Toothfish tagging cruise

ZDLC2 – 06 – 2016

CFL Gambler

4 – 18 June 2016

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Summary

In March 2014, Consolidated Fisheries Ltd (CFL) was awarded MSC certification for Patagonian toothfish (*Dissostichus eleginoides*). An independent review of stock discrimination tools available for fisheries management was undertaken by the National Institute of Water and Atmosphere Research Ltd (NIWA). Recommendations put forward by the NIWA stock discrimination review report included the establishment of a pulsed tag-recapture program in order to firstly establish linkages between juvenile on the shelf and adults in deep waters and secondly to quantify the amount of exchange between adults in the northern and eastern FOCZ and the spawning grounds on Burdwood Bank. An initial tagging trip was conducted from June 4th to the 18th 2016, inclusively, on board CFL's longliner *Gambler*, in the eastern parts of the FICZ/FOCZ from Burdwood Bank to the northeastern edge of the FOCZ. Fishing behaviour was altered in several ways to increase the likelihood of recovering fish in suitable condition and ensuring maximum survival of fish that were released once tagged. In total, two days were spent fishing over the Burdwood Bank, five days in the eastern region (FICZ/FOCZ, south of 50°S) and three days in the northern region (FOCZ, north of 50°S). A total of 407 fish were tagged and released, of which 405 (99.5%) swam away towards the bottom; a favourable outcome. Fish were tagged in all three zones, with 66 tagged off the eastern edge of Burdwood Bank (south), 213 in the eastern region, and 128 in the northeast area. On average, 10.5% of toothfish caught per line was deemed suitable for tagging and none of the changes in fishing behaviour described above had an effect on the proportion of fish identified as suitable for tagging. The tagging cruise has led to the development of a guide for FI Fisheries observers to identify fish suitable for tagging, a tagging protocol to be followed by FI Fisheries observers when on-board the new CFL *Hunter*, and a protocol to follow when retrieving a tagged fish to be actioned by factory bosuns in the absence of FI Fisheries observers. Additionally, a series of eight recommendations are proposed herein; all of which were accepted by CFL's Board of Directors.

Background

In March 2014, Consolidated Fisheries Ltd (CFL) was awarded MSC certification for Patagonian toothfish (*Dissostichus eleginoides*). With this certification came the voluntary condition of undertaking to develop a research plan to continue and enhance current research programs into stock identity. An independent review of stock discrimination tools available for fisheries management was undertaken by the National Institute of Water and Atmosphere Research Ltd (NIWA) as the first year target for the research plan (Parker, 2015). Recommendations put forward by the NIWA stock discrimination review report highlighted the benefits of further research through the use of a pulsed tag-recapture program and the utilisation of PSAT tags as an effective approach for obtaining information about the movement patterns of individual large fish.

A pulsed (intermittent tagging of large number of fish) conventional tag-recapture study was recommended in order to firstly establish linkages between juvenile on the shelf and adults in deep waters and secondly to quantify the amount of exchange between adults in the northern and eastern FOCZ and the spawning grounds on Burdwood Bank. The additional deployment of PSAT tags, although expensive, would provide additional information in terms of the environment experienced by individual fish compared to that of a conventional tagging study.

Aims and Objectives

The overall aim of the project is to utilise the CFL Gambler to undertake longlining along the shelf and upper regions of the slope in order to capture live, healthy fish for tag and release work. Specific objectives to the project include, but are not limited to:

- Establish linkages between juveniles on the shelf and adults on the slope of the FICZ and FOCZ.
- Analyse movement patterns of adult fish between the northern, eastern and southern regions within the FICZ and FOCZ.
- Establish linkages between adults on the slope to the North, East and South to the spawning grounds on the Burdwood Bank.

Additional benefits arising from a mark-recapture study include the validation of growth estimates and the potential for the validation of abundance estimates based on CPUE data.

Study Area

Mature and immature adult Patagonian toothfish were targeted along the edge of the shelf and slope within three regions of the FICZ/FOCZ (Figure 1). The Burdwood Bank is closed to fishing during this time period; however, special permission was requested and granted in order for limited samples to be obtained from this region.

