Considerations for designing sampling strategies in observer programs to ensure representative coverage of key variables

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Summary
Resolution 11/04, which establishes the Regional Observer Scheme (ROS) for the IOTC, requires a minimum level of observer coverage of 5%, and specifies that the coverage should be representative of gear types in a CPC's fleet. From a scientific perspective, there are other very important considerations of representative coverage in addition to gear type – including:

1. fleet/sub-fleet (as defined by flag state, broad gear configurations, broad vessel size category)
2. target species (if clear separation is possible e.g. swordfish versus tuna)
3. A temporal stratum
4. An area stratum

Achieving representative coverage at 5% of some or all of these strata is almost impossible if total coverage is to be retained at 5%. We propose that 5% coverage for each stratum be achieved and that the Scientific Committee consider recommending an amendment to Res 11/04 to give effect to improved representative sampling of total effort under the ROS.

Introduction
Scientific fisheries observer programs exist because detailed information on many aspects of fishing simply cannot be collected, or collected with sufficient rigour, to rely on logbooks and vessel self-reporting. Prohibitive cost is a frequent argument used against the sanctioning 100% observer coverage (where all effort is observed). Until such time as those costs are no longer considered prohibitive (e.g. potentially through Electronic Monitoring with random subsampling of digital data), observer programs are in essence subsamples of total fishing activity. Subsampling requires careful design to achieve scientific analyses. The IOTC's Regional Observer Scheme (ROS) has, as a core objective, "to collect verified catch data and other scientific data related to the fisheries for tuna and tuna-like species in the IOTC area" (IOTC 2017). The preamble to Res 11/04 (IOTC 2011) confirms that scientific data from the ROS is essential for the Scientific Committee to manage stocks of IOTC species, and to support the implementation of CMMs (which include resolutions for non-target/bycatch impacts and other ecosystem impacts).

Given that Res 11/04 only requires 5% observer coverage, it would be extremely challenging to meet the goal (of using observer data to inform management advice) even if there was 100% compliance with all aspects of the ROS. Here we consider how Contracting Parties and Cooperating Non-parties (CPCs) may, in good faith, achieve 5% coverage while inadvertently compromising the scientific purpose of the ROS through failing to achieve appropriately representative coverage. In cases where fishing effort is heterogeneous (in terms of spatiotemporal distribution, gear, target species or other factors), it is unlikely that CPCs can achieve representative sampling while only covering 5% of effort. We propose solutions that the Scientific Committee could consider to strengthen the utility ofRes 11/04.

Sampling design considerations

It is well recognized that sampling design is a core consideration in any scientific study, because non-random, skewed or non-representative sampling strategies cannot readily be used to make scientifically robust inference about pattern or process. Scientifically robust conclusions about fishing can only be made from datasets for which the portion of the population (in the case of tuna fishing, the 'population' can be considered to be the effort relating to a fleet, target species, time or area, or some combination of those) that has been sampled adequately (Ashford 2002). Implicit in this point – that sampling must be at a certain level to be adequate for scientific analysis – is the concept that observer coverage should be representative. Representativeness is explicitly acknowledged in Paragraph 5 (b) of Res 11/04, which states that "…the minimum level of coverage is met and that the observed vessels are a representative sample of the gear types active in their fleet" (IOTC 2011). Gear type is, however, a very limited definition of the range of variables to be considered when defining 'representative' in the context of a scientifically valid sampling design. Spatio-temporal patterns in catch and effort are hugely variable, and failing to account for that variability can lead to significant under-sampling of key fishing effort at times or places, leading to biases and invalidating extrapolations from observed catch (or bycatch) rates to estimate the total catch (or bycatch). For an example, see Maree et al. (2014) supplementary material for the methods that must at times be employed to address relatively minor undersampling of effort in a fishery.

Examples of consequences from 'unbalanced' sampling strategies

It is often difficult to develop a perfect sampling strategy in advance of a fishing season, as one doesn't know what the distribution of effort will be. It's only afterwards, when data are analysed, that over- and under-sampling becomes evident. However, making efforts in advance of a fishing season to ensure some basic considerations of representivity are incorporated into the deployment of observers is highly desirable. We fully acknowledge that this may well result in total coverage in excess of the 5% that Res 11/04 calls for. However, we highlight here that Res 11/04 calls for a minimum of 5%, and there are strong reasons for increasing coverage above that minimum level. In Box 1 we present a hypothetical argument based on actual data reported (to ICCAT)

Box 1 – example of how extrapolation from non-representative data can be misleading

