Submission to the Parliamentary Inquiry into the efficacy and regulation of shark mitigation and deterrent measures.

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I am Dr Laurie Laurenson, I am an academic with research expertise in fish and fisheries biology, remote sensing and have had a particular interest in shark biology for the last 20 years. I currently hold the positon of Associate Professor at the Warrnambool Campus of Deakin University. I have published more than 70 scientific research papers since the 1980s on various aspects of shark biology, fish biology and remote sensing.

This submission addresses the efficacy of the shark mitigation programs (drum lines and shark netting) currently run in New South Wales, Queensland and Western Australia. This submission falls under "(*c) the range of mitigation and deterrent measures currently in use*", although I argue that it has wider implications to the control program and falls more directly under efficacy in general.

Background

Large sharks have been visiting coastal waters for a long time and the opportunity for these animals to attack people is well known (Amin et al. 2014; Cliff and Dudley 1992; Gross 2014). When the attacks occur there is usually a media outcry and it results in poor public perceptions of sharks (Muter et al. 2013, Simpfendorfer et al. 2011). Little seems to have changed since 2011, and this is why Neff (2014) coined the term "the Jaws Effect".

There are many methods used to control the number of shark attacks on beaches from non-lethal removal of animals (Hazin and Afonso 2014), excluding sharks and/or culling them from certain areas (McPhee 2012; Neff 2012). Australia's programs cull, and are what are called density reduction programs (Dudley 1997; Green et al. 2009). The underlying assumption of density reduction programs is that a high fishing effort will catch lots of sharks, this will reduce the numbers of sharks in the area, and this reduction in the numbers of sharks will result in fewer shark attacks (Ferretti et al. 2015). This is a sound argument that makes much sense, but the effectiveness of the process has never been statistically tested (Cliff and Dudley 1992; Dudley 1997; McPhee 2012). The primary evidence used to support culling as an effective management strategy has been the comparison of the numbers of attacks before and after the implementation of culling and comparisons of regions with and without such measures (McPhee 2012).

The observation that the proportion of *fatal attacks* has declined subsequent to the introduction of culling is well founded Dudley (1997). However, people automatically assume that culling is the cause of fewer fatalities. In South Africa and Australia, shark attacks in the 1940s resulted in huge improvements in medical treatment and facilities made available to the first responders to shark attacks (Caldicott et al. 2001). These authors state that the increased survival rates were the result of better training of first-responders and subsequent antibiotic therapies. There have been continued improvements to these processes across time (Goodwin and White 1977). The point here is that there are multiple factors that go into reducing the number of fatal shark attacks, including medical intervention, much better vigilance from surf lifesaving organisations, aerial surveillance etc. The contention that culling is exclusively responsible for the reduction in fatalities and in attacks in general has not been separated from all the other strategies used to reduce the attack rate.

We are not the first to question whether culling is effective in reducing the number of shark attacks, this was first pointed out by Wetherbee et al. (1994) in Hawaii who stated that their impact has been overstated as there does not appear to have been a measurable impact on the attack rates by tiger sharks. Moreover, the observation that there has been an increase in the numbers of shark attacks in California over the last 60 years has also been questioned by Ferretti et al. (2015) who showed that the risk of attack had declined by >91% between 1950 and 2015, despite the fact that the numbers of attacks per year increased from 0.9 (1950s) to 1.5 (2004 to 2013). They attributed the increase in the number of attacks to increases in human population size and subsequent increases in use of coastal waters.

My intent here is to argue that, based on the analysis of 60 years of shark attack data from the greater Sydney area in New South Wales, that we cannot show that there is a relationship between the number of shark attacks and the number of sharks. That is, if we can show that there is a reduction in the number of sharks in an area, then we should also expect a reduction in the number of attacks. There should be an identifiable relationship between these events.

