WG-SAM-11/16 and WG-SAM-11/12 leading to tag loss rate estimate

WG-SAM-09/13: Adding catch at age and survey data to the 48.3 toothfish CASAL assessment.

# Tag recaptures

## Source data/Values

## Processing

Tags are matched and included as recaptures based on the following criteria:

* At least one of the release tags matches at least one of the tags recorded at recapture
* Both recapture and release species are “TOP”
* The tag was released and recaptured in 483
* The recapture season is after the release season (in year recaptures are deducted from the releases), and within 4 years
* Recapture length between 60 and 120cm
* Release length between 40 and 150cm

## Model representation

Estimation.csl

@tag\_recapture 2003Tags

...

@tag\_recapture 2016Tags

tag\_name 2016Tags

sample size

detection\_probability 1

years 2017

step 2

proportion\_mortality 1.0

plus\_group True

class\_mins 60 70 80 90 100 110

recaptured\_2017 1 14 61 78 20 4

scanned\_2017 4373.39 36605.95 89630.76 77711.21 31043.21 10148.01

do\_bootstrap True

r 1e-11

dispersion 8.681729

@fish\_tagged\_penalty

label 2003TagPenalty

tagging\_episode 2003Tags

multiplier 1

...

@fish\_tagged\_penalty

label 2016TagPenalty

tagging\_episode 2016Tags

multiplier 1

## Notes

Recapture data is from 2006-present. For each tagging cohort, the four following years recaptures are included. Scanned numbers based on raised numbers at length.

Dispersion factor calculated in WG-FSA-11/33-rev-1, recalculated as part of the Francis weighting

## References

WG-SAM-17/35 looking at tag recapture duration

# Catches

The catch is split into two sections based on the availability of age data

Pot data not included as it is insignificant

Future catches (for 35 years based on the CCAMLR harvest control rule)

## Source data/Values

## Processing

Catches from 2004 to present are corrected for mammal observation using a GLM with factors nationality, year, month, depth band, area and cetacean presence. The correction factor is the difference between predictions with and without cetaceans, multiplied by the proportion of lines on which cetaceans are observed.

Early catch doesn’t quite match with Hillary 2006

### Scripts

### 1\_CPUE\_SG3 inputs.r

### Assumptions

## Model representation

Population.csl

@fishery FSG1

years 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997

catches 517 732 1954 876 6962 6828 3554.511116 6909.703852 7085.869088 5279.923763 5020.649006 3606.633227 3888.146453

U\_max 0.99999

selectivity SelSG1

@fishery FSGS2

#After correction for depredation since 2004

years 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

catches 3409.777963 4386.914453 6087.082453 4357.774257 5887.269594 7615.662 <Values from 2004 onwards change each year>

future\_years 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052

future\_catches <Constant value to achieve CCAMLR objectives>

Estimation.csl

@catch\_limit\_penalty

label catch\_limit

log\_scale False

fishery FSG1

multiplier 100

@catch\_limit\_penalty

label catch\_limit

log\_scale False

fishery FSGS2

multiplier 100

# Catch composition

The catch is split into two sections based on the availability of age data, For 1988-1997 catch is broken down into 10cm length bins (40-230). Since 1998, the observed length distribution is raised to an age distribution using a year-specific age length relationship based on around 200-300 otoliths.

### Visualisation

The standardised proportions at age show that there are is some internal consistency within the aging, but the strong cohorts are not always linear, suggesting that there is some aging error. Consecutive cohorts seem to be well correlated, suggesting that either there is autocorrelation in recruitment, or that the error in aging is causing a smudging of the cohorts.



Figure 1: Standardised proportions at age (mean and standard deviation of each age equal)

## Model representation

Population.csl

@selectivity\_names SelSG1 SelSGS2 SelSurvey

@selectivity SelSG1

all double\_normal 12 2.95 14.22

@selectivity SelSGS2

all double\_normal 8.63 1.17 9.79

Estimation.csl

@catch\_at FSG1Catch

years 1988 ... 1997

fishery FSG1

at\_size True

sexed False

sum\_to\_one True

plus\_group False

class\_mins 40 ... 230

1988 <Proportions at age data>

...