For the purpose of the tagging trip, the FICZ and FOCZ in which Patagonian toothfish are targeted by the CFL Gambler (600 – 2500m) was divided into three regions: North, East and the Burdwood Bank. The northern region is categorised as the fishing area along the Patagonian slope north of 50°S. The eastern region is categorised as the fishing region along the Patagonian slope south of 50°S and north of 53.5°S. The Burdwood Bank refers to the shallow bank lying to the south of the Falkland Islands (Fig 1).

The purpose of releasing tags at Burdwood Bank is to document post-spawning adult fish dispersing to the north and east for recovery and feeding. Therefore tag release must occur prior to or during the spawning season targeting mature fish. If tagged fish are recaptured in the northern and eastern FOCZ, then evidence would be available linking those areas as spawning and feeding grounds.

Fish tagged in the northern area will be beneficial in documenting the spawning movements to the Burdwood Bank. Fish tagged outside of the spawning season could provide a pool of tagged fish that may migrate south to spawn. Recapture effort over the eastern and southern region of the FOCZ prior to the spawning season may indicate a spawning movement of fish towards the Burdwood Bank.

The tagging of fish to the south and east in deeper waters during the early or post-spawning season may be beneficial for targeting fish during their migration. Smaller fish are more frequently captured within the eastern region of the FOCZ (Figure 2). As such, targeting smaller sub-adult fish for tagging over shallower depths within this

region may be beneficial in understanding the movement of juvenile fish from the shelf to the slope.
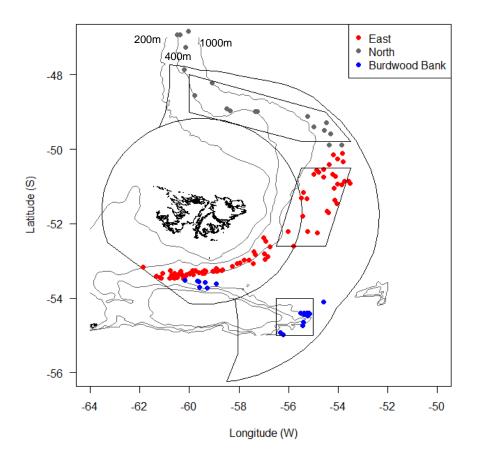

Figure 1: Map showing the areas fished by the CFL Gambler during the proposed sampling dates in previous years. Isobaths shown reflect the 200, 400 and 1000m depth contours. Boxes indicate target areas for tagging toothfish in June 2016.

Methods

The vessel departed Stanley in the evening of 4 June and steamed to the northeastern edge of Burdwood Bank. Fishing behaviour was altered in several ways to increase the likelihood of recovering fish in suitable condition and ensuring maximum survival of fish that were released once tagged. These included: (1) fishing without umbrellas to reduce the incidence of rope burn or entanglement (this was abandoned following the second line due to high depredation); (2) setting fewer lines per day (two, down from four or five) to reduce the soak time; (3) reducing the hauling speed to minimise drag on the fish while hauling; (4) prevention of gaffing to

haul fish on board (gaffing restricted to the umbrella); and (5) reducing the number of hooks per umbrella (to six, from seven) to decrease the probability of hooks getting snagged on the body or resulting in multiple hooks in the mouth. In total, two days were spent fishing over the Burdwood Bank, five days in the eastern region (south of 50°S) and three days in the northern region (north of 50°S). No PSAT tags were deployed during this trip.
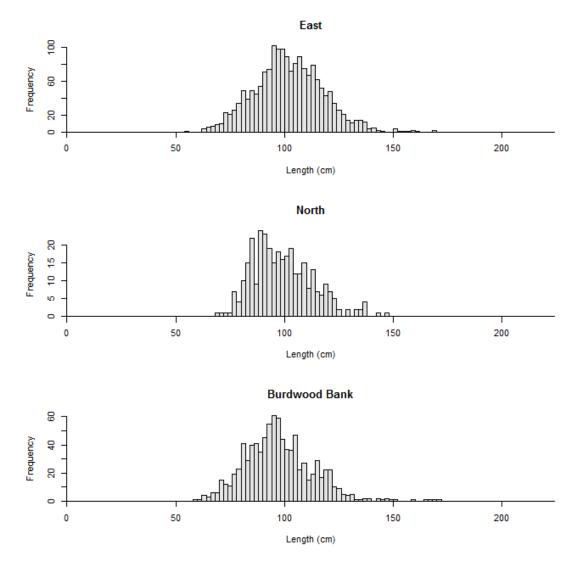

Figure 2: Length-frequency distribution of Patagonian toothfish captured by the CFL Gambler within the three regions of the FOCZ during June in previous years based on Fisheries observers' data.

