



Researchers search for juvenile white sharks to tag and tissue-sample off the coast of Port Stephens in New South Wales. This ongoing field research yields movement, survival and genetic information used in population estimates. Image: CSIRO

Fact sheet, February 2018

## Assessing the size of Australia's white shark populations

*A unique combination of acoustic tagging and genetic and statistical advances has produced the first evidence-based population estimates for Australia's white sharks.*

White sharks are listed as vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 and actions to assist their recovery and long-term viability are prescribed in a national recovery plan for the species. A priority action is to develop an effective means of estimating the size of white shark populations and monitor their status (population trend). This would provide a scientific basis for assessing recovery actions, and for local policies governing human-shark interactions: an issue of significant public concern.

A project led by CSIRO has developed and applied white shark population assessment tools to support national strategies for population monitoring. The project is part of the National Environmental Science Programme (NESP) Marine Biodiversity Hub, an Australian Government initiative that aims to improve the knowledge of key marine species and ecosystems to underpin their management and protection. Tools and techniques employed in the project built on those

developed under the National Environmental Research Program Marine Biodiversity Hub (the forerunner of the NESP).

### Innovative approaches applied to build population models

All white sharks cannot be seen and counted, so scientists use mathematical equations (population, or demographic models) to estimate population size. Building population models requires knowing how many distinct populations there are. Then, for each population, a suite of 'life history' measurements must be gathered in order to give the model a factual base.

Typical life history measurements are:

1. how often adult females breed;
2. the age at which females begin to breed;
3. how many pups are born;
4. how many sharks survive from one year to the next;
5. how fast the sharks grow; and
6. how long the sharks live.

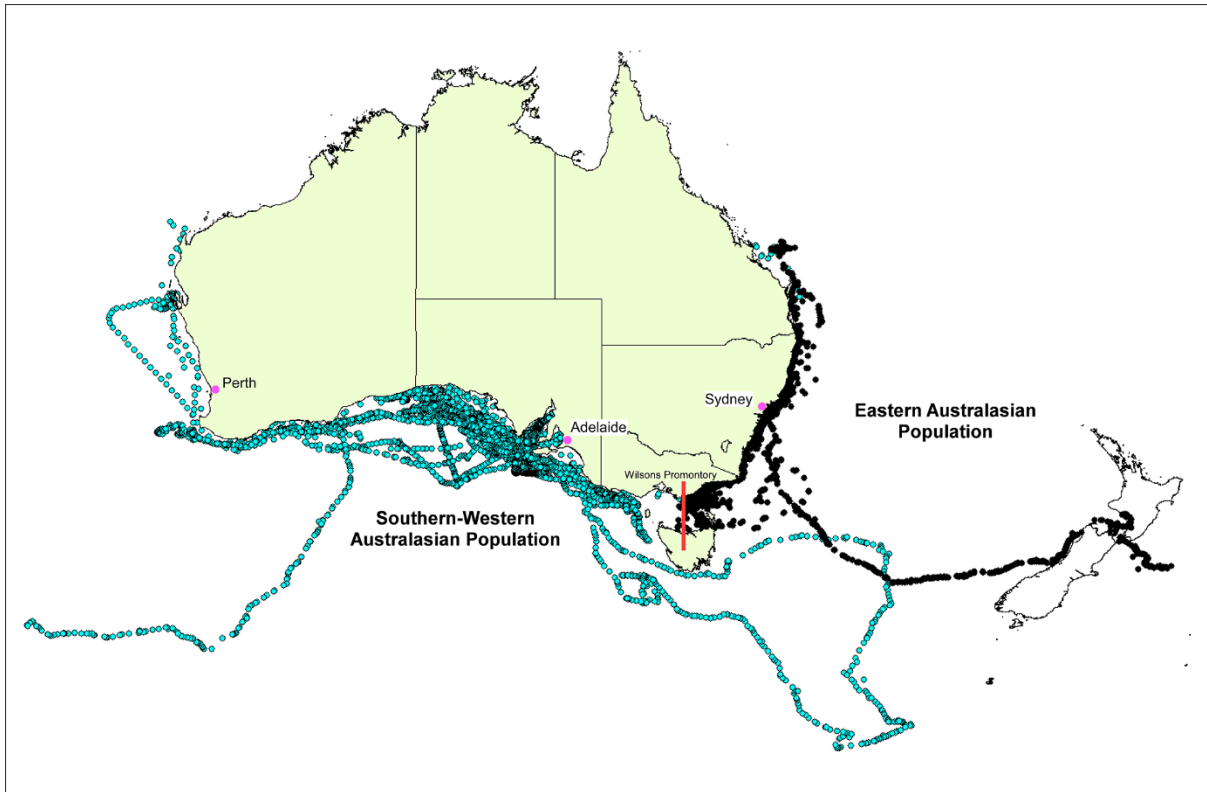
Another important measure is at least one count of a distinct age group, such as the number of juveniles or adults in the population.