1997

dist multinomial

N\_1988 <Number of otoliths read>

...

N\_1997

r 1e-11

#1998-2002 historic data,

#2003-2014 CCAMLR data with catch correction for depredation

#2015 TRAFISH data with catch correction for depredation

@catch\_at FSGS2Catch

years 1998 ... 2017

fishery FSGS2

at\_size False

sexed False

sum\_to\_one True

plus\_group False

min\_class 4

max\_class 47

1998 <Proportions at age data>

...

2017

dist multinomial

r 1e-11

#Sample sizes initially set to the number of otoliths aged

N\_1998 <Number of otoliths read>

...

N\_2017

@estimate

parameter selectivity[SelSG1].all

lower\_bound 1 0.05 0.05

upper\_bound 50 50 500

prior uniform

phase 1

@estimate

parameter selectivity[SelSGS2].all

lower\_bound 1 0.05 0.05

upper\_bound 50 50 500

prior uniform

phase 1

## Notes

Catch sampling for otoliths has varied in recent years between random sampling and stratified sampling. This results in differences between years in the von Bertalanffy parameters.

Both catch selectivities end up being estimated as very close to flat-topped, so no obvious problem with a cryptic biomass sustaining the stock.

# CPUE

## Source data/Values

## Processing

A GLM with factors nationality, year, month, depth band, area and cetacean presence is applied to data since 2003. A standardised prediction is made for years 2004-present to give the CPUE index and cv. CPUE from 1998-2003 is not updated each year.

## Model representation

Estimation.csl

@relative\_abundance CPUESG2

biomass True

q CPUESG2q

years 1998 1999 2000 2001 2002 2003

step 2

ogive SelSGS2

proportion\_mortality 0.5

1998 291.357

1999 353.9203

2000 404.16

2001 364.5833

2002 367.8804

2003 437.5982

cv\_1998 0.029465484

cv\_1999 0.026152357

cv\_2000 0.021927764

cv\_2001 0.023762882

cv\_2002 0.021481778

cv\_2003 0.015567477

dist lognormal

cv\_process\_error .05

@estimate

parameter relative\_abundance[CPUESG2].cv\_process\_error

lower\_bound 0.001

upper\_bound 5

prior uniform

phase 1

MCMC\_fixed true

@estimate

parameter q[CPUESG2q].q

lower\_bound 1e-8

upper\_bound 1e-1

prior uniform-log

phase 1

@relative\_abundance CPUESG3

biomass True

q CPUESG3q

years 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

step 2

ogive SelSGS2

proportion\_mortality 0.5

2004 <Varies each year>

…

2017

cv\_2004 <Varies each year>

…

cv\_2017

dist lognormal

cv\_process\_error .05

@estimate

parameter relative\_abundance[CPUESG3].cv\_process\_error

lower\_bound 0.001

upper\_bound 5

prior uniform

phase 1

MCMC\_fixed true

@estimate

parameter q[CPUESG3q].q

lower\_bound 1e-8

upper\_bound 1e-1

prior uniform-log

phase 1

## References

WG-FSA-10/P06 describes the standardisation of the CPUE.

# Survey

Primarily for icefish, the survey produces an index of recruitment around Shag Rocks.

## Model representation

Estimation.csl

@relative\_abundance Survey

years 1987 1988 1990 1991 1992 1994 2000 2002 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2015 2017

