# An analysis of the extent of IUU fishing in Subarea 48.3

## A report for the UK Government in respect of

## South Georgia and the South Sandwich Islands

## By

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# 1 Introduction

The original report of which this is a summary was prepared in February 2002 for the UK Government in respect of South Georgia and the South Sandwich Islands. For reasons of commercial and surveillance confidentiality, only the executive summary is presented in this public document, along with an appendix, which explains the methods used. A full description of the methods, data used and results will be provided in a report to CCAMLR in October 2002.

The methods used to estimate IUU catch, and the results of this and the main report, are currently being prepared for publication. 

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List of acronyms used

| | |
|---|---|
| FPV | Fishery Protection Vessel |
| CCAMLR | Commission for the Conservation of Antarctic Marine Living Resources |
| GSGSSI | The UK Government in respect of South Georgia and the South Sandwich Islands |
| SGMZ | South Georgia Maritime Zone |
| IUU | Illegal, Unregulated and Unreported fishing |

## 2 Summary of the report (Executive summary)

1. During the review of the South Georgia toothfish fishery for certification by the Marine Stewardship Council, the UK Government in respect of South Georgia and the South Sandwich Islands (GSGSSI) commissioned MRAG Ltd to produce a statistical analysis of IUU (Illegal, Unregulated and Unreported) fishing for toothfish in Subarea 48.3. This report describes a new method for estimating IUU catch of fish and birds. It utilises high quality, well-documented FPV cruise data. It takes explicit account of both “seen” and “unseen” IUU fishing through a simulation model to arrive statistically rigorous estimates and confidence intervals of fish and bird catch by IUU vessels. This method has not been used previously to estimate IUU activity in CCAMLR. We recommend its continued use in Subarea 48.3 and extension to other regions of the Antarctic.

2. Of the sources of information on IUU fishing, Fishery Protection Vessel (FPV) cruises are the most consistent and reliable. The track of the FPVs on their cruises to South Georgia covers all possible areas of fishing for toothfish in Subarea 48.3, including the high seas areas of Subarea 48.3 to the west of the South Georgia Maritime Zone (SGMZ) and all areas within the SGMZ. The FPV track, extended by its radar range, covers all the fishing areas used by the licensed fishing fleet.

3. There is considerable other activity in the SGMZ year-round, with between 3 and 30 vessel visits to the administrative centre King Edward Point (KEP) each month. Periods of highest activity are the summer, when there are many tourist vessels and some fishing vessels (fishing for icefish) in the area, and in the winter when there is a large fleet of licensed toothfish longline vessels and a krill trawler fleet. This large number of vessels acts as a deterrent to IUU vessels, especially along the north coast of South Georgia. They also provide alternative sources of surveillance information. Additional surveillance techniques, such as satellite monitoring, are being developed.

4. We developed a model (described in more detail in the appendix, section 3) that uses data from FPV cruises in Subarea 48.3, and the encounters between FPVs and IUU fishing activity, to estimate the total number of days of IUU fishing that could occur during each year. For each IUU incident detected by the FPV, we calculated a theoretical maximum time over which this IUU activity could have occurred. This was the time that elapsed between the FPV cruises that were immediately prior to and immediately subsequent to the incident, where these prior and subsequent cruises had not detected that same IUU activity (i.e. the same vessel). In other words, for each IUU incident we know when it was seen, and the closest adjacent times in which it was not seen – the difference being the theoretical maximum time that the vessel can have been present.

5. This theoretical maximum time was converted to actual IUU fishing time using a simulation model. For each year, the model simulated 1000 IUU fishing incidents during the year, and from the known FPV cruise pattern calculated both the observed IUU activity and the known real IUU activity. We considered IUU activity to have been observed when the IUU vessel and the FPV vessel were in the same place at the same time. When this occurred, the FPV was assumed to detect IUU activity according to an “encounter probability”. The encounter probability was estimated from the known encounters of FPV with licensed vessels. Thus for each encounter between an IUU vessel and an FPV we obtained an estimate of total IUU fishing time.

6. The total annual IUU catch of toothfish and birds was calculated using a second simulation model. Subarea 48.3 was divided into 6 Areas for the purposes of calculation of fish and bird catch

associated with IUU fishing. The catch rate of fish was calculated for each Area and each year using reported catch and effort data. The catch rate of birds was calculated separately for summer and winter using previously published CCAMLR observer data obtained in the early licensed fishery (1997) when few vessels used mitigation measures. For each of 10,000 simulations fish and bird catch rates were obtained randomly from parent distributions, for each IUU-FPV incident.