An understanding of white shark movement patterns is also needed in order to distinguish overall trends from local fluctuations in shark numbers (which may simply reflect changes in distribution). White sharks are extremely mobile, migrating across distances of thousands of kilometres. Their abundance in any one region can therefore vary between seasons and from year to year.

All these parameters are difficult to measure for white sharks. Furthermore, any increase in numbers would be gradual and difficult to detect, given the species' slow rate of reproduction. This project has addressed these challenges with a unique application of electronic tagging and tracking, collection and archival of tissue samples, and a combined genetic and statistical technique called 'close-kin mark recapture'.

### Identifying eastern and western populations

Tagging data and genetic evidence suggests two populations of white sharks exist in Australia: an eastern population ranging from Tasmania to central Queensland and across to New Zealand, and a southern-western population ranging from western Victoria to north-western Western Australia. The eastern population was the first to be targeted for population assessment.



This map shows the tracks of 70 white sharks fitted with satellite telemetry tags by CSIRO and research partners since 2000. Image: CSIRO

### Monitoring juveniles in the east: abundance, movements and survival

Adult white sharks are difficult to find and sample off eastern Australia, but juveniles are known to aggregate at coastal nursery areas near Port Stephens, New South Wales, and Ninety Mile Beach in eastern Victoria. CSIRO has been tagging and tissue sampling juvenile white sharks at Port Stephens since 2007 and the work is being continued by the New South Wales Department of Primary Industries (NSWDPI). Satellite tracking tags and long-life acoustic tags are used to monitor shark movements, habitat use and survival. The acoustic tags can be tracked for up to 10 years by a network of acoustic receivers along the east coast maintained by Australia's Integrated Marine Observing System.

From the acoustic tagging data, it is estimated that 73 percent of juveniles in the eastern population survive from one year to the next. (Survival includes natural survival, and survival from accidental capture by fishing operations and targeted catches by devices such as nets and drum-lines.)

Aerial surveys have been trialled to estimate the number of juveniles, and baited remote underwater video systems tested (with NSWDPI) for counting juvenile white sharks, monitoring tagged individuals and estimating size and growth. The novel advance that has been developed in this project, however, involves estimating adult abundance.

### Close-kin: counting adults from sibling pairs

For the eastern Australasian white shark population, the number of adult sharks was counted without the need to catch or even see the adults. Instead, their

distinctive genetic marks were identified in the genes of their offspring. DNA sequencing of tissue samples collected from 214 juveniles identified the parents and related individuals (kin), and mitogenome sequencing identified the sex of the parents. More than 70 individuals were found to share a parent. 'Close-kin' analyses were then applied to provide life history measurements for the population model.

The close-kin approach, which CSIRO has used to measure southern bluefin tuna stocks, is likely to revolutionise the way that fish (and other animal) populations are assessed worldwide. It provides three important measures for the population model: a) the number of breeding adults; b) how frequently they breed, and c) their rates of survival.

a) *The number of breeding adults* in a population relates directly to the number of related individuals (in this case siblings). A smaller adult population will have a larger proportion of related individuals, and vice versa.

b) *Breeding frequency* is measured by looking at the age gaps between related individuals. For example, if a one-year-old shark and a two-year-old shark sampled in the same year have the same mother, she must have given birth in successive years.

3) *Adult survival rates* can also be estimated from the DNA analyses because, for two animals to be half siblings, their shared parent must have survived the interval between the two juveniles' respective birth years. If there is a long age gap between the two juvenile sharks, the shared parent must have lived a long time. The adult survival rate for both the eastern and southern-western populations was estimated to be approximately 90 percent. This means that for 100 sharks alive this year, 90 would be expected to be alive next year.

### Total size estimate for the eastern population

Using close-kin mark recapture, this project estimated the number of adults in Australia's 2017 eastern white shark population to be 750 (with a range of 470–1030). Because juvenile survival rates are known for the eastern population, a total population estimate is also possible, and is 5460 (with a range of 2909–12,802). This direct estimate of total white shark abundance and survival is calculated from data gathered across the geographic range and life-history of the population and provides a pathway to estimate total population trend.

### No evidence of an increase in the eastern adult population

The eastern adult population has been stable since the onset of white shark protection (at the end of the 1990s). This is consistent with the long time it would take for the effects of the various control programs and levels of fishing that existed pre-protection (which focused mostly on juveniles) to flow through to the adult population.

### Adult population size estimate for the south-western population

For the southern-western population, adult abundance and survival estimates were calculated from data on the number of sibling pairs detected in 175 high-quality DNA samples collected from sub-adult and young adult males across the southern-western population range, from Geraldton in WA to western Victoria.

The DNA samples came from a variety of sources including necropsies of accidentally killed sharks, recovery of DNA from degraded tissues such as preserved jaws, and dedicated scientific sampling trips conducted by CSIRO, the South Australia Research and Development Institute, Flinders University, and the Western Australian Department of Primary Industries and Regional Development (Fisheries).