step 1

proportion\_mortality 0.5

q Surveyq

biomass True

ogive SelSurvey

1987 301.7713067

1988 727.2887557

1990 1752 # 5142.626012

1991 771.5069343

1992 1379.788214

1994 1467.5197

2000 502.4634315

2002 758.1715134

2004 323.2983502

2005 410.1716331

2006 392.9253769

2007 15.39489011

2008 79.79823064

2009 61.88936806

2010 137.0508893

2011 2633.338326

2012 105.9

2013 218.1

2015 119.209

2017 21.132

cvs\_1987 0.302372117

cvs\_1988 0.68030303

cvs\_1990 0.490 # 0.56679868

cvs\_1991 0.353267579

cvs\_1992 0.359258936

cvs\_1994 0.50560166

cvs\_2000 0.451717902

cvs\_2002 0.361572376

cvs\_2004 0.4066967

cvs\_2005 0.351062012

cvs\_2006 0.392693142

cvs\_2007 0.577856184

cvs\_2008 0.433094592

cvs\_2009 0.548667745

cvs\_2010 0.284156803

cvs\_2011 0.7712253

cvs\_2012 0.380

cvs\_2013 0.713

cvs\_2015 0.472672

cvs\_2017 0.582

dist normal

cv\_process\_error 0.5

@estimate

parameter relative\_abundance[Survey].cv\_process\_error

lower\_bound 0.001

upper\_bound 5

prior uniform

phase 1

MCMC\_fixed true

@estimate

parameter q[Surveyq].q

lower\_bound 1e-8

upper\_bound 1e-1

prior uniform-log

phase 1

## References

Survey reports are listed in Table 1, e.g. WG-FSA-17/44

# Survey length composition

The samples are not currently aged routinely, but sensitivities using aged compositions where available showed similarly poor fit to the model.

## Model representation

Population.csl

@selectivity SelSurvey

all double\_normal 2 1.17 9.79

Estimation.csl

@proportions\_at SurveyLength

years 1987 1988 1990 1991 1992 1994 2000 2002 2004 2005 2006 2007 2008 2010 2011 2012 2013 2015 2017

step 1

proportion\_mortality 1.0

at\_size True

sexed False

sum\_to\_one True

plus\_group False

ogive SelSurvey

class\_mins 10 15 ... 75

1987 <Proportions by length class and year>

...

2017

N\_1987 <Number of hauls in Shag Rocks>

...

N\_2017

dist multinomial

r 0.00001

@estimate

parameter selectivity[SelSurvey].all

lower\_bound 1 0.05 0.05

upper\_bound 30 40 500

prior uniform

phase 1

## References

Survey reports are listed in Table 1, e.g. WG-FSA-17/44

# Model Output

## Source data/Values

## Processing

### Scripts

### Assumptions

## Model representation

Output.csl

@print

parameters false

fits\_every\_eval false

objective\_every\_eval false

parameters\_every\_eval false

parameter\_vector\_every\_eval false

fits true

resids true

pearson\_resids true

normalised\_resids true

estimation\_section true

requests false

initial\_state false

state\_annually t

state\_every\_step true

final\_state true

results false

yields true

unused\_parameters true

covariance True

@quantities

all\_free\_parameters true

fishing\_pressures true

nuisance\_qs true

B0 true

R0 true

SSBs true

recruitments true

YCS true

true\_YCS true

actual\_catches false

ogive\_parameters selectivity[SelSG1].all selectivity[SelSGS2].all #selectivity[SelSGSD].all

fits true

normalised\_resids false

tagged\_age\_distribution true

@print\_sizebased\_ogives\_at 10 15 ... 220

@selectivity\_at SelSG1-at-age

ogive SelSG1

years 2000

step 2

proportion\_mortality 0.5

sexed False

@selectivity\_at SelSGS2-at-age

ogive SelSGS2

years 2000

step 2

proportion\_mortality 0.5

sexed False

@abundance vulnerable

biomass true

mature\_only false

step 2

proportion\_mortality 0.5

ogive SelSGS2

years 1985 ... 2017

# Data weighting

The data weighting is an iterative process. Initially the following weights are assigned to the data sources:

* Catch CPUE: Estimated cv, process error = 0.05
* Catch length distribution 1988-1997: Historic values for sample size, r=1e-11
* Catch age distribution 1998-present: Number of otoliths aged, r=1e-11
* Survey abundance: estimated CV, process error = 0.5
* Survey proportions at length: Number of hauls in Shag Rocks, multinomial r=0.00001
* Aging error: c=0.1
* Tag recaptures: r=1e-11, dispersion=8.681729

