# 2017 – 2018 Sustainability Measures

## *Patagonian Toothfish (Dissostichus eleginoides)*



TOO-SM-2018

**Falkland Islands Government**
**Directorate of Natural Resources**
**Fisheries Department**
**Stanley, Falkland Islands**

**09 May 2018**

DESIRE THE RIGHT

## Contributing Scientific Staff

Thomas J. Farrugia, Haseeb S. Randhawa, Andreas Winter, Alexander Arkhipkin


Falkland Islands Government
Directorate of Natural Resources
Fisheries Department
PO BOX 598
Stanley, Falkland Islands
Tel: +500 27260
Fax: +500 27265

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Director of Natural Resources

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## Toothfish Fishery

**Designated on Schedule 2:**    Falkland Islands Gazette Vol 16 No. 17 15 September 2005

**Amended:**    Falkland Islands Gazette Vol 16 No. 24 23 December 2005

**ITQ Register Opened:**    1 January 2006, Falkland Islands Gazette Vol. CXIV No. 18 31 December 2005

**Dates within which the Fishery Operates:** 1$^{st}$ January – 31$^{st}$ December

**Valid Fishing Areas:** Falkland Island Conservation Zones in depths greater than 600 m (Figure 1).

**Seasonally Closed area:** 32,412 km$^2$, closed 01 June – 31 August (Figure 1).
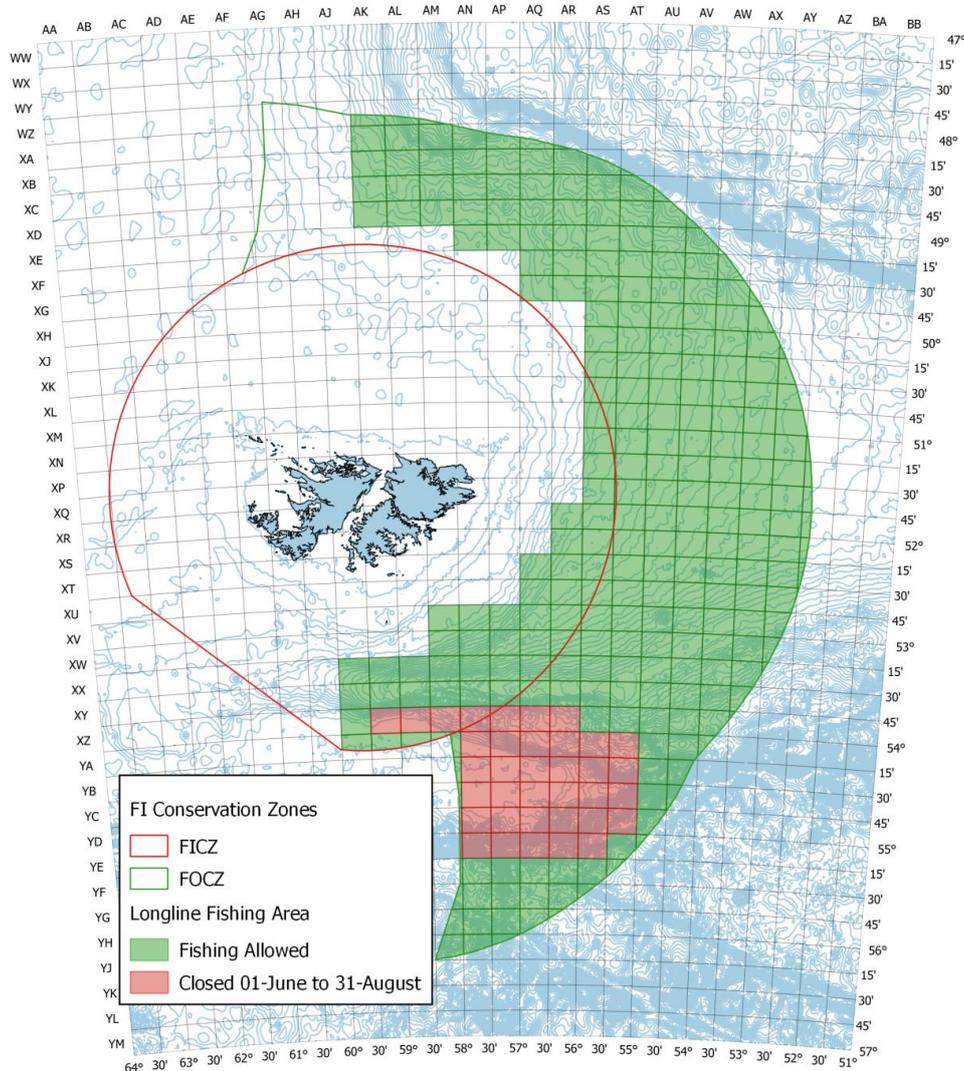