7. Three years were analysed, 1998/99, 1999/00 and 2000/01. Each year covered fully the period 1 October – 30 September, thus including one summer and one winter period. The estimated total toothfish catch attributable to IUU fishing was 667 t, 1015 t and 196 t in 1998/99, 1999/00 and 2000/01 respectively (a total over the three years of 1879 t). The estimated total bird catch was 574 birds, 2200 birds and 544 birds respectively. 95% confidence limits were calculated to be 41-1778, 472-1744 and 23-481 respectively for fish and 122-1823, 825-5422 and 110-1813 respectively for birds.

8. CCAMLR estimates of IUU catch over the fishing seasons 1998/99, 1999/2000 and 2000/2001 are 664, 559 and 350 t respectively. These are already taken into account in CCAMLR assessments. Revised assessments will have to take into account our new estimates, but preliminary investigations suggest that the effect on current population status and TAC will be negligible. Our new figures show that the level of IUU catch dropped considerably in 2000/2001 to less than 5% of the total (legal + IUU) catch in Subarea 48.3. Surveillance records indicate that this decreasing trend has continued into 2002, probably as a result of increasing surveillance since 1999. Continual development of surveillance potential is required to inhibit the return of IUU vessels to Subarea 48.3.

9. When viewed against the estimated IUU catch in the whole CCAMLR area, the contribution from Subarea 48.3 has been proportionally much less than from other areas. The IUU catch for South Georgia over the period 1998/99 to 2000/2001 was 9.5% of the total IUU catch for the CCAMLR Area over this period. By contrast, 32% of the total CCAMLR legal catch was taken from South Georgia. The equivalent values for 2000/2001 are 2.6% and 30%. Whilst South Georgia continues to be a major source of legally caught toothfish, the percentage of IUU catch coming from this area has fallen to a very low level.

10. Historically, there appear to have been two periods when IUU fishing in Subarea 48.3 has been high. The first, 1992 – 1994, coincided with an expansion of longline fisheries around South America, and was curtailed by the implementation of the South Georgia Maritime Zone by the UK in August 1993, followed by several IUU vessel arrests in 1994. The second appears to have been 1999 - 2000, following increased pressure on IUU vessels fishing in the Indian Ocean sector of CCAMLR due to a number of arrests by France and Australia.

11. The FPV has not encountered any IUU fishing activity in Subarea 48.3, including the SGMZ, since December 2000 (time of writing: May 2002). This is probably wholly attributable to the increased FPV and other surveillance activity in the SGMZ since 2000. Continual development of surveillance potential is required to inhibit the return of IUU vessels to Subarea 48.3.

# 3 Appendix: Methods used for calculation of IUU effort and catch

## *3.1 Methods*

### 3.1.1 Model for estimating days fished and total catch

We assume that FPVs are effectively randomly searching for IUU activity in Subarea 48.3. We can calculate overall IUU activity if we know the relationship between the likelihood of FPV detection and the total number of days fishing that IUU vessels were engaged in during the year. Our starting point is to estimate the theoretical number of days IUU fishing that are represented by actual encounters between FPVs and IUU vessels, and then to convert this to the total IUU activity in the area.

Estimates of days IUU fishing were made by year (October to September inclusive). For each FPV IUU sighting we estimated the earliest possible date that the IUU vessel can have been fishing from, and the latest possible date that it can have been fishing to, based on the dates of previous and subsequent FPV cruises on which activity by that IUU vessel was not detected. The estimated number of days fishing for the illegal cruise[1] detected by an FPV, $i$ , in year $y$, $D_{i,y}$, was thus calculated from FPV encounters with IUU vessels, as:

$$D_{i,y} = L_{i,y} - E_{i,y} \qquad (1)$$

where $L$ is the latest and $E$ is the earliest date that the vessel can have been fishing. For instance, if FPV cruises were in June, July and August, and an illegal vessel was detected in Area 3[2] in July, the earliest that that vessel can have been fishing would be the date that the FPV searched Area 3 in June and did not find anything. The latest would be the date that the FPV searched Area 3 in August and did not find anything.

Earliest and latest dates were based on prior and subsequent cruise dates by the FPV, but they could also have utilised information on the prior and subsequent presence of other vessels (such as fishing vessels). However, Annex 1 shows that the areas most frequently covered by other vessels are Areas 2 and 4, whereas all recorded incidents have been in Areas 6, 1 or 3. Furthermore, although fishing vessels cruise ships and research vessels do report sightings of vessels which may be fishing illegally, they are not under an obligation to do so. These reports, therefore, may not be completely reliable. For these reasons we only consider reports by protection vessels to be confirmed data. To our knowledge, over the period covered by this study there were no instances when a confirmed illegal incident was reported by a non-FPV vessel, and that incident was not also independently detected by an FPV.