We have analyzed the number of shark attacks occurring in the greater Sydney area and compared this to the number of sharks found in the same waters and the number of people using the water (50 years of data, the analysis can be provided if required). We found a strong correlation between the number of sharks and the number of people in the area (GAM: $X^2_{3.2,55.8}=14.70$, $P=0.005$, $R^2=0.25$) but could not identify a relationship between the number of shark attacks and the number of sharks in the area (GAM: $X^2_{2.9,56.1}=1.80$, $P=0.712$, $R^2=0.09$). To reiterate, there are more people in NSW using the beaches and there is a relationship between the number of people using the beaches and the number of shark attacks. In contrast, there are fewer sharks in the water but there is no statistical link that we can identify between the number of sharks in the water and the number of shark attacks.

Conclusions

The study we completed focused on whites, bulls and tiger sharks because these are the species usually involved in attacks. We expected to find a relationship between the culling of sharks and the number of attacks with there being a direct correlation, but we did not. Also remember that previous studies relied on fatal/serious injury attacks before and after culling in their analysis to show that culling actually reduces the number of attacks (we have used all unprovoked attacks). But these studies have not factored in all the other strategies that have been used to reduce the impact of attacks. We understand that we are expressing views that contradict previous work, that is, a reduction in large shark numbers is responsible for declines in fatal and serious shark attacks (Dudley 1997; Green et al. 2009). We hold the view that the small temporal and spatial scales of these earlier studies did not consider the highly random nature of shark attacks, and were unlikely to detect potential reductions in such events, but rather reflected periods where these happen to be less frequent. To that end, we know that the number of shark attacks has fluctuated widely over the last 60 years, but have never been very large.

Many shark species, including white (Bonfil et al. 2010), bull (Heupel et al. 2015; McCord and Lamberth 2009; Simpfendorfer et al. 2011) and tiger sharks (Ferreira et al. 2015; Heithaus et al. 2007) can travel large distances in relative short periods of time (up to 5 $km.hr^{-1}$) and have large spatial ranges (>100 km). In contrast, existing culling programs tend to be implemented at localized spatial scales (i.e. ~10 km). Thus, there is a mismatch in scale between management control and the ecology of the targeted species. It is argued (anecdotally) that culling can help with restricted range, territorial sharks that are potentially responsible for attacks (i.e. rogues in a confined area). However, recent tagging studies (Bonfil et al. 2010; Ferreira et al. 2015; Heithaus et al. 2007; Heupel et al. 2015; McCord and Lamberth 2009; Simpfendorfer et al. 2011) demonstrate that such territoriality, at least in white, tiger and bull sharks, is difficult to support.

The two important factors that potentially impact the argument that culling is effective in reducing the number of attacks have not been given the importance they deserve. Firstly, the level of increased vigilance on the part of surf lifesaving organizations following the early attacks almost certainly had an impact on the numbers of shark attacks, moreover, such vigilance still forms a mainstay of shark attack management systems. Secondly, there is the potential that changes in the numbers of shark attacks has occurred as a result of periodic aggregations of sharks, such as feeding (Sprivulis 2014) or reproduction. We cannot quantify the degree to which such factors influence the number of shark attacks, but the contention that culling is the main driver in reducing the number of attacks is difficult to justify given the number of confounding processes that influence the frequency of these events.

The take home message from the analysis we have completed is that culling cannot been shown to be effective in reducing the number of shark attacks, despite having 50 years of data to analyze (at least in the greater Sydney area). Part of the reason we think that culling is ineffective is because large sharks can travel very large distances in very short periods of time. So for a culling program to be effective, it needs to cull all sharks from a much wider range. That is, the current culling programs cannot protect single beaches without culling sharks from the entire area, with the area defined by how far and how quickly sharks can move (about 100 km per day). But even this is not the real issue, the real issue is that the wider public actually believes that culling sharks reduces the chances of them being attacked. The analysis we have completed demonstrated that this belief is incorrect. The culling strategy currently in use cannot be shown to reduce the chances of being attacked by a shark. They remain insignificantly low, but still finite.