Tagging objectives

Parker (2015) estimated that 3000 fish would need to be tagged in the Falkland Island waters in order to recapture 100 fish. This is based on an exploitation rate near 3% (Paya and Brickle, 2008) and accounts for 4.5% of the catch or requires 5% more fishing time per year. Comparatively, South Georgia has tagged over 40,000 fish since their tagging programme began in 2000 and they have recaptured over 2000 fish (or approximately 5%) as of 2013 (CCAMLR, 2013).

It is aimed to tag 1000 fish per year over the next three years. Fish tagging will be undertaken through a pulsed tagging trip over two weeks during June of each year to coincide with the start of the spawning season off Burdwood Bank, with an objective of tagging 400 toothfish, and supplemented by scientific fisheries observers stationed onboard the CFL Gambler during standard observation periods to tag an additional 50 to 100 fish per month.

Station layout and equipment

The tagging station was set up on the sorting table adjacent to the hauling bay within the dry section of the factory. The station included a measuring board, a hanging balance, the pre-loaded sharp needles with tags (one small and one large), and the tag release sheet and pencils (Fig 3). Additional equipment was stored nearby, including a stretcher for transporting fish and syringe to administer oxytetracycline to the fish until stocks ran out.

Identification of fish suitability

When tagging was taking place, all fish were considered tagging targets and were assessed by the scientific staff (Haseeb or Brendon). This ensured no gaff was used, the minimisation of the time that the fish was kept out of the water, and the gentle handling of the fish. When using umbrellas, these were utilised in retrieving the fish onto the vessel in order to support the weight of the toothfish. In their absence, the gaff was used to retrieve the line rather than gaffing the fish.

Figure 3: Photograph of the tagging station adjacent to the hauling bay in the dry area, showing the measuring board, loaded tag applicators, and bolt cutters. Spring balance not shown in this photograph.

Immediately upon being retrieved into the hauling bay, fish were passed through the hatch onto the sorting table and an assessment was undertaken on the suitability of each fish for tagging (Table 1). Wet gloves were worn when handling the fish while avoiding touching of the eyes, and gills when lifting the operculum to assess their colour. Fish were not hung vertically in a manner that stretched the backbone. Scientific staff was stationed as close to the hauling bay as possible to identify whether the fish was a suitable target for tagging. Instructions were communicated to the entire factory crew by either the 1st or 2nd deck bosun.

Tagging procedure

Once the fish was identified as suitable for tagging it was immediately carried across to the sampling table. Remaining hooks were removed using pliers or bolt cutters with minimal injury to the fish (Fig 4a). Fish were then placed gently onto the measuring board and two tags were applied to each fish (both yellow; one large and one small) using appropriate applicator tools (Fig 4b). Tags were inserted into the dorsal muscle at the second dorsal fin angled downward so that the barb was firmly

lodged behind the forward edge of the second or third dorsal fin rays, and backwards to reduce effect of drag on the tag (Fig 4c). Fish were transported by two crew members from the sampling table to the spring balance in a stretcher so that the eyes of the fish were covered at all times (Fig 4d). Tag codes, length (cm) and weight (g) were recorded for each tagged fish. Due to limited stocks of oxytetracycline, only a proportion of fish were injected in the flesh with the compound at a concentration of 25-35 mg/kg of fish as per McFarlane and Beamish (1987). Oxytetracycline provides the dual benefit of acting as an antibiotic to aid fish survival as well as to create a mark on the otolith of the fish for future validation of growth zones. The quantity injected was recorded. Due to limited availability of oxytetracycline, two concentrations of were used, 100 and 200mg/ml, and noted for each injected fish. Fish were transported by two crew members and released directly from the stretcher, headfirst into the water from the hauling bay (Fig 4e). The likely fate of the fish was recorded, i.e. was it swimming normally following release or did it seem groggy.