Next we need to adjust $D$ so that it represents accurately the total number of days of IUU fishing during a year that is indicated by the FPV encounter with an illegal vessel. If we define $A$ as adjusted days fishing, then

[1] All mentions of cruises in this document are synonymous with "campaigns", and refer to time spent on the fishing grounds only.

[2] The analysis proceeded by dividing Subarea 48.3 into 6 Areas, based on their relative densities of toothfish and birds. Area 1 was around Shag Rocks, Area 2 was NW of South Georgia Island (SG), Area 3 was NW of SG, Area 4 was NE of SG, Area 5 was SE of SG, and Area 6 was west of Shag Rocks, outside the South Georgia Maritime Zone.

$$A_{i,y} = p_{a,y} D_{i,y} \tag{2}$$

where $p$ is the correction factor used to convert IUU days fishing assumed from FPV encounters into real IUU days fishing. $p$ is defined by year and area. $A$ is the total number of days of IUU fishing that occurred during the year which are represented by the $i^{th}$ encounter of the FPV with an IUU vessel. Section 3.1.2 discusses this in more detail and presents our methodology for estimating $p$.

Adjusted days fishing was then combined with area- and season- specific estimates of fish catch rates and bird bycatch rates to produce estimates of catches of fish and birds. Each illegal cruise $i$ was assigned an area of fishing, $a$, corresponding to the area in which the FPV detected the vessel. Then the fish catch of the cruise was

$$C_{i,y} = A_{i,y}.\ CPUE_{a,y} \tag{3}$$

where *CPUE* was the CPUE of licensed vessels in that area in year $y$. The estimated number of birds caught by that illegal cruise, $B$, was

$$B_{i,y} = H_{a,y} A_{i,y} (q\ M_{a,s} + (1-q)\ M_{a,w}) \tag{4}$$

Where $H$ is the average number of hooks per day used by the licensed fishery in year $y$ (thousands) in the area in which the IUU vessel is recorded to have been fishing (this was derived from CCAMLR data – see Section 3.2.4). The proportion of fishing days that took place in the summer is $q$ (and in the winter is 1-q). $M_{a,s}$ is the bird mortality rate (per thousand hooks) in summer in area a, and in winter this is $M_{a,w}$. Section 3.2.5 details our methodology for estimating bird bycatch rates.

The total estimated fish and bird catch is estimated for each year by

$$C_y = \Sigma C_{i,y} \tag{5}$$

$$B_y = \Sigma B_{i,y} \tag{6}$$

for all $i$ in year y.

In order to calculate both point estimates and confidence intervals for the annual fish and bird catches, 10000 sets of values of CPUE, H and M were drawn from probability distributions determined through analyses of existing fish catch and effort and bird bycatch data described in subsequent sections of this report. The estimate of the correction factor, $p$, used in these calculations was obtained using the method described in the next section.

### 3.1.2 Estimating $p$ using a simulation model of IUU fishing activity

For a number of reasons, calculations based solely on earliest and latest dates, $D$, of IUU cruises actually detected by the FPV are not likely on their own to produce good estimates of IUU fishing effort, $A$ (see equations 1 and 2). Firstly, it is possible that an illegal vessel arrives and departs the zone between protection vessel cruises and is not recorded. This may occur when the illegal vessel cruise duration is less than inter-FPV-cruise duration. Secondly, protection vessels may have an imperfect detection rate. Thirdly, by basing D on the prior and subsequent FPV cruises are effectively assuming that after detection by an FPV, IUU vessels continue fishing right up to the date of the next FPV cruise, regardless of the encounter with the FPV. While theoretically possible, it would be surprising if an encounter with a protection vessel did not have some deterrent effect on an illegal vessel[3]. Thus the detected illegal cruise might be expected to be curtailed, being completed sometime between the encounter and the next time the protection vessel is in the area or the planned end of the IUU cruise. Fourthly, and by the same token, we assume that the earliest that an illegal vessel can have been present was just after the last protection vessel cruise, but in fact the illegal vessel would have arrived in the area some time between the last FPV cruise and the encounter (i.e. a shorter time).

We approach the estimation of the correction factor *p* in equation 2 through simulation modelling. Taking the actual FPV record for a year (October through September) we randomly place an IUU cruise within the year, assigning it an IUU cruise duration drawn randomly from a specified distribution. We assume that an IUU vessel conducts fishing on each day during its cruise in one of the Areas in 48.3. We do not know which area this is, or when the FPV will search it. The search date is therefore assigned a random position within the FPV cruise. If the IUU vessel has not arrived in zone at this point, or has departed, then the FPV will miss it. If the IUU vessel is in the zone, there is still a chance that the FPV will miss it. This will be a combination of the probability that it is simply not seen even though the FPV searched the Area(s) within which it was fishing, and the probability that it has never been fishing in the same Area as the FPV was searching. This combined probability is called the encounter probability.