**Figure 1.** *Map of the FICZ, FOCZ and seasonally closed area for the longline fishery*

**Fishery Timetable**

| Date | Event |
|---|---|
| 1st January | Fishery opens |
| March | Data review on previous year's fishery |
| April/May | Stock Assessment |
| Jun/July | Industry presentation and consultation |
| August | Final review and gazetting of TAC/TAE information |
| September | Advise ITQ holders of TAC or TAE and Catch Entitlements for forthcoming year |
| By 1st October | Set Vessel Units, Allowable Effort and Allowable Catch Complete VU, TAE and TAC Report for Industry Input to Fisheries Department Budget Proposals Allocation of staff and resources |
| November | ITQ holders to submit information as to how catch entitlements will be exercised |
| 31st December | Fishery Closes |

**Vessels (2017)**

There is currently one longliner operating full time in the Falkland Islands fishing zones, the *CFL Hunter* which replaced the *CFL Gambler* in May 2017. The CFL Gambler had been operating in the Falklands since 2004. In 2016, *CFL Gambler* operated in Falkland waters for a total of 200 fishing days (197 on the longline (L) licence; 3 on the experimental (E) licence), alternating between the north-eastern and southern parts of FICZ/FOCZ. In 2017, due to the transition to the new vessel, the *CFL Hunter,* longline fishing only took place on 181 days (178 on L-licence; 3 on E-licence) primarily in the north-eastern and southern parts of the FICZ/FOCZ. The *CFL Hunter* was not ready to fish commercially until July 2017, therefore two other longline vessels were chartered in order to reach the TAC, and these accounted for 23% of the toothfish longline catch.

**TAC (2018)**
- 1,040 tonnes green weight
- TAC to be reviewed every year as new information becomes available
- Up to 15% of the TAC may be carried forward to the following year or brought forward from the next year. Such carryovers can only operate from one year to the next and cannot accumulate over multiple years. Any revision of the TAC could override any such carryover in TAC

## Harvest Control Measures

Harvest levels are set using a precautionary approach in two ways. First, the major sources of uncertainty in harvest levels, namely unreported (IUU) catches and whale depredation, are now explicitly taken into account (see Toothfish Stock Assessment). Secondly, the fishing mortality ratio ($F/F_{MSY}$) is capped at 2/3 $F_{MSY}$ (Figure 2) as suggested by the UN Food and Agriculture Organization (Caddy and Mahon, 1995; Doubleday, 1976) and used for species like carangids (Khalifa and Mehanna, 2006), and Greenland halibut (ICES, 2001) which live in deep cold waters and have a long life span. This provides a buffer between the estimated catch that ensures MSY and the actual harvest of toothfish. Although the $F/F_{MSY}$ ratio has been slowly increasing over the last 5 years, we are still well below a 2/3 ratio (Figure 3).

The age-structured production model in CASAL generates annual estimates of biomass and spawning stock biomass (SSB), and can calculate forward projections of these estimates pursuant to assumptions of future catches. Based on the CASAL model output, the following illustrative figure and decision matrix of harvest control rules have been established to manage the Falkland Islands toothfish longline fishery.
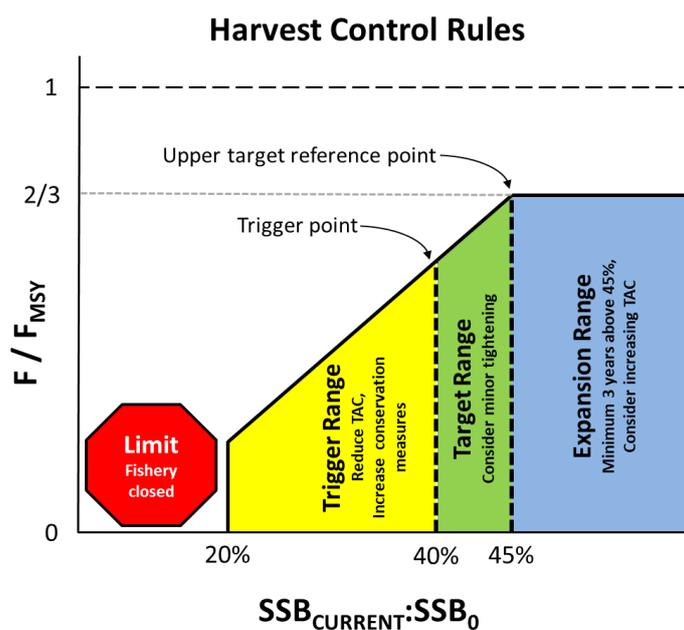


**Figure 2. FIFD toothfish fishery Harvest Control Rules.** *Levels of Spawning Stock Biomass (SSB) reference points with corresponding changes in fishing mortality. Fishing mortality is capped at 2/3 $F_{MSY}$ (grey dashed line) as a precautionary approach. See decision matrix for more detailed description at each reference point. Diagram is illustrative only and not to scale.*

Decision matrix:

1. **Expansion range:** If the ratio of $SSB_{current}$:$SSB_0$ has remained above the upper target reference point (45%) for 3 consecutive years and the SSB projection with the current TAC shows no decrease below 45% for at least 10 years (one generation) under precautionary assumptions, the Director may authorize an increase in longline TAC to a level that continues to show no projected $SSB_{current}$:$SSB_0$ decrease to below 40% (trigger point) for at least 10 years under precautionary assumptions.

