Marine Biodiversity Hub

National Environmental Science Programme

Towards a national population assessment for white sharks

A unique combination of acoustic tagging and genetic and statistical analysis is contributing to the first evidence-based estimates of white shark population size and status in Australia.

White sharks are listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity 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 is working to provide a national assessment of white shark population size, and develop 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 will build on those developed under the National Environmental Research Program Marine Biodiversity Hub (the forerunner of the NESP).

Innovative approaches needed to build population models

All sharks cannot be seen and counted, so scientists use mathematical equations (population, or demographic models) to estimate population size. Building the models requires knowing how many populations there are, and then, for each population: how often adult females breed, the age at which they start breeding, how many pups are born, how many sharks survive from one year to the next, how fast sharks grow, and how long they live. Another important factor is at least one count of an age group (such as the number of juveniles or adults) in the population. This gives the model a factual base.

An understanding of white shark movement patterns is also needed 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 is addressing these challenges with a unique application of nursery area surveys, electronic tagging, and a combined genetic and statistical technique called 'close-kin mark recapture'.

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 a western population ranging from western Victoria to north-western Western Australia. Initial steps to estimate population size have been taken in eastern Australia where nursery areas have been targeted to estimate the number of juveniles, their survival and their genetic relatedness.

Acoustic tagging is being used to monitor white shark movement patterns and demographics for use in a population model. Image: Justin Gilligan, NSW DPI

Considerable information has been collected on the population west of Bass Strait, including the electronic tagging and tissue sampling of more than 200 sharks. This field work will be extended, and the data analysed, during this project. Aerial and vessel surveys will also search for nursery areas to provide further options for monitoring.

Monitoring juveniles: abundance, movements and survival

Coastal waters off Port Stephens, NSW, and Ninety Mile Beach in eastern Victoria are the two known east coast nursery areas for white sharks. More than 50 juveniles have been fitted with satellite tracking and long-life acoustic tags to monitor movements, habitat use and survival. Aerial surveys have been trialled to estimate the number of

juveniles, and baited remote underwater video systems (BRUVs) will be trialled (with the New South Wales Department of Primary Industries) to test their utility for counting juvenile white sharks, monitoring tagged individuals and estimating size and growth. The novel advance that will be applied and developed in this project, however, involves the estimation of adult abundance.

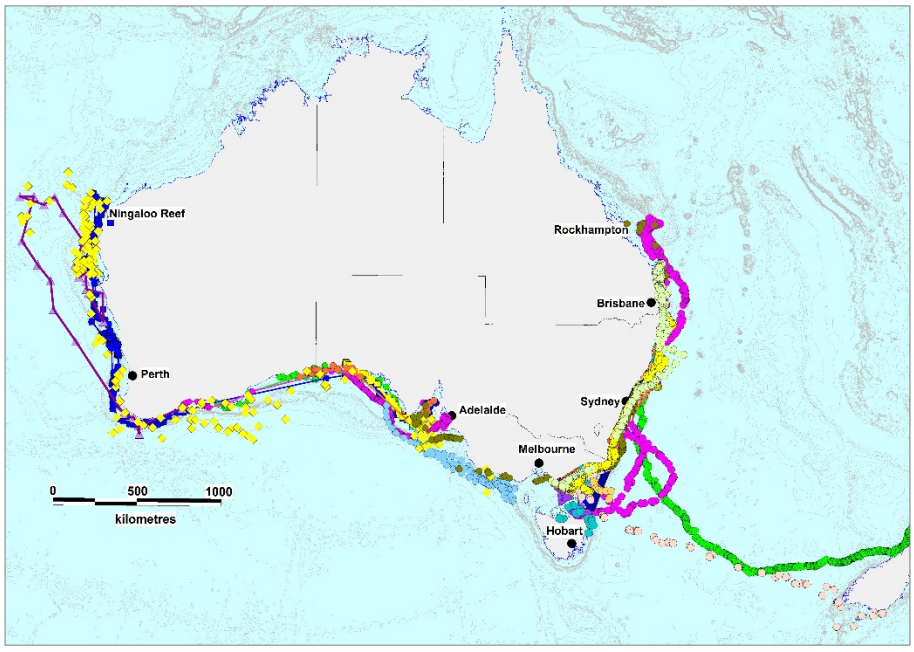
Close-kin: counting adults from half-sibling pairs

Close-kin mark recapture is being used to provide a direct count of breeding adults. This technique, which has been used to measure southern bluefin tuna stocks, is likely to revolutionise the way that fish (and other animal) populations are assessed worldwide. It uses genetic analysis of tissue samples to identify sharks that are related by sharing one parent (half-siblings). The number of half-siblings in a population is directly related to the number of breeding adults. A smaller adult population will have a larger proportion of related sharks, and vice versa. Furthermore, the age gap between related juveniles indicates breeding frequency. For example, if a one-year old shark and a two-year old shark sampled in the same year have the same mother, that adult must have pupped in successive years.

Extended families reveal population trend

While the number of related juveniles relates directly to the number of adults that produced the population, it does not show population trend (change over time). Meeting this challenge involves taking the complexity of close-kin mark recapture one step further. The same genetic samples could be used to identify animals that share one grandparent and this in turn could be used to estimate the number of adults in the previous generation. Comparing this estimate with the present number of adults would show the generational change in population size, revealing the population trend without the wait for future data.

The extension of close-kin mark recapture involves comparing larger components of the white shark genome between individuals and will be tested in this project. If successful, the novel technique may be applicable to other species for which other methods of population assessment are unreliable or unavailable.



Satellite tracking of white sharks by CSIRO highlights extensive movements between South Australia and north-western Western Australia, and along the east coast including to New Zealand, but limited movements east and west through Bass Strait. Image: CSIRO

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 – measuring key biological parameters using close kin mark recapture, electronic tagging and targeted surveys, and combining these in population models – will significantly improve our understanding of white shark populations in Australia.

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.

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