The weighting steps are as follows:

1. The model is run with the default weightings
2. The effective sample size of the catch proportions at age and length is scaled according to method TA1.8 from the R dataweighting package. Process errors for catch and survey compositions are constrained to be small (less than 0.002) and the model is rerun.
3. The effective sample size of the catch proportions at age and length is scaled according to method TA1.8 from the R dataweighting package and the model is rerun.
4. Tag dispersion is rescaled according to the method Reweight.tags in the dataweighting package.
5. Process errors for catch and survey compositions are freed up to be estimated and the model is rerun

# Papers used in the development of the assessment

Table 1: Papers relevant to the assessment of Toothfish in 48.3

|  |  |
| --- | --- |
| **Meeting** | **Paper summary** |
| FSA-17 | WG-FSA-17/44 Report of the UK groundfish survey at South Georgia (CCAMLR Subarea 48.3) in January 2017. M. Belchier, V. Foster, S. Gregory, S. Hill, V. Laptikhovsky, P. Lafite and L. Featherstone  *Icefish survey report used to provide index of TOP recruitment*  WG-FSA-17/53 Assessment of Patagonian toothfish (D. eleginoides) in Subarea 48.3. T. Earl and S. Fischer  *Update of assessment using partial data from 2016/17 season.*  WG-FSA-17  *3.20 Recommends to only use complete seasons of data that have been quality checked by the CCAMLR secretariat in future.*  *3.21 Recommends fitting survey as biomass and proportions in composition (Already done)*  *3.26 Look at additional work to identify the source of successively decreasing estimates of SSB0 between assessments.* |
| SAM-17 | WG-SAM-17/35 Sensitivities in the assessment of the Patagonian toothfish (D. eleginoides) in Subareas 48.3 and 48.4 to truncation of tagging data. T. Earl  *Looking at the effect of including different numbers of years post release in the assessment. No change to 48.3 (48.4 reduced from 6 to 4 years for consistency). There is some outstanding bias in the tag recaptures not explained by the double-tagging effect.*  WG-SAM-17  *2.12 Recommendation to re-estimate the tag loss and instantaneous mortality using the most up to date data. Reduce years if tagging to four to reduce bias from double-tagging.* |
| FSA-16 | NA |
| SAM-16 | NA |
| FSA-15 | WG-FSA-15/30 Report of the UK groundfish survey at South Georgia (CCAMLR Subarea 48.3) in January 2015. M. Belchier, S. Gregory, N. Fallon, J. McKenna, S. Hill, M. Soffker (United Kingdom), P. Lafite (South Africa) and L. Featherstone (United Kingdom)  *Icefish survey report used to provide index of TOP recruitment*  WG-FSA-15/59 Assessment of the Patagonian Toothfish (D. eleginoides) in Subarea 48.3. T. Earl, M. Soeffker and C. Darby (United Kingdom)  *Update of assessment*  WG-FSA-15  *4.34 Investigate sources of mis-fitting to age composition and survey index*  *4.36 Evaluate the effect of alternative data weighting approaches*  *4.117(i)-(vii) Areas to develop stock assessments* |
| SAM-15 | WG-SAM-15/29 Fishery selection for Patagonian toothfish in CCAMLR Subarea 48.3, asymptotic or dome shaped? C. Darby, V. Laptikhovsky and M. Soeffker (United Kingdom)  *Dome shaped selectivity unlikely*  WG-SAM-15/30 A potential link between the D. eleginoides stocks of Statistical Subareas 48.3 and 48.4. M. Soeffker, M. Belchier and V. Laptikhovsky (United Kingdom)  *Tags between 48.4 and 48.3 (mostly males moving to SG and females to SR) Lack of older and younger fish in 48.4 and different growth curves.*  *WG-SAM-15*  *2.23 Recommendation to document choice of priors* |