2. **Target range:** If the ratio of $SSB_{current}:SSB_0$ is between 40% and 45% (within the target range), current longline TAC is reviewed in relation to stock trends. Current TAC may be maintained if $SSB_{current}:SSB_0$ has increased from the previous assessment, or if the SSB ratio projection shows a level status under precautionary assumptions. TAC may not be increased, but it may be decreased if age-structure distributions anticipate weak recruitment.

3. **Trigger point and range:** If the ratio of $SSB_{current}:SSB_0$ falls to ≤ 40% (trigger point), longline TAC will be decreased to a level that projects an increasing SSB trend under precautionary assumptions. The magnitude of the proposed TAC reduction will be examined using three methods (adapted from ICES, 2017):
   a. Indexed to the reduction of the MSY estimates
      i. $TAC_{year} = TAC_{year-1} * (MSY_{year} / MSY_{year-1})$
   b. Indexed to the reduction of the SSB estimates
      i. $TAC_{year} = TAC_{year-1} * (SSB_{year} / SSB_{year-1})$
   c. Indexed to the reduction in SSB ratios
      i. $TAC_{year} = TAC_{year-1} * (SSB\ ratio_{year} / SSB\ ratio_{year-1})$

TACs obtained from all three methods will be projected forward in the stock assessment model and the trends in SSB will be compared. The final method will be chosen based on it returning the SSB ratio to above 40% within 10 years (one generation) of the SSB ratio falling below 40%. If more than one method meets this requirement, the chosen method will also depend on discussions between the Fisheries Department and industry.

4. **Limit reference point:** If the ratio of $SSB_{current}:SSB_0$ is ≤ 20%, the longline fishery will be closed pending comprehensive evaluation of conditions required to rebuild the stock. The Director may authorize test fishing to measure biological parameters of the stock, subject to close monitoring by the Fisheries Department.
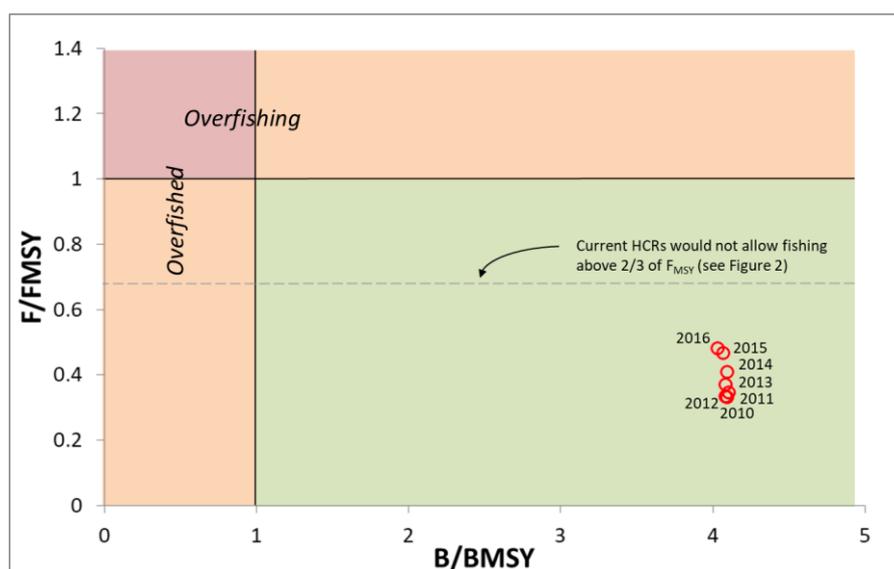


***Figure 3.*** *Kobe plot of the ratio of biomass to biomass at MSY vs. the ratio of fishing mortality to fishing mortality at MSY from 2010 to 2016. The grey dashed line represents the 2/3 $F_{MSY}$ level.*

## Conservation and Management Priorities

**Ensure the long-term sustainability and prevent the over-fishing of toothfish**
- Maintain the Spawning Stock Biomass (SSB) at 45% or higher of $SSB_0$.
- Limit the toothfish catch by longliners (or potters) to the sustainable catch limit (annual TAC).
- Minimize toothfish bycatch in other fisheries, particularly of juveniles on the shelf.
- Keep spawning areas protected from impacts of fishing during spawning season (i.e. Burdwood Bank spawning grounds closure). Limited access may be granted for research purposes.
- Continue research on the biology and ecology of toothfish, and on the prosecution of the fishery (e.g. conversion factor of HGT to green weight, effect of hook size on catch, etc…).

**Reduce impacts on seabirds, marine species (including bycatch), habitats and VMEs**
- Continue to implement the management strategy on reducing incidental seabird mortalities set out in the National Plan of Action – Longlining plan, and achieve all targets set out in the plan.
- Maintain coverage by Scientific Observers to collect data and enforce other procedures which reduce impacts.
- Encourage and help maintain the culture of "good housekeeping" on longliners with respect to seabirds, bycatch and other best-practice licence conditions.
- Better understand the habitats and VMEs in the areas where longlining takes place.
- Reduce the impacts of fishing on sensitive benthic ecosystems.

**Management, compliance and catch documentation**
- Maintain full VMS coverage in and out of Falkland Islands Government Conservation Zones.
- Ensure full compliance with the *Dissostichus* Catch Documentation Scheme.
- Maintain monthly fisheries monitoring reports for toothfish.
- Maintain the regular monitoring of TAC usage within the longline fishery.
- Ensure daily catch reporting via e-log books is continuous and accurate.