Results

A total of 407 fish (5.2 mt in total weight) were tagged from 18 lines, of which 405 (99.5%) swam away towards the bottom; a favourable outcome. The fate of the other two fish was unclear at the time of release. Fish were tagged in all three zones, with 66 tagged off the eastern edge of Burdwood Bank (south) (two days of fishing effort as per E-licence conditions), 213 in the eastern region of the FICZ/FOCZ (five days of fishing effort on L-licence), and 128 in the northeast area (north) of the FICZ/FOCZ (three days of fishing effort on L-licence) (Fig 5). Sixty fish from Burdwood Bank were injected with oxytetracycline (90.9% of fish tagged in this region; 14.7% overall).

All 407 fish were measured and weighed. Total length and weight ranged between 67 to 167 cm (mean = 103.4 ± 16.7 cm) (Fig 6) and 3.1 to 63.0 kg (mean = 12.82 ± 7.81 kg), respectively. Tagged toothfish from the south were significantly larger than those tagged from the other two regions ($p < 0.001$) with means of 111.4 ± 17.8 cm in the south (range = 67 to 159 cm), 102.8 ± 16.8 cm in the east (range = 69 to 167 cm), and 100.2 ± 14.7 cm in the north (range = 70 to 160 cm), respectively (Fig 7).

A

C

B

D

E

Figure 4: Photographs depicting the different steps involved in tagging fish: A) cutting of the hooks with bolt cutters to minimise injury to the fish; B) Brendon using applicators to apply two tags to an immobilised toothfish; C) illustration of how tags should be applied, i.e. inserted into the dorsal muscle of the second dorsal fins angled downwards and backwards with tag barb lodged behind the forward edge of 2nd and 3rd dorsal fin ray; D) fish transported by two crew members from the tagging station to the spring balance using a stretcher; and E) fish released from the stretcher over the side of the vessel from the hauling bay, head first into the water.

Table 1: Suitability assessment for tagging of fish

Assessment category	Do not tag	
Hook injuries	Hook injury outside the mouth areas (outside the lips, jaw, or cheek), or in the back of the mouth or throat.	
Gills	Gills pink or white. Gills must be bright red as per photo on the right.	
Bleeding	Any visible bleeding from gills, or excessive bleeding elsewhere	
Body	Visible damage to fish body with open wounds	
Organs	Visible damage to eye or penetration of body cavity, including by crustaceans (amphipods/lice) and hagfish	
Scales	Abrasions or single area of recent scale loss equal to or exceeding the area equivalent to the fish tail	

Similarly and unsurprisingly, fish from the south were significantly heavier than those originating from the other two regions, i.e. 16.3 ± 9.0 kg in the south (range = 3.1 to 47.0 kg), 12.4 ± 7.8 kg in the east (range = 3.2 to 63.0 kg), and 11.7 ± 6.6 kg in the north (range = 3.6 to 50.0 kg), respectively. Overall, the length to weight relationship can be defined as $y = 0.0051 \, L^{3.1551}$ (r-square = 0.944) and does not deviate significantly (p > 0.05) based on origin of tagged fish (Fig 8).

The proportion of tagged fish on lines without umbrellas (N = 2) off Burdwood Bank was excluded from further analyses due to evidence of high rates of depredation by sperm whales (Fig 9). On these lines, excluding fish taken via depredation, only two and five fish were caught, of which 0 and one were tagged, respectively. Therefore, 406 fish were tagged from 16 lines (15 with umbrellas, one without), mean of 25 ± 15 tagged fish per line (range = 2 to 75). From these 16 lines, a proportion of 25.4 ± 10.5% of toothfish caught per line was deemed suitable for tagging (range = 6.2 to 50.7%).
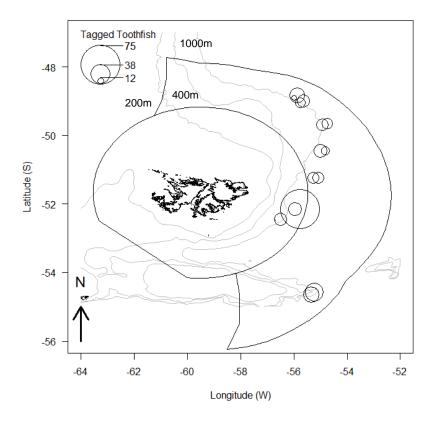

Figure 5: Map showing the distribution of toothfish tagged during the pulsed tagging trip in June 2016 on board CFL's Gambler. Isobaths shown reflect the 200, 400 and 1000m depth contours. Circles are proportional to the number of tagged toothfish per station (range = 1 to 75 tagged toothfish).

