Northwest Atlantic Fisheries Organization

Serial No. N5530 **NAFO SCR Doc. 08/30**

Requirements to estimate fishing effort from VMS transmissions

by

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INTRODUCTION

Commercial fishing vessels are required to carry and use a VMS in the NRA to transmit position every two hours. Scientific Council, as part of their routine stock monitoring, require information on fishing effort and this can be acquired from VMS information (Campanis, 2007; Campanis and Thompson, 2007; Thompson and Campanis, 2007; Campanis *et al*., 2008). Currently, vessels transmit position at two-hourly intervals. This has been used to estimate fishing effort, but there are concerns regarding precision and bias. Last year, Scientific Council requested that NAFO move to a one-hourly transmission frequency, and transmits speed and course along with the position variable (NAFO, 2007:48).

METHODS

Monte Carlo analysis uses a computer to artificially take a large number of samples from a simulated defined population. In this paper, the population was a fishing vessel that would fish for five hours and then steam for one hour, giving a six hour fishing cycle in total. Sampling was undertaken at regular intervals, ranging from every 10 minutes to every 180 minutes. The time of the first transmission was chosen at random. The information transmitted was (a) Position only, and (b) Position and speed. Speed was calculated from position only transmissions by calculating the distance between successive transmissions and dividing by the transmission interval. A vessel was said to be fishing f the estimated or transmission speed feel within a certain speed range, selected to represent typical trawling speeds. The ranges were 1.00 -5.99, 2.00 – 4.99 and 3.00 – 3.99 kts. A total of 10 000 samples were taken for each run of the model.

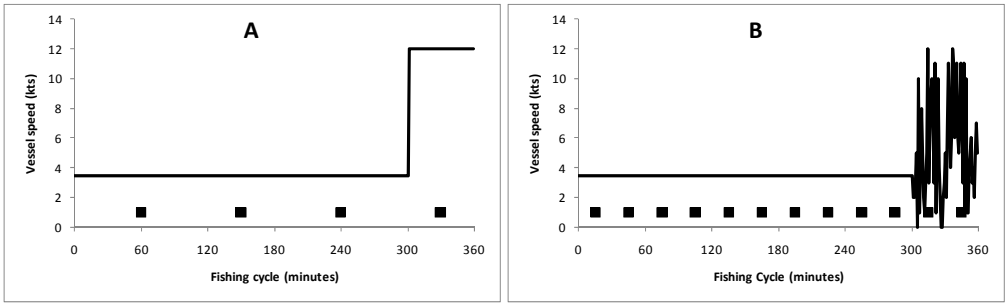

Figure 1. Schematic showing two different patterns of fishing throughout a six-hour cycle and the VMS transmissions (solid squares). (**A**) Vessel trawling for five hours at 3.5 knots and then steaming at 12 knots for one hour with a VMS transmission interval of 90 minutes starting in this example at 60 minutes into the cycle. (**B**) Vessel trawling for five hours at 3.5 knots and then steaming at a random speed between 0 and 12 knots for one hour with a VMS transmission interval of 30 minutes starting in this example at 15 minutes into the cycle.