# Sustainability Strategies and Research Objectives

➢ **Target species**

1. Update and refine the stock assessment model as needed.

*2016 update: Inclusion of catches out-of-zone, optimizing natural mortality, and empirically evaluating the umbrella factor.*

*2017 update: IUU catches were estimated along with unrecorded whale depredation; Spanish-system longline and umbrella-system longline were modelled as different fisheries; and the two components of the objective function were re-weighted to equalize between the CPUE index fits and the catch-at-age distribution fits.*

Current objectives:

- Run computer simulations to project trends of SSB over time under different TAC scenarios, and to evaluate the harvest control rules under different stock conditions
- Incorporate new research findings into stock assessment model (e.g. growth and age structure will be used to refine length-at-age parameters and calculate catch-at-age)

2. Conduct focused research projects to address knowledge gaps in the biology and ecology of toothfish, particularly for issues related to the fishery. These projects should lead to peer-reviewed publications.

*2017 update:*

- *Ongoing research projects to better understand toothfish stock discrimination in the south Atlantic (otolith microchemistry and shape analysis, toothfish morphology, tagging, and demography). Other research projects include toothfish growth, age-structure, and recruitment index.*
- *A survey of juvenile toothfish distribution was undertaken in January 2017 (report ZDLT1-01-2017). Substantial nursery grounds of juvenile toothfish (10-12 cm total length) were found in shallow waters of the southern part of the Falkland Shelf at depths 70-110 m. There, juvenile toothfish benefit on preying small rock cod (4-5 cm total length) and compete for this resource with similar sized icefish. There is no large predatory fish present as both next generation of toothfish (25-32 cm) and icefish (30-32 cm) inhabit deeper waters off shelf (120-140 m).*
- *A total of 1,033 toothfish have been tagged to date. There have been 19 recaptures. 5 satellite tags were also deployed during the June 2017 CFL Hunter research cruise.*

Current research objectives:

- Complete the reports and overall conclusion from the stock discrimination studies and the investigation into seeding from southern South America.
- Studies to develop a "recruitment index" for better estimation of the shelf population. Data to come primarily from the summer and winter Loligo fishery pre-season surveys.
- Continue the toothfish pulsed-tagging programme through 2019 with the aim of tagging 3,000 toothfish in the longline fishing areas. Tagging will also be undertaken by observers while on the CFL Hunter. Tagging will establish linkages between juveniles on the shelf and adults on the slope and quantify the movement of adults to and from the spawning ground.

Future research objectives:

- Studies of dispersal of larvae and early juveniles from the spawning grounds in Burdwood Bank onto the South Patagonian Shelf.

- Fish identified as "skip-spawners" will be compared to spawners using annual growth rates. In theory, skip-spawning fish should have faster growth rate in the concomitant year. This will be explored using historic and current data.
- Multidisciplinary research cruise will be scheduled for the first part of December 2018 with the main task to contour the distribution of small juveniles before and straight after their arrival to the shallow water nursery grounds.

### 3. Maintain a toothfish sample collection.

*2017 update: The FIFD collection is currently holding 24,540 otolith samples going back to 1999 (of which 5,148 have been aged), and 1,088 histological slides of gonads since 2004.*

Current research objectives:

- 20 fish from FI, Chile and South Georgia are being analysed for morphometrics.
- Over 300 whole frozen gonads from 2014 and 2015 still need to be processed.
- The older samples in the collection will be organized and inventoried.

### 4. Explore potential improvements to fishing gear to better target toothfish.

*2017 update: A hook trial experiment was conducted aboard the CFL Hunter during the June 2017 research cruise. 4 hook types were randomly assigned to sections of longlines and all toothfish and bycatch were measured.*

Current research objectives:

- Determine if hook size or shape influences catch rates of toothfish throughout the Falkland Islands conservation zones.

### 5. Build science capacity at FIFD to address current and future research questions on toothfish.

*2017 update: CFL continues to support 50% of a toothfish scientist position (Brendon Lee) who enrolled in a PhD programme in January 2017. His topic of research is: "Spatial and temporal delineation in the population structure of Patagonian toothfish (*Dissostichus eleginoides*) around the Falkland Islands: ontogenetic and environmental effects".*

Current research objectives:

- Analyse the current state of knowledge about toothfish and identify the most pressing questions to inform future research.

## ➢ **Habitat and ecosystem species**

### 1. Maintain 50% Scientific Observer coverage annually for the longline fleet.

*2017 update: The observer coverage in 2016 was 49.7%, just below the target.*

Current research objectives:

- Continue to assess scientific observer coverage and ensure that it is at least 50%.
- Reassess the duties of observer to make sure that they are collecting the most important data while at sea.