The process is illustrated in figure 3.1. The year is illustrated by a line extending 365 days. The first simulated IUU cruise occurs from day 20 to day 60. Since this is prior to any FPV cruise, it is undetected and the IUU cruise is assigned its full, simulated, number of days. The second IUU cruise takes place just after the end of the first FPV cruise, but overlaps with the next two FPV cruises. It is missed by the first one (modelled using the encounter probability acting at the time of the downward-pointing arrow) but correctly located by the third FPV cruise (at the second downward-pointing arrow). Each of the upper row of downward-pointing arrows is the (random) day on which the FPV searches an Area in which the IUU vessel is fishing.

[3] Obviously, when a vessel is arrested it will stop fishing immediately. Whilst arrests have been made, it has been more common to encounter longline buoys alone, which are subsequently lifted. Vessels have also been encountered outside the South Georgia Management Zone, in international waters inside the CCAMLR Area, in which case they are either inspected (if they are CCAMLR Members) or asked to leave the CCAMLR Area (non-CCAMLR Members).

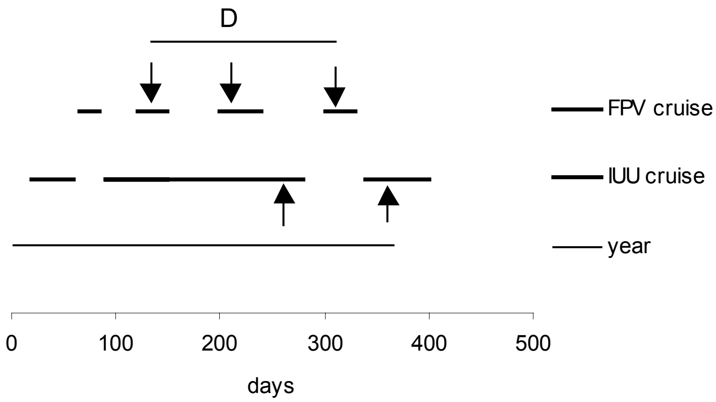


Figure 3.1 Schematic representation of the stochastic model.

Following the encounter between the FPV and the IUU vessel, the IUU vessel modifies its behaviour and leaves at some random time before the next FPV cruise. This may be before the end of its planned cruise duration, earlier than it would have if it had remained undetected (shown by the first upwards-pointing arrow in Figure 3.1). By modelling the behavioural response this way, we are in fact saying that if the IUU vessel is encountered close to the end of its planned cruise it will probably take the risk and finish it. If it has a long time still to run on its cruise it will not want to extend its fishing time in 48.3 by very much and will, in any case, finish its cruise sometime before the FPV is next in the area. Note that this is a more conservative assumption of IUU vessel response than the alternative, that the IUU vessel would leave Subarea 48.3 immediately.

Our estimate of the number of days fishing, according to the methodology outlined in section 3.1.1, is the duration D – the time between the previous search of the Area in which the IUU fishing was detected and the next search of the Area.

The final case is that of the third IUU cruise, which starts on day 340 after the last FPV cruise and has a randomly chosen cruise duration of 60 days. We chose to run these simulations individually for each year of the study period, because each has a quite different set of FPV cruises. Therefore, we only assign the IUU fishing days up to the end of the year and the IUU cruise is stopped at the second upwards-pointing arrow. This introduces a small edge effect, which is unlikely to have a significant effect on the results.

The above model probably mimics the interaction of IUU and FPVs fairly well. However, the choice of a random time during the FPV cruise for a possible “sighting” of the IUU vessel is at first sight counter-intuitive. One would think that it would be better to assign the random sighting time during the period of overlap of the IUU and FPV cruises rather than for the whole FPV cruise. But this would mean that there was no increased probability of detection of an IUU vessel with increased overlap between the FPV and IUU cruises – there would be as much chance of detection if the two cruises overlapped by one day as by 8 days. By reference to the diagram below, we would naturally expect that IUU1 cruise would be more difficult for the FPV to detect than IUU2.

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                 Time-->
FPV        -------------------
IUU1                 xxxxxxxxxxxxx
IUU2         xxxxxxxxxxxxx
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Each IUU cruise simulated therefore generates a real number of days fished and an FPV-estimated number of days fished. The ratio of real to estimated days fishing over 1000 simulated IUU cruises is *p*, and this is used to adjust the estimates of IUU fishing days made from real encounters of FPVs and IUU according to equation 2.

We ran simulations of 1000 IUU fishing operations for each year under a number of scenarios of assumed distributions of IUU trip length. Estimates of *p* derived from these runs (i.e. for sightings in 1998, 1999 and 2000) were then used in the main model (section 3.1.1 above).