RESULTS

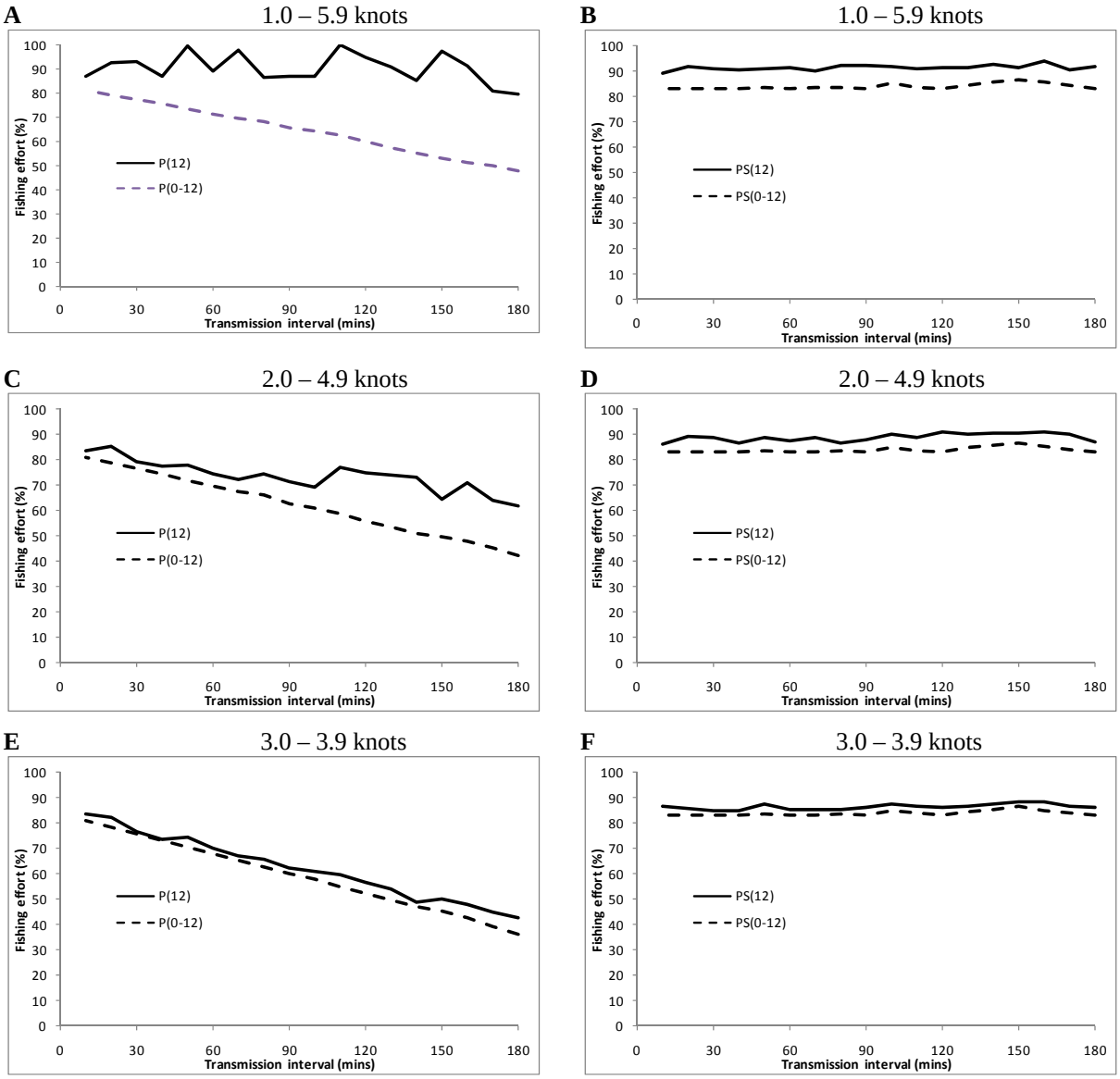

Figure 2. Results of the Monte Carlo simulations to determine the effects of transmission frequency and the fishing speed range on the sample average percentage of time fishing over a six-hour cycle. The know time fishing for the population was five hours or 83% and a one-hour period not fishing (steaming). Two different steaming patterns were chosen. In the left hand graphs (**A**, **C**, **E**) the vessel was steaming at 12 knots, and the right hand graphs (**B**, **D**, **F**) the vessel speed is random between 0 and 12 knots. The activity of the vessel is determined from its speed. In the top row (**A**, **B**) the vessel was said to be fishing if its speed was 1.0 – 5.9 kts, In the middle row (**C**, **D**) the vessel was said to be fishing if its speed was 2.0 – 4.9 kts, and in the bottom row (**E**, **F**) the vessel was said to be fishing if its speed was 3.0 – 3.9 kts.

Fishing Error Bias

Bias is taken to be the estimation of an average fishing effort that is either above or below the true fishing effort. The true fishing effort is known here to be 83% of the total time (Figure 2) because we have set up an artificial sampling program to sample a known population with a precisely defined fishing effort. This is Bias can occur in three ways:

- Sampling is not randomly distributed through the fishing-non-fishing cycle. We know this to be true as sampling is undertaken at regular time intervals. However, this bias may not be significant since the initial sample time (the first VMS transmission) is assigned randomly.
- Fishing is taken to occur when the boat is travelling at a certain speed (either 1–6, 2–5, or 3–4 kts) and there are two ways in which a boat could be travelling within these speeds when not fishing (a) when steaming speed is randomly assigned to be between 0–12 kts, and (b) when speed is calculated using from two successive positions with the vessel goes from a fishing to steaming.
- The speed range used to determine fishing is too wide or inappropriate

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Position only transmissions (the current situation)

- There is a general tendency to increasingly under-estimate fishing effort with increasing transmission intervals. The under-estimation is minimal with 10 minute intervals and rather large wit 120 minute intervals.
- The under-estimation is further increased when the non-fishing speed is randomly assigned to be between 0–12 kts.
- The under-estimation is reduced when the accepted speed at which fishing occurs is 1–6 kts and this can even lead to over-estimation of the fishing effort.