### 2. Continue to collect bycatch data.

*2017 update:*

- *Biological data (length, sex, maturity) are collected for* Antimora rostrata, Macrourus holotrachys *and skate species on a regular basis. Catches of these species remain low with no*

*changes in trends over recent years (FIFD observer data). Opportunistic data are collected from other species and the collection of invertebrate by-catch continues to grow.*

- *Seabird observations continue by observers at roughly 25% of their time on the vessel. In 2016 no sea bird mortalities were observed.*

Current research objectives:
- Ongoing data collection of invertebrate, fish and ETP species caught in the long-line fishery.
- Studies of the main population parameters such as age, growth and reproductive potential are being conducted for by-catch species including *Antimora*, grenadiers and skates.

| 3. | Gather habitat and VME species information during longlining operations, develop a predictive model for the presence of VME species, and determine the impact of the fishing gear on habitats and VMEs. |
|---|---|

*2017 update:*
- *A program to deploy CTDs on a subset of lines off the CFL Hunter was initiated. These data will be used to monitor seasonal and annual temperature and salinity changes in the bottom habitat.*
- *Underwater cameras were deployed on longlines during and after the 2017 CFL Hunter research cruise. The primary aims are to assess the benthic biodiversity in areas targeting toothfish in the FICZ/FOCZ and to assess the impacts of umbrella-system longline on the benthos. This initial test was encouraging that the methodology is feasible.*

Current research objectives:
- Analyse the CTD data, and develop a systematic sampling scheme for the cameras.
- Development of a predictive VME model is underway, which will be used to assess the potential overlap between longline gear and areas of high VME species densities.

| 4. | Examine options to further reduce bycatch. |
|---|---|

*2017 update: A hook trial experiment was conducted aboard the CFL Hunter during the June 2017 research cruise. 4 hook types were randomly assigned to sections of longlines and all toothfish and bycatch were measured.*

Current research objectives:
- Determine if hook size or shape influences rates of bycatch of grenadier, *Antimora*, and skates throughout the Falkland Islands conservation zones.
- Verify the average individual weight currently used to estimate the total weight of bycatch.
- Develop 'move-on' rules (similar to CCAMLR) to avoid large fish and VME bycatch.

| 5. | Develop the invertebrate and fish taxonomic collection held at FIFD. |
|---|---|

Current research objectives:
- FIFD is organising the collection, with the aim of incorporating it into larger institutional curatorial databases overseas, such as the British Natural History Museum in London.

| 6. | Regularly update observer manuals and NPOA documents. |
|---|---|

Current research objectives:
- Both the observer manual and NPOA for seabirds are being revised to ensure that they reflect the current management and research strategies of the FIFD.

> ➢ **Management, compliance and catch documentation**

**1.** Ensure that the fishing fleet is equipped with technologies and amenities that allow observer and research operations and facilitate compliance with management regulations.

*2017 update: FIFD provided input during the planning and development of the new CFL vessel, the CFL Hunter. This input ensured adequate observer and research accommodations on the vessel, and new facilities such as a large discharge hold to avoid discharging offal during fishing operations (seabird mitigation measure).*

Current research objectives:

- Continue to suggest modifications to facilitate the work by observers and researchers.
- Analyse the efficacy of the tori line, responsible for the only bird death in the last 5 years.

**2.** Regularly assess the harvest control rules (HCR) to ensure that they are adequately responsive to potential changes in the stock status.

*2017 update: HCRs were refined and clarified to better describe the actions that will be taken under different stock conditions.*

Current research objectives:

- Simulations from a range of stock depletion levels are being undertaken to evaluate the efficacy of the HCRs to increase or rebuild a hypothetically depleted stock.

**3.** Develop move-on rules for by-catch and VME species.

Current research objectives:

- FIFD is currently working with CFL to develop efficient and responsive "move-on" rules for bycatch and VME species. These rules will dictate what actions should be taken to identify and respond to situations where a longline set captures an unusually high amount of certain species (e.g. sharks, corals, sponges, etc…).
- Several models are being explored, including the CCAMLR Conservation Measures 22-06 and 22-07.

**4.** Ensure adequate reviews of FIFD take place.

*2017 update: Regular internal audits and reviews of specific fisheries measures (stock assessment, licensing advice, ITQ program, etc…) are being conducted*

Current research objectives:

- Develop a strategy to implement a regular external review of the fishery.

**5.** Maintain the excellent compliance record of the fishing fleet.

*2017 update: no compliance issues have been found in recent years.*

Current research objectives:

- Continue to cultivate and encourage the culture of compliance and cooperation between industry and management.

**6.** Meet the Marine Stewardship Council milestones, requirements and principles.

*2017 update: Dr Thomas Farrugia was hired on a 2-year contract as a dedicated toothfish stock assessment scientist. He will dedicate part of his time to ensuring that the MSC principles are met and that the fishery evolves along with the changes in MSC.*