Ramos-Cartelle et al. (2016) reported observer coverage to ICCAT, for the Spanish longline fleet in the Atlantic Ocean, with a summary of the seabird-fisheries interactions from 2010-2014. The reported seabird bycatch rate was zero, which the authors attribute to the use of night-setting and the type of fishing. Although it's encouraging that no seabirds were recorded caught, a closer inspection of Figure 1 (pg. 8, Ramos-Cartelle et al. (2016), reproduced below) it is evident that all observed effort was in the central South Atlantic. To illustrate the problem, assume that the observed area were not a 'hotspot' for seabird bycatch, but othermore coastal areas, superimposed in red on the image, were of high seabird bycatch risk. If this were true (and we make no claims here, we merely illustrate the hypothetical example) then the true bycatch from this fleet would not be known from the observer data, nor would extrapolations from the observed population to the rest of the fleet's effort be valid. This point is used to illustrate shortcomings of non-representative sampling protocols, and should not be read as implying that Ramos-Cartelle et al. (2016) were misrepresenting seabird bycatch rates.

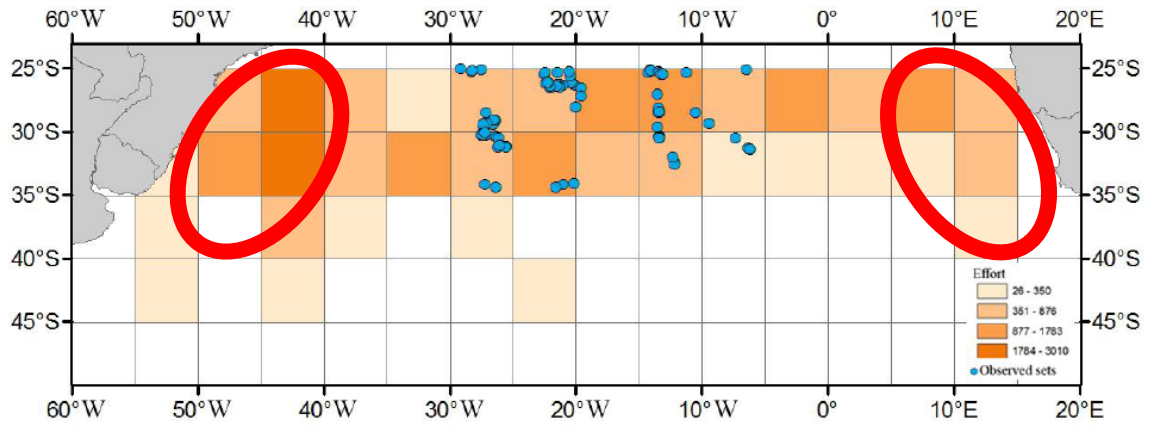

Figure 1. Position of sets observed in the South Atlantic (Latitude ≥ 25° S) from 2010-2014 (blue spots) and 5°x5° nominal effort (Task II-thousands hooks) in these areas during the combined period (colour scale).

Cost-benefit analyses for determining the best compromise between effort required to deliver robust, representative data versus cost for fisheries observers deployments consistently return values of ~20% coverage (e.g. Lawson 2006, Black et al. 2007, Debski et al. 2016). As such, the current level of 5% required coverage by IOTC already places a considerable constraint on the utility of ROS datasets, and BirdLife is on record as recommending 20% coverage for scientific observer programmes in tuna longline fisheries of the IOTC and elsewhere (e.g. Bristol et al. 2006, Black et al. 2007). The representativeness of observer coverage should be mandatory at 5% for all significant 'representativeness' variables; this is highly likely to result in >5% coverage of total effort. Representative strata could include:

1. fleet/sub-fleet (as defined by flag state, broad gear configurations, broad vessel size category)
2. target species (if clear separation is possible e.g. swordfish versus tuna)
3. Time (by summer/winter, quarter year or month, depending on fleet)
4. Area stratum (5x5° may be too small, unless there is large amounts of widespread effort)

We further recommend that Res 11/04 should be amended to reflect this expanded definition of what constitutes 'representative coverage'.

It is important to acknowledge that specific research requirements may require 'biased' sampling effort. For example, an albatross species of particular conservation concern from tuna longline bycatch might congregate in an area and in a particular season with very low coverage. It would be of great scientific and conservation value to direct observer coverage to vessels that regularly fish or that intend to fish in that part of the ocean. However, when coverage is at 5%, such directed observer deployments cannot be accommodated without serious compromise to other uses of the observer dataset. But such directed deployment would not undermine ROS data if coverage >5% were accepted, and other key 'representative strata' were observed at the proposed 5% level.

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