| Other 2015 | Sensitivity testing for Patagonian toothfish in Subarea 48.3 (Earl 2015, unpublished)  *Investigating the impact of uncertainty in length-weight relationship, recruitment steepness and age-length relationship on the assessment estimates of historic stock development.*   * *The length-weight relationships were estimated consistently, and so only a minor change to the assessment was observed by using values from different years.* * *Steepness in the range 0.4-0.99 had little impact on the stock development* * *The age-length relationships were estimated based on data from each year 1998-present. Using each of these estimates as the input parameters for the assessment resulted in a wide range of stock development, the current assumed values are at the extreme end of the range leading to higher biomasses and lower exploitation rate.* |
| FSA-14 | WG-FSA-14/49 Nine years of tag-recapture in CCAMLR Statistical Subarea 48.3 – Part II: Spatial movement and analysis. M. Soeffker, C. Darby and R.D. Scott (United Kingdom)  *Looking at maturity of females, and distances travelled by tagged fish between release and recapture* |
| SAM-14 | WG-SAM-14/35 Nine years of tag-recapture in CCAMLR Statistical Subarea 48.3 – Part I: General data characterisation and analysis. M. Soeffker, C. Darby and R.D. Scott (United Kingdom)  *Tag overlap, and growth impairment effect by vessel*  WG-SAM-14  2.29 CASAL version 2.30-2012-03-21 rev 4648 be considered the current approved CCAMLR version |
| FSA-13 | WG-FSA-13/17 Report of the 2013 UK South Georgia Groundfish Survey (CCAMLR Subarea 48.3)  M. Belchier, S. Gregory, K. Brigden, D. Johnston, N. Fallon and L. Featherstone (United Kingdom)  *Icefish survey report used to provide index of TOP recruitment*  WG-FSA-13/29 A brief characterisation of Patagonian toothfish tag survival and tag detection in CCAMLR Statistical Area 48.3. M. Soeffker and R. Scott (United Kingdom)  *Tag loss rate from double tagging and tag detection by vessel*  WG-FSA-13/30 Preliminary assessment of Patagonian toothfish in Subarea 48.3  R. Scott (United Kingdom)  *Update of assessment*  *Investigation of splitting catch time series into 2 vs 3 periods*  WG-FSA-13  *4.18 Re-estimate survey process error, and age survey*  *4.19 Recommended using 2-fleet model*  *4.21 Use average recruitment and CV from 1992-2006 for projections*  *4.93 MPD B0 estimates are validated by the secretariat rerunning assessment.*  *4.96 Differences in B0 from different versions of CASAL not explained* |
| SAM-13 | NA |
| FSA-12 | WG-FSA-12/37 Results from the reduced groundfish survey conducted in CCAMLR Subarea 48.3 in January 2012. J. Brown, S. Gregory, A. Stanworth, V. Carretero, G. Baker and M. Belchier (United Kingdom)  *Icefish survey report used to provide index of TOP recruitment* |
| SAM-12 | WG-SAM-12/19 Movement of Patagonian toothfish (Dissostichus eleginoides) in Subarea 48.3. T. Peatman, S.M. Martin, J. Pearce and R.E. Mitchell (United Kingdom)  *Movement rates low, around 30km/yr* |