As described above, fishing behaviour was altered and these changes, along with other factors were included in linear modelling analyses with the proportion of toothfish per line deemed suitable for tagging as the response variable. Predictor variables in the model included: (1) number of hooks per umbrella (6 or 7); (2) number of umbrellas (300 or 400); (3) latitude (range = 48.83°S to 54.65°S); (4) fishing depth (mean = 1153 ± 153 m; range = 771 to 1339 m); and (5) soak time (mean = 1087 ± 380 minutes; range = 598 to 1807 minutes). None of these predictors affected the proportion of toothfish caught per line as suitable candidates for tagging with the "Null" model selected as the "best" model (Table 2) and all parameter estimates' 95% confidence interval (based on unconditional variance) including "0" (Table 3).
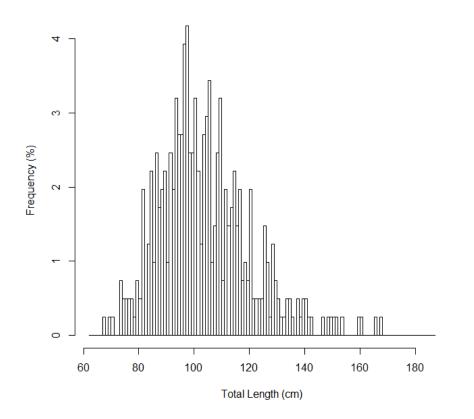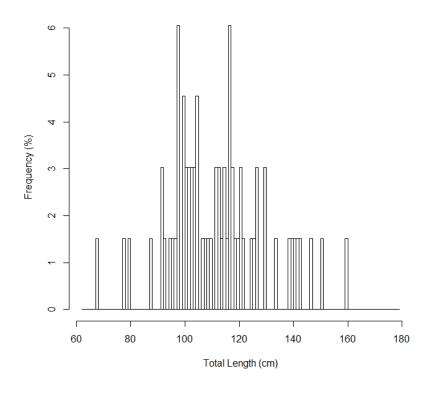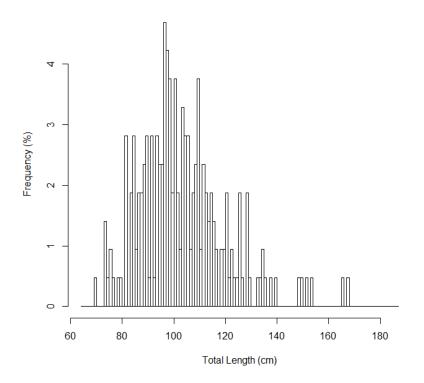

Figure 6: Length frequency distribution of toothfish tagged on the June 2016 pulsed tagging trip on board CFL's Gambler (mean total length = 103.4 cm; range = 67 to 167 cm; N = 407).
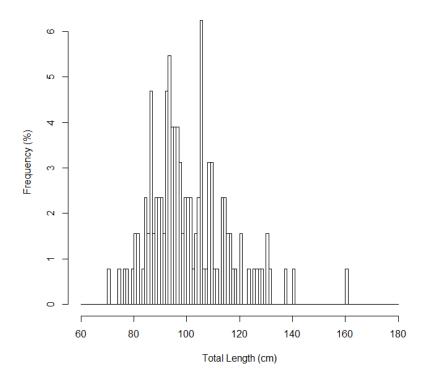
A

B

C

Figure 7 (See above and previous page): Length frequency distribution of toothfish tagged on the June 2016 pulsed tagging trip on board CFL's Gambler: (A) southern area on the eastern edge of Burdwood Bank (mean total length = 111 cm, N = 66); (B) eastern region bounded by 50°S to the north and 53.5°S to the south (mean total length = 103 cm, N = 213); and (C) northern area north of 50°S (mean total length = 100 cm, N = 128).