## Stock Assessments

### Stock management history

| | |
|---|---|
| **2005: FIFD/RRAG** | The first attempt at assessing toothfish in the Falkland Islands was conducted in 2005 (FIFD) using Fox and Schaefer Production and CEDA models. The models indicate a strong stock decline with the standing stock being reduced to about 50% of initial size with CPUE expressed in numbers of fishing days, and down to 35–38% with CPUE expressed in numbers of hooks recovered. Two ASPMs were used (RRAG); one with a Beverton-Holt stock recruitment relationship and another using trawler CPUE to estimate yearly recruitment. Their estimates showed similar declines in biomass as the fishery progressed. Current biomass was at between 38% and 46% of its pre-exploitation level and MSY was between 912 and 3000 t. There was a poor fit to CPUE between 1994 and 1996 which was attributed to IUU catches or changes in catchability and/or mortality. During this time (mid 90s), there was considerable IUU activity in the SW Atlantic, and when their model was adjusted to allow an estimated level of extra catch, the fit improved and 5000 tonnes of extra catch was estimated. |
| **2006: First year of ITQ systems.** **TAC = 1,500 t** | Establishment of Burdwood Bank Seasonally Closed Area |
| **Assessment for 2007: FIFD / RRAG** **TAC = 1,500 t** | ASPM (RRAG) and Fox and Schaefer production models (FIFD) tested. RRAG assessment showed spawning stock biomass between 18,000 to 18,500t with MSY estimates at 1,468 and 1,640t. FIFFD assessment (CEDA v3.0) MSY ranged between 1,293 and 1,569 t. |
| **Assessment for 2008: FIFD / RRAG** **TAC = 1,200 t** | ASPM model tested under different parameterisations and with/without recruitment index. Stock assessments produced a range of MSY estimates leading to the reduction of the toothfish TAC from 1,500 t in 2007 to 1,200 t for 2008. |
| **Assessment for 2009: FIFD** **TAC = 1,200 t** | ASPM (Payá & Brickle 2008) was used. The updated stock assessment had similar results than the previous one (MSY 879-1,757 t). There was no strong evidence that 1,200 tonnes TAC should be modified. |
| **Assessment for 2010: FIFD** **TAC = 1,200 t** | ASPM (Payá & Brickle 2008) was used. The spawning biomass in 2008 was estimated between 14,575 and 21,216 tonnes and corresponds to 42-53% of the virgin spawning biomass. MSY was estimated between 1,130 and 1,312 tonnes, Fixed catch projection showed that the current 1,200 tonnes TAC produced surplus production slightly greater than the catches. There is no strong evidence that 1200 tonnes TAC should be modified. |
| **Assessment for 2011: FIFD** **TAC = 1,200 t** | ASPM. Umbrella CPUE was transformed to line CPUE using the ratio between line CPUE to umbrella CPUE. The ratio value was the mode (0.263) of a gamma distribution fitted to data 2007, 2008 and 2009 (Payá and Brickle 2009). MSY (879-1,757 tonnes) were 2-34% greater than 2007 MSY. Fixed catch projection showed that the current 1,200 tonnes TAC produced surplus. There is no strong evidence that 1,200 tonnes TAC should be modified. |
| **Assessment for 2012: FIFD** | An Age-structured production model (ASPM) using CASAL (Bull et |

| | |
|---|---|
| *TAC = 1,200 t* | al 2012) was used for the first time. The main assumption is that the stock comprises two fisheries; trawl and longline. Umbrella line correction factor (0.263) was used. The global MSY (trawlers and longliners) was calculated as 1,610 mt. To estimate the proportion available to longliners the mean trawler catch over the last 5 years (174 mt) was removed from the global MSY leaving 1,436 mt. As this is a new model and due to some uncertainty coupled with the continued decline in SSB we recommend that the TAC for 2012 remain at 1,200 tonnes. We also recommend that the temporal spawning area closure on the Burdwood Bank continue during 2012. |
| *Assessment for 2013: FIFD*<br><br>*TAC = 1,200 t* | ASPM using CASAL. The same methodology as last year's assessment was applied with the addition of catch and effort data to 31st December 2011. We also recommend that the temporal spawning area closure on the Burdwood Bank continue during 2013. |
| *Assessment for 2014: FIFD*<br><br>*TAC = 1,200 t* | ASPM using CASAL. Two changes: 1) model assumption that there are four 'fisheries'; longline, finfish trawlers, Loligo trawlers (early season), and Loligo trawlers (late season). Loligo separated because of the different catch selectivities of the two seasons. 2) A statistical anomaly may be having an effect of standardised CPUEs from early years. Until this effect can be better statistically accounted for, pre-1996 CPUE data are excluded. There is no basis for either decreasing or increasing the TAC from 2013. The temporal closure of the Burdwood Bank should continue for the foreseeable future as an important fishery management tool. |
| *Assessment for 2015: FIFD*<br><br>*TAC = 1,040 t* | ASPM using CASAL. Two versions of the model were tested: 1) Include the CPUE tuning indices of all three fisheries in the optimization: longline, finfish trawl, and Loligo trawl similar to the previous assessment. 2) Include the CPUE tuning index of only the longline fishery (but still includes the actual toothfish catches taken in those fisheries). This takes into account uncertainty caused by toothfish being a non-targeted in finfish and Loligo fisheries, such that catch does not have a definitive proportionality with the fishing effort.<br>The Patagonian toothfish stock in the Falkland Islands appears to be in decline. The probability of being below 0.45 ratio is 33%, while the probability of being below 0.40 (a commonly used guideline by the Marine Stewardship Council; Stuart Hanchet, NIWA, pers. comm.), is 23%.<br>A 13.3% reduction in TAC was thought to be prudent.  This reduction is indexed to the reduction in MSY between 2012 and 2014. To increase protection of toothfish aggregations on their spawning ground (Burdwood Bank) the fishing ban was extended to June 1st – August 31st, and the area of closed fishing was expanded considerably on the eastern part of Burdwood Bank with closure of areas south of 54 S and shallower than 1700 m. |
| *Assessment for 2016: FIFD*<br><br>*TAC = 1,040 t* | Assessment was continued with the CASAL ASPM, using model version II: CPUE tuning index of only the toothfish longline fishery but catches of all three fisheries that take toothfish (longline, finfish trawl and *Loligo* trawl). Three changes were made to the stock assessment: (a) inclusion of catches out-of-zone, to better represent time-series impacts on the toothfish population, (b) optimizing natural mortality within the ASPM, (c) empirically |