Position and speed transmissions

There is no progressive under- or over-estimation of fishing effort with increasing transmission times.

There is some over-estimation of fishing effort when the speed of the vessel in the non-fishing period is randomly assigned to 0–12 kts, because some mis-assignment occurs. This is reduced when the limits of the acceptable speed to assign fishing is narrow.

Fishing effort Precision (or error)

The Monte Carlo simulation allows for the standard deviation of the sample fishing efforts to be estimated. There difference among standard deviations for all the different sampling regimes was small and so only the average of all the standard deviations is show here (Figure 3). It is important to realise that the error here refers to the estimated fishing efforts from a single fishing cycle. The appropriate error statistic in a field sampling situation would be around the mean fishing effort for an entire cruise. A cruise may consist of 50 trawls (i.e. 50 fish cycles) and so the error of this would be much smaller and follow the formula: $sem = s/\sqrt{n}$. When this is taken in to account, it is found that the standard error on an overall fishing effort for an entire trip is only a few percent. However, it must be appreciated that the mean value may be biased, as documented above.

Tracking error

The estimation of fishing effort is not the only variable to be considered. It is also desirable to gain an understanding of where the vessel may be at any moment in time. Transmissions at a two-hourly intervals means that we know the vessels position to within approximately 12 miles, and one-hourly transmissions mean we know a vessels position within 65 miles (Figure 4).

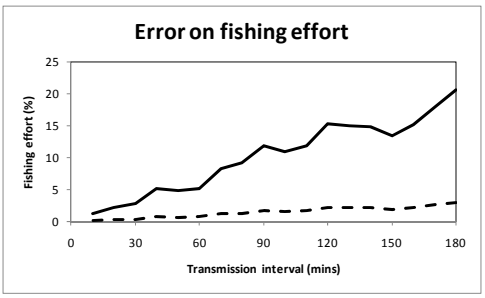

Figure 3. The standard deviation (solid line) and standard error of the mean (dashed line, n = 50) of the percentage fishing effort for the 10 000 samples taken in the Monte Carlo simulations. This is an average plot as the errors for all the plots shown in figure 2 were similar in shape.

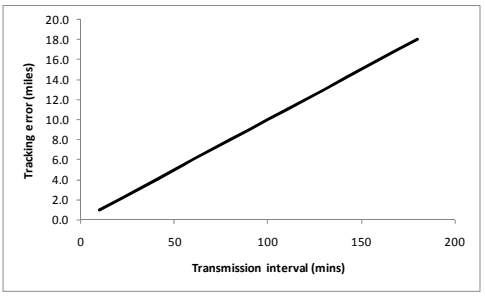

Figure 4. The relationship between the vessel tracking error and its VMS transmission frequency for a vessel steaming at 12 knots.

CONCLUSIONS

Currently, the commercial fishing vessels transmit their positions every two hours within the NRA. Neither speed nor course is currently provided to the Secretariat by the monitoring stations. Scientific Council requested that VMS should transmit positions and speed (and course) every one hour. The above analysis showed that, for the artificial fishing cycle chosen, which is fairly representative of a typical trawl in the NRA:

- The Monte Carlo analysis showed that the transmissions of the speed variable alone would remove most of the bias in the estimation of the fishing effort.
- The Monte Carlo analysis showed that the reduction of the transmission frequency to one hour would also significantly reduce bias, but is less effective than the transmission of a speed variable in reducing bias.
- The Monte Carlo analysis showed that the selection of too wide a range of speeds to determine trawling can over-estimate the fishing effort.
- The Monte Carlo analysis supports the Scientific Council request and indicates that there is no need to go to transmission frequencies of less that one hour for the determination of fishing effort in the NRA.

Scientific Council stresses that the calculation of fishing effort would be greatly enhanced if gear type and target species could be better identified through VMS.

References

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