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COMMENT

# Survival of the fittest technology — problems estimating marine turtle mortality

**Corey J. A. Bradshaw***

Key Centre for Tropical Wildlife Management, Research School of Environmental Studies, Charles Darwin University, Darwin, Northern Territory 0909, Australia

A recent exchange in MEPS between some eminent marine turtle ecologists (Chaloupka et al. 2004b, Hays et al. 2004), which centred on the methodology of estimating fisheries-related mortality (FRM) of marine turtles (Hays et al. 2003, Chaloupka et al. 2004a), has provided readers with some interesting points for discussion. Hays et al. (2003) started the ball rolling by attempting to provide a global estimate of FRM by examining the fate of satellite-tracked individuals from 3 different species. Chaloupka et al. (2004a) then provided a detailed analysis of the fate of loggerhead turtles tracked using satellite telemetry following their capture and subsequent release during pelagic longline fishing operations. In their discussion, the latter devoted a large section outlining their opinion that the estimates provided by Hays et al. (2003) were flawed. The arguments continued in a Comment by Hays et al. (2004) and a Reply Comment by Chaloupka et al. (2004b).

Both research groups have provided an incredible wealth of knowledge regarding FRM estimation for marine turtles. As they have both reiterated, however, we are still a long way from providing truly robust FRM estimates and their spatial and temporal variation. The one thing that we do know is that many turtle populations worldwide are still in trouble (Márquez 1990, Casale et al. 2004, Lewison et al. 2004), despite recent, local success stories in reducing incidental mortality in trawl fisheries (Robins & McGilvray 1999, Robins et al. 2002). Thus, the debate is not about whether turtles are succumbing directly and indirectly to fishing operations; rather, it focuses on the best methodology to determine the magnitude of the problem.

Herein lies the conundrum. Both research groups attempted to estimate FRM using distinct techniques. Hays et al. (2003) examined the peculiar fate of individual turtles that had been tracked successfully for many months. They attributed sudden movements of the near-real-time location data to inland villages, the sudden increase in the rate of high-quality locations at sea (indicating the tracking units were no longer submerged), or the sudden emergence of the unit from the water (indicated by a loss of electric current in the on-board conductivity switches) as evidence for direct predation by (human) fishers. These peculiarities contrasted starkly with the normal, unexplained and sudden cessation of transmitter signals indicative of technological failure.

Chaloupka et al. (2004a), on the other hand, instrumented turtles caught during longline fishing and subsequently released them. The fate of their study animals was argued to be confounded by unit failure, so no real estimates of FRM could be made (despite exhaustive statistical analyses and the authors' claim that they had provided robust estimates of post-hooking mortality; see Chaloupka et al. 2004b). Neither did they report any peculiar behaviour of the location/sensor data post-release that may have suggested a fate different to that of simple technological failure, nor were sensors operational in many cases for long enough prior to failure to rule out faulty equipment as the leading cause of transmission loss.

This appears therefore to be a case of experimental apples and oranges — long-term evidence of technological performance followed by behaviour suggestive of human predation (rather than unit failure) in the case of Hays et al. (2003) versus the estimation of individual survival post-hooking by Chaloupka et al. (2004a). So, what is the dispute? Chaloupka et al. (2004a) argued rather vigorously that the sample size on which the Hays et al. annual mortality estimate was based was too small to have any statistical meaning. Indeed, one should note that the 95 % binomial confidence intervals narrowing as a function of the number of tracking days (Fig. 2 in Hays et al. 2003) necessarily assumes that the true mean FRM for marine turtles is 0.31. The reality is slightly more complex. Fig. 1 demonstrates how the detection of varying numbers of suggested turtle deaths and the associated change in the number of tracking days alters the confidence limits of annual mortality estimates. Perhaps Hays et al. (2003) should have refrained from

*Email: corey.bradshaw@cdu.edu.au

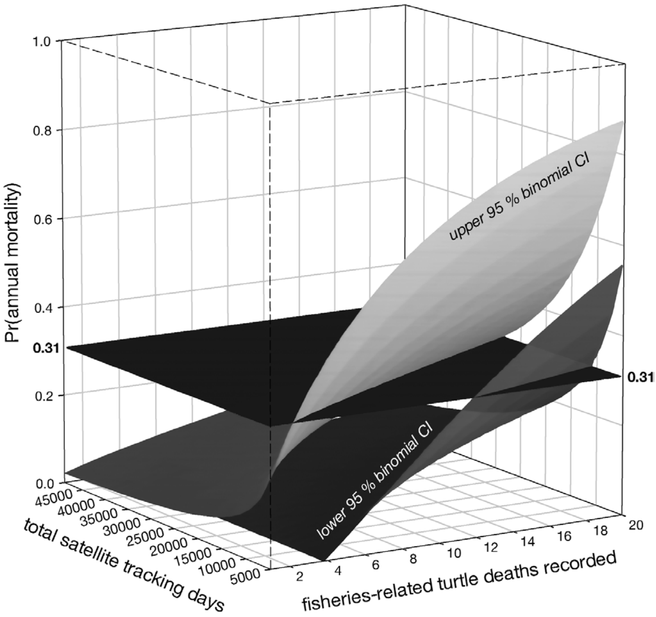


Fig. 1. Binomial 95% confidence intervals (CI) for the estimate of annual fisheries-related mortality estimated as a function of the number of satellite-tracked turtles deemed to have died due to fishing operations and the number of satellite-tracking days. The plane at Pr(annual mortality) is the mean estimate provided by Hays et al. (2003)

citing a particular value for annual FRM and instead only portrayed the confidence limits. This is because the true mean has equal likelihood (in this case, 95%) of falling anywhere between the upper and lower FRM limits for particular values of turtle deaths and tracking days.

Unfortunately for those studying long-lived and clandestine species such as marine turtles, high variance in life history parameter estimation is a fact of life. However, does this render estimates and their associated variance functionally useless? Some researchers may adopt that opinion, but as the crisis of species extinctions continues, a rough guide for a demographic parameter is far more useful than none at all. Population viability analyses (PVA) incorporating measurement error, and environmental and demographic stochasticity are common tools that conservation biologists now use regularly to assess the long-term persistence potential for a wide range of taxa. Therefore, let us not 'throw the heuristic baby out with the numerical bath water' (Brook et al. 2002). After all, even coarse demographic estimates can help guide policy makers when making important decisions such as listing species as threatened, or incorporating control measures to reduce incidental and direct mortality in susceptible species.

One final word regarding the nucleus of the Hays–Chaloupka debate — is it feasible to infer turtle death from satellite data? With all the aforementioned caveats and discussion, my opinion is that it is possible, provided the following conditions are met: (1) the satellite unit deployed should have demonstrated sufficient temporal performance to provide a strong baseline comparison of normal versus peculiar behaviours; (2) simple loss of transmission unaccompanied by anomalous data prior to the loss should never be taken as a mortality; and (3) more than one indication of anomalous behaviour should be available before inferring death as the cause (e.g. sudden, linear movement with 'dry' sensor data).

I hope that marine researchers will continue to debate the approaches used to estimate demographic parameters that are notoriously difficult to quantify. I hope that we refine our techniques based on these debates, and more importantly, I hope that we continue to merge our ideas and datasets. I would therefore also like to re-iterate the closing comments made by Hays et al. (2003): fostering collaboration between different research groups is essential to increase sample sizes and obtain more precise (and hence, more meaningful) estimates of at-sea survival.

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