| | |
|---|---|
| | evaluating the umbrella factor of the longline fishery and applying the best umbrella factor fit in the final stock assessment model. |
| | Total biomass continued to show a declining trend since the start of the fishery but the rate of decline has slowed. CPUE in the longline fishery (which represents the abundance tuning index for the ASPM) has been increasing slowly since 2006. |
| | Maximum sustainable yield (MSY) allowable to the longline fishery was estimated at 1276.5 tonnes. Total biomass and spawning stock biomass in 2015 were calculated by the CASAL ASPM at 24,243 tonnes and 7,079 tonnes respectively. The ratio of $SSB_{2015}$ : $SSB_0$ (current spawning stock biomass to unfished spawning stock biomass) was 0.445, just below the prescribed threshold reference point. However, a retrospective analysis of $SSB_{current}$:$SSB_0$ showed a continual improvement of the ratio with every yearly addition of data. Accordingly, even though the historic depletion of the toothfish stock has not been fully arrested as of 2015, the biomass trend is correcting itself along with increasing CPUE in the longline fishery. |
| | Based on the evidence of a slowly recovering toothfish stock, the recommendation from this stock assessment is to maintain the TAC for longline fishing at its current level of 1,040 tonnes. |
| *Assessment for 2017: FIFD* <br><br> *TAC = 1,040 t* | Assessment was continued with the CASAL ASPM. Three modifications were made to the stock assessment: (a) Non-FK-licensed longline catches, including out-of-zone catches, were estimated as a separable factor in the stock assessment, together with unrecorded whale depredation, (b) Spanish-system longline and umbrella-system longline were now modelled as different fisheries, rather than empirically adjusting their CPUEs through a scaling factor, (c) the two components of the CASAL ASPM objective function were re-weighted to equalize between the CPUE index fits and the catch-at-age distribution fits. |
| | Total biomass and spawning stock biomass in 2016 were calculated by the CASAL ASPM at 30,288 tonnes and 10,337 tonnes respectively. The ratio of $SSB_{2016}$: $SSB_0$ (current spawning stock biomass to unfished spawning stock biomass) was 0.452, just above the upper target reference point. However, a retrospective analysis of $SSB_{current}$:$SSB_0$ showed a continual improvement of the ratio with every yearly addition of data. The standardized longline CPUE index also shows a decline. The modal catch age in the longline fishery has shown a small but statistically significant increase over the past 10 years. Natural mortality was estimated by the CASAL ASPM at 0.168 $year^{-1}$, close to the composite average previously used for the Falkland Islands stock. Forward-calculation of the CASAL ASPM projects that SSB will decline to 40.6% - 41.6% of $SSB_0$ in 2022, before increasing. Thus, SSB is not projected to decrease below the trigger threshold, and the recommendation from this stock assessment is to maintain the TAC for longline fishing at its current level of 1,040 tonnes. |

## *Current Assessment (2018): FIFD*

Assessment was continued with the CASAL ASPM. Four modifications were made to the stock assessment: a) adjusting the maturity data to take into account that "immature" and "mature resting" fish are not distinguishable, b) changing the gear type of six longline sets in 2013 that were conducted with a Spanish-system longline rather than an umbrella-system longline, c) using a lower whale depredation rate in line with the most up-to-date data, and d) including ageing data through the end of the stock assessment year (2017).

All other procedures were followed from the previous stock assessment. Catch, effort and observer length / frequency measurements were updated through 2017.

**Input model parameters**

| Plus group | 31+ | |
|---|---|---|
| Initial year | 1987 | |
| Stock-recruitment relationship | Steepness: 0.75 Recruitment variability: 0.60 | Beverton and Holt |
| Mortality (M) | | Model optimization |
| Selectivity curve | LL: logistic FIN: double-normal LOL: double-normal | |
| Von Bertalanffy growth parameters | $k$ : 0.06292 $t_0$ : -2.46533 $L_{inf}$ : 159.279 | FIFD observer data |
| Size - weight parameters | $a$ : $5.06238 \times 10^{-9}$ $b$ : 3.154409 $N$ : 28,762 | FIFD observer data |
| Age - length key | 2007 to 2017 $N$ : 5,742 | FIFD age data |

**Results**

Model-estimated fits of toothfish total biomass and spawning stock biomass show declining trends since the start of the fishery. The standardized longline CPUE index shows a level trend since the 2007 when the gear switched from Spanish-system to umbrella longlines. The modal catch age in the longline fishery has shown a small but statistically significant increase over the past 15 years. Natural mortality was estimated by the CASAL ASPM at 0.174 year$^{-1}$, close to the composite average previously used for the Falkland Islands stock. Total biomass and spawning stock biomass in 2017 were calculated by the CASAL ASPM at 31,891 tonnes and 11,293 tonnes respectively. The ratio of $SSB_{2017}$: $SSB_0$ (current spawning stock biomass to unfished spawning stock biomass) was 0.482.

