

Policy Annexure A

Guidelines for the adaptive management of white shark tour licensing

Introduction

South Australia's White Shark Tour Licensing Policy 2016 establishes a framework for the adaptive management of white shark tour licensing. An adaptive management approach ensures that white shark tours do not impact on white sharks by enabling policies for white shark tour licensing to be refined over time.

This approach is informed by a scientific monitoring program which is undertaken at the Neptune Islands Conservation Park by the South Australian Government. This program records the arrival and departure of white sharks from the Neptune Islands. The comparison of data between years enables trends in the effects of white shark tours to be determined.

As outlined in South Australia's White Shark Tour Licensing Policy 2016, refinements to licensing arrangements may be triggered should these trends reach predetermined 'decision ranges'.

Measuring the effects of white shark tours on white sharks

The annual mean white shark residency at North Neptune Islands is an indicator of the effects of white shark tours on white sharks. White shark residency is defined as the number of days between the first and last detection of a white shark, without any gaps in detection exceeding five consecutive days (Bruce and Bradford 2013).

Information about white shark residency is collected through the tagging of white sharks and the installation of acoustic monitoring receivers at the Neptune Islands. These receivers record the identification number, time and date each time a tagged white shark enters the detection range of a receiver. This data enables the residency of each tagged white shark that visits the Neptune Islands and the annual mean residency of all tagged white sharks to be determined (Bruce and Bradford 2011).

Any effects that may have occurred as a result of white shark tours prior to 2001-03 cannot be quantified because the residency of white sharks at the Neptune Islands was not studied before this period.

It is assumed that data collected when white shark tours were less frequent, between 2001 and 2003, provides the best available representation of 'natural' residency levels at the Neptune Islands. It is also assumed that the 24 white sharks monitored between 2001 and 2003 were representative of white shark residency at North Neptune Islands at that time.

Analysis of white shark residency

As outlined in South Australia's White Shark Tour Licensing Policy 2016, changes in licensing arrangements will be considered when there is clear scientific evidence that warrants a response. Therefore it is necessary to identify statistically significant trends in residency while also discounting the influence of the natural variations in mean residency which can be expected to occur from year to year.

This is achieved by analysing the mean and standard deviation of annual white shark residency each year using a method based on the central limit theorem. The central limit theorem states that independent variables tend to be normally distributed, and such data have known properties. For example, normally distributed data have about 68 per cent of their values within one standard deviation of the mean, and about 95 per cent of their values within two standard deviations of the mean.

The properties of a normal distribution curve are used to estimate the probability that the annual residency recorded in any given year has occurred as a result of natural variation, or is reflective of an effect arising from tours or some other factor. Each year data collected is analysed and compared with the 2001-03 baseline data. This enables conclusions to be made about trends in white shark residency at the site.

White shark residency data collected to date are not normally distributed. To enable comparison of results between years, data can be normalised using a \log^{10} transformation. Consequently, mean residency will be expressed as a \log^{10} value. Unless otherwise indicated, all \log^{10} values are presented as \pm one standard deviation.



Decision ranges

Target range $\leq 0.70 \log^{10}$ days

The Target range is the range of mean white shark residency values which are thought to represent an insignificant effect from tours. It is based on the assumption that baseline residency levels in 2001–03 are optimal for the recovery of the white shark. The Target range includes annual assessments of white shark residency that are similar to those observed 2001–03 ($0.65 \log^{10}$ days). More specifically, it includes all white shark residency values that are less than, or equal to 0.1 of a standard deviation above the 2001–03 baseline mean white shark residency.

A comparison between the Target range and the 2001–03 baseline is depicted in Figure 1 below. The South Australian White Shark Tour Licensing Policy 2016 provides direction should mean white shark residency fall within the Target range.

Response range $\geq 1.20 \log^{10}$ days

The Response Range includes all mean white shark residency values which are thought to impact on white sharks. It is based on the assumption that mean white shark residency values that are significantly above those observed in 2001–03 may impact on white sharks. The Response range includes annual assessments of white shark residency that are significantly above the 2001–03 baseline. More specifically, it includes all white shark residency values that are more than 1 standard deviation above the 2001–03 baseline.

The Response range is triggered when:

- 1) Level 1 - the mean white shark residency at the North Neptune Islands is between 1 and 2 standard deviations of the 2001–03 baseline ($1.20 - 1.76 \log^{10}$ days)
- 2) Level 2 - the mean white shark residency at the North Neptune Islands is more than 2 standard deviations above the 2001–03 baseline ($\geq 1.76 \log^{10}$ days)

A comparison between the Response range and the 2001–03 baseline data is depicted in Figure 1. The South Australian White Shark Tour Licensing Policy 2016 provides direction should the Response range be achieved.

Caution range $0.70 - 1.20 \log^{10}$ days

The Caution range includes annual assessments of white shark residency that are above the Target range and are below the Response range. A comparison between the Caution range and the 2001–03 baseline data is depicted in Figure 1. The South Australian White Shark Tour Licensing Policy 2016 provides direction should the Caution range be triggered.

References

Bruce BD, Bradford RW (2013), The effects of shark cage-diving operations on the behaviour and movement of white sharks, *Carcharodon carcharias*, at the Neptune Islands, South Australia. *Marine Biology* 160: 889–907.

Bruce BD, Bradford RW (2011), The effects of berleying on the distribution and behaviour of white sharks (*Carcharodon carcharias*), at the Neptune Islands, South Australia. Final Report to the Department of Environment and Natural Resources, South Australia.