The DNA analyses identified 41 closely related pairs in the southern-western white shark dataset: 27 half-sibling pairs that shared either a mother or father, and 14 full-sibling pairs that were each from the same litter and shared both parents.

The southern-western adult population is estimated to number 1460 sharks (with an uncertainty range of 760–2250). Direct estimates of juvenile survival rates (a crucial piece of information obtained by tagging a relatively high number of juvenile sharks) are not available for the western population, so a whole-of-population estimate has not been compiled.

#### No evidence of an increase in the western adult population

As in the east, the southern-western adult population size is estimated to have been stable since the onset of white shark protection.

#### Further monitoring needed to see trend in total population

Estimating the trend in total population size requires continued sampling and close-kin analyses, using methods and institutional relationships developed in this project.

It is possible, but unknown, that juvenile numbers have increased as a result of legislative protection enforced since the late 1990s. But sharks take 12–15 years to become mature adults, so any consequent increase in the adult population would not occur until the next few years. Based on current sampling rates the signal of any increase will take five years or more to detect with a reasonable degree of certainty, and more time will be needed for the southern-western population than for the eastern population. This is because current sampling in the south-west is limited to older animals as there are no identified nursery grounds where samples of juveniles can be reliably collected. Increased sampling rates and targeted sampling of juveniles may allow the signal to be detected sooner.

#### Significant advances in understanding

Providing reliable information on the size and trend of Australia's white shark populations has hitherto been an impossible task. Advances being made in this research – building coordinated national sampling regimes to measure key biological parameters using close-kin mark recapture, and conducting electronic

tagging and targeted surveys, and combining these in population models – will significantly improve our understanding of white shark populations in Australia.

## Answers to five questions frequently asked about sharks

### 1 Are shark numbers increasing?

There is no evidence that shark numbers are increasing. Adequate data required to make formal population estimates for bull sharks or tiger sharks do not yet exist and are difficult to collect. For white sharks, there is no evidence of an increase in adult population size. In fact, both the eastern and southern–western populations have been stable since the onset of protection in the late 1990s. Sharks are highly mobile and while there are patterns to their movements, local abundance can change in response to factors unrelated to overall population size. This means the incidence of attacks or sightings cannot be reliably used to infer shark population trends. The numbers of large and potentially dangerous shark populations cannot increase rapidly because these species are long-lived and have low reproductive rates. This is especially true for species that have low population numbers to begin with. Any apparently rapid changes are more likely to be related to factors such as short term shifts in distribution, along with more awareness and surveillance.

### 2 Are shark attacks increasing?

Yes, but we don't know why. As in other areas of the world, the overall number of shark attacks has gradually increased in the past few decades in Australia. Many different factors unrelated to shark numbers contribute to the overall increase in shark attacks. These include human population trends, changes in human population distribution and regional demographics, as well as variations in lifestyle and behaviour of people over time. However, clusters of shark attacks cannot be attributed to increases in human use of the ocean, or sudden increases in overall shark population size, because neither of these change over such short periods.

### 3 Are there more shark attacks where the shark numbers are high?

No. There are, for example, high human-use areas where white sharks are abundant but the incidence of shark attack is low. The drumline program in Western Australia revealed a significant number of tiger sharks present in coastal waters off Perth, yet no attacks have been attributed to this species in the area since 1925 according to the Australian Shark Attack file. Incidence and frequency of shark attack may not relate directly to local shark abundance and cannot be used as a proxy for shark population trend.

### 4 Have shark sightings increased?

Yes. The number of sharks sighted has significantly increased, as has the number of shark-related media reports. The impression given is that shark numbers have increased. What is not taken into account is the increase in surveillance effort and the increase in the rate and ease of reporting. There has been a significant increase in the resources, assets and tools used to detect and monitor sharks and relay this information to the public and media. This includes real-time reporting of the

detection of tagged sharks, publically available satellite-based shark tracks, sightings by aerial surveillance and public reporting of sightings via social media and other web-based platforms. The more we have the ability to look into the marine environment for sharks, the more sightings there will be.

## 5 Can humans share the waters with sharks?

Yes. Sharks are a part of Australia's natural environment and it is not unusual for people and sharks, even large and potentially dangerous ones, to be in the same area at the same time without incidence of shark attack. That is not to say that the sighting or detection of a potentially dangerous shark should be dismissed: such sightings should be taken seriously and represent a potential risk, even if the actual risk of any one animal being involved in an attack is unknown. How to effectively respond to such sightings, taking into account their increase in frequency due to the increase in surveillance and reporting effort, will continue to be a challenge to agencies vested with public safety.

For more information visit: [www.nespmarine.edu.au](http://www.nespmarine.edu.au)



The NESP Marine Biodiversity Hub is funded by the Australian Government's National Environmental Science Programme. Our goal is to assist decision-makers to understand, manage and conserve Australia's environment by funding world-class biodiversity science.