**Recommendation**

At 0.482, the $SSB_{current}$:$SSB_0$ ratio is well above the prescribed target reference range. MCMC projections show that SSB is likely to continue to decrease until 2024, at which point it will be 0.436

of $SSB_0$, still above the trigger range that would require additional conservation measures. SSB ratio is then projected to increase back above 0.45 by 2029. Over 74% of the MCMC projections show that the SSB ratio will be above 0.45 by 2052.

Based on the evidence of a toothfish stock that stands at an acceptable level of abundance, and projected to increase in the near future under current fishing pressure, the recommendation from this stock assessment is to maintain the TAC for longline fishing at its current level of 1,040 tonnes.

An additional recommendation is to develop a strategy to address the bycatch of toothfish in the trawl fisheries, specifically the finfish fishery. There has been a shift in fishing behaviour of the finfish fishery in the last two years, which had led that fishery to catch much more toothfish than in previous years. To minimize the threat to the toothfish stock from bycatch, this change in behaviour could be addressed by closing certain areas or depths to trawling.

**TAC = 1,040 t**
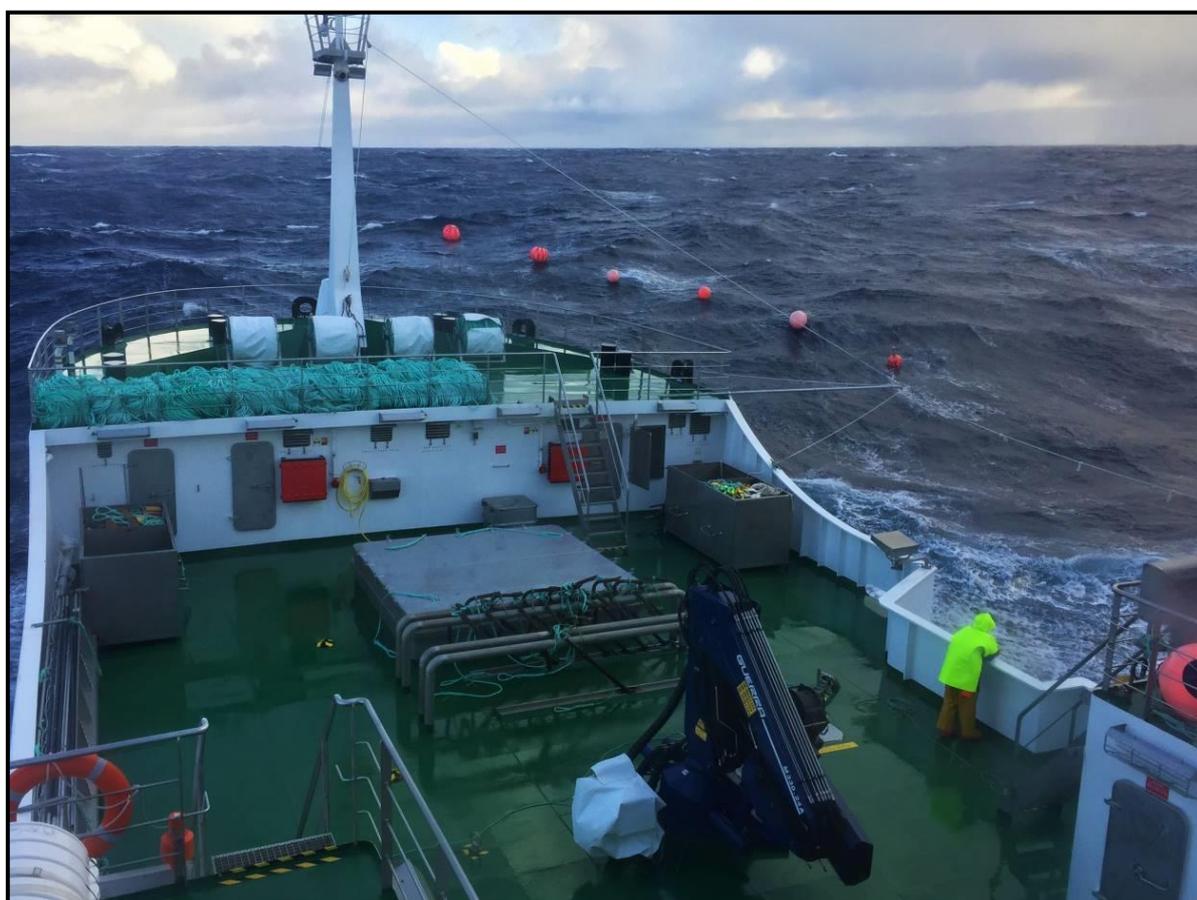
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