| FSA-11 | WG-FSA-11/29 Results from the groundfish survey conducted in CCAMLR Subarea 48.3 in January/February 2011. J. Brown, S. Gregory, K. Brigden, R. Benedet, O. Hogg, P. Brewin and L. Featherstone (United Kingdom)  *Icefish survey report used to provide index of TOP recruitment*  WG-FSA-11/33 Rev. 1 Preliminary assessment of toothfish in Subarea 48.3. T. Peatman, R.E. Mitchell, G. Parkes and D.J. Agnew (United Kingdom)  *Derivation of 0.006377 tag loss factor*  *Depredation correction of CPUE included*  *Discussion of 2 vs 3 fleet model*  WG-FSA-11  *4.19 Concern about poor fit to recruitment survey, but current weighting approach is appropriate*  *6.17 Removal of historic data should be accompanied by justification and assessment of impact* |
| SAM-11 | WG-SAM-11/12 Models of tag shedding for double tagging as a function of time at liberty and approximate solutions for the single tagging model in CASAL. S.G. Candy (Australia)  WG-SAM-11/18 Estimates of the tag loss rates for single and double tagged toothfish (Dissostichus mawsoni) fishery in the Ross Sea. A. Dunn, M.H. Smith (New Zealand), D.J. Agnew (UK) and S. Mormede (New Zealand)  *Discussion of double tagging effect, and its application to the Ross Sea fishery* |
| FSA-10 | WG-FSA-10/38 Results of the groundfish survey carried out in CCAMLR Subarea 48.3 in January 2010. R.E. Mitchell, M. Belchier, S. Gregory, L. Kenny, J. Nelson, J. Brown and L. Feathersone (UK)  *Icefish survey report used to provide index of TOP recruitment*  WG-FSA-10/P05 The Patagonian toothfish: biology, ecology and fishery. M.A. Collins, P. Brickle, J. Brown and M. Belchier  *Everything about Toothfish*  WG-FSA-10/P06 Estimating the impact of depredation by killer whales and sperm whales on longline fishing for toothfish (Dissostichus eleginoides) around South Georgia. J. Moir Clark and D.J. Agnew  *Background to the depredation model used to estimate total fisheries removal and CPUE.*  WG-FSA-10/35 Results of the research fishing activities conducted by Chile in Management A of Subarea 48.3 from 2005–2008: the importance of conserving the big older fishes. C.A. Moreno and P. Rubilar (Chile)  *Summary of CPUE and catch characteristics of catch in 48.3A* |
| SAM-10 | WG-SAM-10/11 Rev. 1 Estimation of natural mortality using catch-at-age and aged mark-recapture data: a simulation study comparing estimation for a model based on the Baranov equations versus a new mortality equation. S.G. Candy (Australia)  *Simulation testing estimation of M*  WG-SAM-10  *Discussion of estimates of M* |
| FSA-09 | WG-FSA-09/09 REPORT OF THE UK GROUNDFISH SURVEY AT SOUTH GEORGIA (CCAMLR SUB-AREA 48.3) IN JANUARY 2009  M. Belchier, R.E. Mitchell, M.A. Collins, L. Kenny, M. Taylor, J. Nelson and L. Featherstone (United Kingdom)  *Icefish survey report used to provide index of TOP recruitment*  WG-FSA-09/16 DEPREDATION AROUND SOUTH GEORGIA AND THE IMPLICATIONS ON STOCK ASSESSMENT OF D. ELEGINOIDES. J. Moir Clark, D.A. Agnew, P. McCarthy and M. Unwin (United Kingdom)  *Origin of catch correction model*  WG-FSA-09/22 Rev. 1 COMPARISON OF THE PRECISION OF DIRECT VERSUS AGE LENGTH KEY METHODS OF ESTIMATING CATCH-AT-AGE PROPORTIONS  S.G. Candy (Australia)  *Sampling ages based on length binned samples rather than unbinned samples*  WG-FSA-09/28 Rev. 1 PRELIMINARY ASSESSMENT OF TOOTHFISH IN SUBAREA 48.3. D.J. Agnew and T. Peatman (United Kingdom)  *Tag data 2000-2009 included in paper (only 2003 onwards used in assessment)*  *Inclusion of survey data (1999-2008)*  *Change to catch at age from catch at length* |
| SAM-09 | WG-SAM-09/13 ADDING CATCH AT AGE AND SURVEY DATA TO THE 48.3 TOOTHFISH CASAL ASSESSMENT  D.J. Agnew and M. Belchier (United Kingdom)  *Investigating the suggestions from FSA-07*  *Growth parameters estimated within model?*  *investigate sex disaggregation*  *3.5 Incorporating survey data into assessment – exclude September surveys, use length frequencies for all available surveys.* |