Discussion

Overall, all objectives of this tagging cruise were achieved: (1) we managed to capture and tag healthy fish using longline fishing method along the shelf and slope from all three targeted areas on-board CFL's Gambler F/V; and (2) we exceeded our target of 300 tagged fish during this pulse tagging expedition. Furthermore, the outcomes for tagged fish seemed generally favourable with 99.5% of tagged toothfish swimming downwards a few seconds following release.
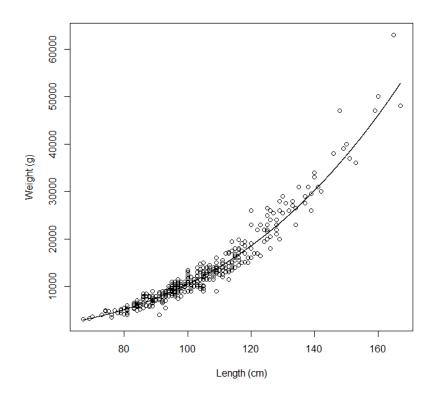
Figure 8: Length to weight relationship of toothfish tagged during the June 2016 pulsed tagging trip on board CFL's Gambler. The line represents the best fit for a power function defined as Weigth = 0.0051*Length$^{3.1551}$.

Table 2. Summary of the top 5 models for Proportion of toothfish identified as suitable for tagging based on AICc. Models are shown including the ΔAIC_c and Akaike weights (w_i) of each model given the data.

Model	ΔAIC_c	w_i
Null	0.00	0.36
1	2.23	0.12
4	2.69	0.09
3	2.96	0.08
2	3.04	0.08

1, Depth; 2, Number of hooks per umbrella; 3, Number of umbrellas; 4, Soak Time; 5, Latitude

Figure 9: Photograph showing an example of toothfish lost to depredation by a sperm whale in the absence of umbrellas.

Table 3: Summary of Linear Models with Proportion of observed toothfish deemed suitable for tagging as the response variable with Depth, Number of hooks per umbrella, Number of umbrellas, Soak time, and Latitude as fixed effects. Predictor variable relative importance weights [$w_+(i)$], ranks, weighted model average parameter estimates, and 95% confidence intervals. Estimates for fixed effects in bold indicate those with a 95% confidence interval bounded away from "0".

Fixed effects

Predictor variable	$w_+(i)$	Rank	Parameter estimate	Confidence interval
Depth	0.22	1	0.00015	-0.00021 to 0.00051
No. Hooks/umbrella	0.15	4	-0.00327	-0.17179 to 0.16525
Number of umbrellas	0.16	3	0.00014	-0.00128 to 0.00156
Soak time	0.18	2	-0.00005	-0.00021 to 0.00012
Latitude	0.15	4	0.00257	-0.03550 to 0.04064

Our main findings suggest that the proportion of toothfish on each line identified as suitable for tagging is not affected by fishing behaviour, i.e. the use of umbrellas, soak time, length of the line, number of hooks per umbrella. Hence, the significance of this finding: ***toothfish tagging can be undertaken by Fisheries Observers as part of their routine workload on board the longliner***. The only caveat being that hauling speed was not taken into account during this exercise; although reduced during tagging, the exact speed was not quantified nor included in our analyses and varied from line to line. In the future, hauling speed should be estimated either in m/s or as a proportion of the normal fishing hauling speed. However, our recommendation would be for hauling to be performed as per normal fishing behaviour when Fisheries Observers are on board and reduced to ~75% during pulsed-tagging trip in June 2017 and 2018; with the exact speed to be altered, if required, following assessment by the chief-scientist in consultation with the vessel's Captain or Officers.

The biological data on the fish tagged suggest that toothfish tagged from the south (eastern edge of Burdwood Bank) were larger and heavier than fish from the other localities. The fishing grounds on Burdwood Bank are closed from June 1st to August 31st each year during what is considered the spawning season for toothfish in this area, hence it would be expected that the population off Burdwood Bank at this particular time of the year would consist *primarily* of larger mature spawning or post-spawning individuals. Monitoring movement of this population during the spawning season using PSAT tags in both June 2017 and 2018 will provide crucial information on dispersal to feeding/recovery grounds following spawning.

