Simulating deep-divers visual detection rates

ABU-10

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Physeter macrocephalus (photo Adrien C. Gannier)

INTRODUCTION

Visual detection of long-diving cetaceans is always subject to randomness. First, surfacing cetaceans may be detected or not at a given distance, their perception depending on a number of human, logistical and environmental factors (Barlow *et al*., 2006). Second, a survey boat can easily sail above cetaceans during their diving phase and miss them: this phenomenon is usually called “availability bias”.
Intuitively, it may be supposed that the detection rate of a diving cetacean is closely related to its surface/dive time ratio and linked to platform speed: at a given speed, the more time is spent underwater, the lower would be the ratio (detected schools / present schools). Conversely, we might expect that for a given surface/dive ratio, the faster the survey boat, the lower the ratio (detected/present).
We studied both aspects of the detection process with a simulation based on experimental surface/dive cycles for three different species: the fin whale (*Baleanoptera physalus*), the sperm whale (*Physeter macrocephalus*), the Cuvier’s beaked whale (*Ziphius cavirostris*).

Baleanoptera physalus (photo Adrien C. Gannier)

METHODS

A custom software was written with Matlab. For simulations, fixed parameters were: the number of observers, the effective detection radius (set equal to 1,000 m for all species), the spatial area (area length and width), the population density (0.05 ind./km2) and mean school size (1, 1.5 and 2, respectively for SW, FW and CBW). We ran the simulation for a fixed transect with random cetacean distribution, and whales were assumed to be static on the x,y plan, with a realistic surface-dive cycle.
Surface/dive cycles were typical figures for each species, as recorded during GREC surveys in the NW Mediterranean Sea (Table 1). Surface/dive cycles were simple for both fin and sperm whale (stereotyped surface and dive duration), and complex for Cuvier’s beaked whale (combination of surface sessions with both feeding and recovering dives).
For fin whale, a “short-diver” the surface/total time ratio was 14%, for the sperm whale a deep-diver with simple cycle, the ratio was 20%, and for Cuvier's beaked whale, a deep diver with complex dive cycle, the surface/total time ratio was 11%.

Species	Feeding dives duration mean (sd)	Number of short dives	Short dives duration mean (sd)	Surface duration mean (sd)	Surface/Total cycle duration ratio
Fin whale	12 (2)	0 (0)	-	2 (0.75)	0.14
Sperm whale	40 (7)	0 (0)	-	10 (2)	0.2
Cuvier’s b. w.	61 (10)	3 (1)	13 (3)	3 (1)	0.11

Table 1: Surface/dive cycles for three whale species in the Mediterranean Sea (taken from GREC field data 1990-2010).

Boat speed was set to vary from 1 m/s (about 2 knots) to 15 m/s (about 30 knots, the speed of a fast semi-rigid boat). Averages and variances were obtained with 10,000 runs of the simulated transect.
We compared the detection ratio defined as the number of school detected divided by the number of school present within the survey strip.

REFERENCES

Barlow J, M.C. Ferguson, W.F. Perrin, L. Ballance, T. Gerrodette, G. Joyce, C.D. MacLeod, K. Mullin, D.L. Palka, G. Waring, 2006. Abundance and densities of beaked and bottlenose whales (family Ziphiidae). J. Cetacean Res. Manage. 7(3): 263–270

RESULTS

The detected/present ratio was expressed as a function of boat speed, comparing the three species (*Figure 1 and 2*). Results were focused on two particular survey modes: an abundance survey mode, where the area of study was sampled only once by each platform, and. The second survey mode was “biological sampling”: a survey during which the number of different detected cetaceans during a given amount of time had to be maximized, for example if the aim is to photo-identify or biopsy as many distinct individuals as possible.

For the abundance survey mode, our simulation highlighted several interesting results:
- for slower boats (1 to 4 m/s), the detection ratio was much higher for the FW, a short diver, than for both long-diver species: at 1 m/s the FW ratio was almost the double than the sperm whale's one (90% vs 47%),
- for very fast boats (over 10m/s), detection ratio were similar for SW and FW (detection rate 21% and 19%), and much lower for CBW (about 11%)

In the “abundance survey mode”, very fast platforms missed about 90% of the Cuvier’s beaked whale population. For slow boats (5 knots), about 70% of the sperm whale and CBW was missed during the visual transect.

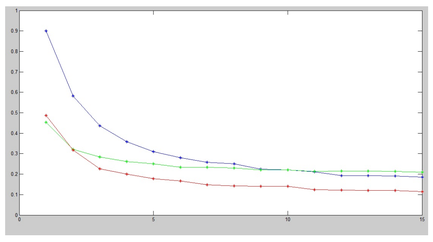

Figure 1:
Detected/present ratio as a function of boat speed, for three species, abundance survey mode.
Blue: fin whale – Green: sperm whale – Red: Cuvier’s beaked whale

For the “biological sampling” mode, our simulation showed that each species had a specifical trend :
- for fin whale, detection rates were high: about 90% of the individuals are contacted at very low speed (1 m/s) and very high speed (over 10 m/s), but there is a minimal detection rate (80%) for 2-5 m/s speed range,
- for sperm whale, detection rates increased from about 50% at 1 m/s to about 95% for 15 m/s, but rates are closing their maximum for speed above 10 m/s,
- for Cuvier’s beaked whale, detection rates were lower than for SW and increased almost linearly with speed, to reach a maximum of 80%.
Consequently, the speed option for “biological sampling” mode has to take the species into account, a very high speed being efficient for CBW but not for FW, and a moderately high being acceptable for sperm whales.

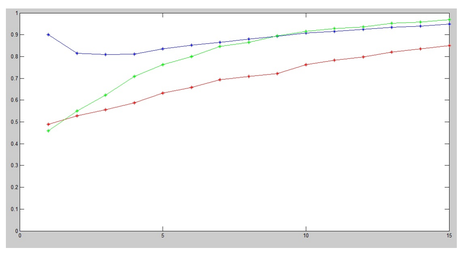

Figure 2:
Detected/present ratio as a function of boat speed, for three species, biological sampling survey mode.
Blue: fin whale – Green: sperm whale – Red: Cuvier’s beaked whale

DISCUSSION and CONCLUSION

Speed effects shown by simulation were more complex than expected, with distinct trends for the different species. To optimize the detected/present ratio, the speed choice has to take the survey aim into account.
For abundance survey mode, it is confirmed that conventional boat surveys with speed between 10 and 15 knots tend to results in very low detection rates for deep divers, as already observed during actual surveys (Barlow et al., 2006). Slow boats offer a much higher detection rate for deep divers. However, even for abundance surveys, there is always a time constraint since a pre-defined sampling has to be carried out during the “good weather” field season. When no suitable methodology is available to estimate the availability bias, our simulation can be used to correct density estimates obtained by survey, and to optimize platform choice.
For biological sampling survey mode, short and deep divers showed different results, the former featuring a high detection rate even at low speed. Fast boats are to be preferred to obtain more biological samples of deep divers, in a given field time.
Risk mitigation of high-intensity noise sources is another example of potential use of this kind of simulation: we have shown that fast platforms (possibly including helicopters) are more efficient to increase the detection rate of long divers in a given mount of time, in a definite area.

Ziphius cavirostris (photo Adrien C. Gannier)