| FSA-08 | WG-FSA-08/28 GROUNDFISH SURVEY IN CCAMLR SUB-AREA 48.3 IN APRIL 2008 WITH PRELIMINARY ASSESSMENT OF MACKEREL ICEFISH  M.A. Collins, R.E. Mitchell, C.E. Main, J. Lawson, J. Watts, J. Slakowski, L. Featherstone and O. Rzewuski (UK)  *Icefish survey report used to provide index of TOP recruitment* |
| SAM-08 | NA |
| FSA-07 | WG-FSA-07/29 Preliminary assessment of the South Georgia toothfish stock, 2007. D.J. Agnew, R. Hillary and J. Pearce (United Kingdom)  WG-FSA-07  *Report: Investigate issues including use of catch-at-age and tag recapture at length bias in 48.3 assessment.* |
| SAM-07 | WG-SAM-07/13 An assessment strategy evaluation framework for testing the application of a CASAL based management system to the HIMI fishery  I.R. Ball and S.G. Candy (Australia)  WG-SAM-07/7 Comparison of estimators of effective sample size for catch-at-age and catch-at-length data using simulated data from the Dirichlet-multinomial Distribution  S.G. Candy (Australia)  *Method of calculating sample size* |
| FSA-06 | WG-FSA-06/51 Report of the South Georgia groundfish survey (Subarea 48.3) in January 2006. M.A. Collins, C. Jones, J. Clark. S. Fielding, J. Slakowski, T. North, W. Reid and J. Watts (United Kingdom)  *Icefish survey report used to provide index of TOP recruitment*  WG-FSA-06/53 Assessment of toothfish in Subarea 48.3, 2006  D.J. Agnew, R. Hillary, M. Belchier, J. Clark and J. Pearce (United Kingdom)  WG-FSA-06/54 Estimates of natural and fishing mortality from toothfish mark–recapture and catch-at-age data at South Georgia  R.M. Hillary and D.J. Agnew (United Kingdom)  WG-FSA-06/59 A proposal methodology to assess the Patagonian toothfish stock abundance at CCAMLR Subarea 48.3 using ASPM  O.C. Wöhler and P.A. Martínez (Argentina) |
| FSA-SAM-06 | WG-FSA-SAM-06/06 Using mark-recapture and catch-age data to estimate fishing and natural mortality for the Patagonian toothfish at South Georgia. R.M. Hillary and D.J. Agnew (United Kingdom)  WG-FSA-SAM-06/13 Review of some assumptions for modelling Patagonian toothfish dynamics at CCAMLR Subarea 48.3  A. Aubone, P.A. Martínez and O.C. Wöhler (Argentina) |
| Other 2006 | Hillary, R.M., G.P. Kirkwood and D.J. Agnew (2006), An assessment of toothfish in Subarea 48.3 using CASAL. CCAMLR Science  *Description of the first CASAL assessment for 48.3.*   * *Tag loss rate: 0.0036y-1* * *Initial Tag mortality: 10%* * *Growth retardation period: 6 months* * *M: 0.165* * *Maturity at length parameterisation* * *External estimates of sample size for catch proportions at length, CPUE CV followed by an iterative reweighting for one step.*   *Sensitivities:*   * *Including survey estimates of young fish* * *Two fleets for catch vs one* * *Varying M* * *Varying h (stock recruit steepness)* * *Alternate growth models* * *Removing CPUE* * *Removing tagging data* * *Removal of tagging cohorts* |
| FSA-05 | WG-FSA-05/18 Parameters for the assessment of toothfish in Subarea 48.3. D.J. Agnew, G.P. Kirkwood, A. Payne, J. Pearce and J. Clarke (United Kingdom)  *Beverton-Holt invariants presented*  WG-FSA-05  4.18 Discussion about recruitment uncertainty in projections |

1. Throughout this document the data included is that which was available at the end of the 2016/17 fishing season, i.e. the extent of the data is the same as for the assessment presented at WG-FSA-17. [↑](#footnote-ref-1)