Recommendations

On the heels of the success of this toothfish tagging trip, we make the following recommendations:

1. In order to meet the target of tagging 3000 toothfish over a three year period, it is imperative that a tagging protocol be added to the key tasks of Fisheries Observers on board longliners. It is recommended that Fisheries Observers tag the first one or two toothfish identified as suitable candidates on each line sampled (sampling target of 50 to 75% of lines per trip). Tagging should occur within the first 10-15 minutes of hauling so not to disrupt commercial activities. The recommendation is for **tagging to occur under normal**

commercial fishing behaviour (including normal commercial hauling speeds). A protocol will be developed by Haseeb Randhawa (Fisheries Scientist – Biology) and Brendon Lee (Fisheries Scientist – toothfish), in consultation with Joost Pompert (Fisheries Observers – Coordinator), to be in place and communicated to Fisheries Observers by August 15th 2016. The timeframe for tagging would be from August 2016 to May 2019.

2. In order to meet the target of tagging 3000 toothfish over a three year period, it is imperative that an annual pulsed tagging event take place in both 2017 and 2018 with a target of 400 fish to be tagged during each trip. The recommendation is for tagging to occur under normal commercial fishing behaviour, with the exception of **reduced hauling speed to approximately 75% of normal commercial hauling speed**. It is also recommended that all fish tagged during pulse tagging trip be injected with oxytetracycline at 30mg/kg.

3. It is recommended that five PSAT tags be released on large toothfish measuring 120 to 150 cm, including two on Burdwood Bank during the spawning season, two in the northern area of the FICZ/FOCZ (north of 50°S), and one in the eastern area of the FICZ/FOCZ (between 50 and 53.5°S). These tags should only be applied if the suitability of the fish has been identified as excellent following a recovery period in a tank on board the vessel. A specific protocol will be developed by Haseeb Randhawa and Brendon Lee in time for the 2017 pulsed tagging trip.

4. It is recommended that CFL undertake an education campaign about the rationale and merits of tagging toothfish aimed at its officers and crew. **It should be clearly outlined that this is a CFL initiative supported by the Fisheries Dept.** We suggest that this information be shared verbally with the officers and that a laminated poster be developed by CFL and placed in key strategic areas on board the Gambler.

5. It is recommended that CFL and the Fisheries Dept investigate the best way to return valuable data from tagged-recaptured fish when no observer is on board. This may be by returning the entire fish, or have members of the crew collect the data and biological samples from the fish on board the vessel, and

return these to the Fisheries Dept. **The aim would be for a formal procedure to be in place before the end of August 2016**.

6. It is recommended that an information poster be developed aimed at informing officers and crew of longline vessels fishing within the FICZ/FOCZ or in the vicinity of the 200 nautical mile limit of the FOCZ on what to do in the event of recapture of a tagged toothfish. Both an English and Spanish version of this poster will be developed by Haseeb Randhawa and Brendon Lee by the end of August 2016.

7. It is recommended that CFL investigate the feasibility of incentivising the tagging programme by providing cash rewards to members of the crew for each milestone achieved during pulsed tagging trips. These monetary incentives should compensate crew for lost income due to decreased fishing activity and the release of over 5 mt of toothfish during the pulsed tagging exercise.

8. It is recommended that CFL and the Falkland Islands Fisheries Dept investigate the feasibility of incentivising the tagging programme by providing cash rewards to members of the crew when a tagged toothfish is recaptured. These monetary rewards are aimed at providing an incentive for identifying tagged fish from the catch and returning the entire fish (or tags and biological information/samples) to the Fisheries Dept for further processing.

Acknowledgments

We thank the officers and crew of CFL's Gambler for their hospitality and cooperation during this tagging trip at sea. The cooperation and assistance of CFL's board of Directors is gratefully acknowledged. We thank John Barton (Director, Directorate of Natural Resources, Falkland Islands Government) for approving an exemption to fishing in the temporally-restricted area off Burdwood Bank and Bernard Eccles (Licensing Officer, Directorate of Natural Resources, Falkland Islands Government) for organising an E-licence for this trip.

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