White Shark *Carcharodon carcharias*: status and management challenges

Conclusions of the Workshop on Great White Shark Conservation Research

Wildlife Conservation Society
Central Park Zoo, New York, NY, USA

20-22 January 2004

1. Introduction

This paper is one of the products of an international Workshop that aimed to share, compare and synthesise the research findings of participants and identify conservation priorities for White Sharks *Carcharodon carcharias*. This species has been identified by many range states as of particular conservation and management concern because of its biological vulnerability.

Twenty invited experts attended from Australia, New Zealand, Canada, Mexico, South Africa, United Kingdom and the USA. They included researchers working on the movements and migrations of White Sharks, population census through photo-identification of individuals, trade in White Shark parts, population genetics and management of non-consumptive utilisation, and specialists in international conservation and management policy.

This brief summary of the status of White Shark research, conservation and management represents one of the outputs of the workshop. It was developed through discussion and consensus during the meeting and represents an overview of the current state of knowledge of the species, with particular emphasis on the management challenges posed by the species' biology and behaviour.

2. Biology

The White Shark is a relatively rare but ecologically important apex predator that is recorded in low numbers in comparison with other large sharks, even in its known centres of abundance. For example, 27 White Sharks were recorded captured over a ten-year period in a Northwest Atlantic shark fishery that took 100,000 sharks (<0.03% of the total)[1]. The total oceanic longline bycatch of White Sharks reported by scientific observers and in logbooks in the Northwest Atlantic (north of the equator) averaged just 400 individuals/year during 15 years 1986-2000, or 0.5% of the 18 shark species identified[2]. Its life history parameters (late maturity, low fecundity, low natural mortality, longevity etc., see Table 1) mean that this species has a particularly low intrinsic rate of population increase[3,4,5,6,7,8]. This, combined with the vulnerability of the species to exploitation at coastal aggregation sites, makes it particularly prone to depletion.

Table 1. White Shark *Carcharodon carcharias* estimated life history parameters[5,8]

Age at maturity (years)	female: 12-14, male: 9-10
Size at maturity (cm)	female: 450-500, male: 350-410
Longevity (years)	≥23-36
Maximum size (cm)	≥640
Size at birth (cm)	109-165
Average reproductive age (years)	>20?
Gestation time (months)	>12?
Reproductive periodicity	2 or 3 years?
Litter size	Approximately 5 pups (2-10 pups/litter)
Intrinsic annual rate of population increase	0.04-0.056
Natural mortality	0.125

The results of recent satellite, archival and acoustic tracking of White Sharks tagged in Australia[9], South Africa[10] and off the Northeast Pacific coast[11,12] have significantly improved understanding of the local movements and long distance migrations of the species, sometimes along common 'highways'. Photographic identification studies have also helped to elucidate residency patterns, movements between study sites and longer-term site fidelity between migrations[12,13,1415,16]. Juvenile sharks often remain in very small areas for weeks at a time, within longer stretches of coastal waters for months, but may then undertake long-distance coastal migrations of over 3,700km over a period of less than six months[9]. Conversely, large adults undertake regular long migrations offshore, away from seasonal coastal feeding sites[17,11,12], and are pelagic in the open ocean for at least nine months of the year in some individuals (one shark tagged off the Californian coast travelled to Hawaii twice in consecutive years)[11]. Both juveniles and adults were found to return to the original tagging location when the tracking period was sufficiently long term. A genetic study has also provided evidence of gender-biased dispersal and reproductive mixing, with males sometimes migrating (and successfully reproducing) across the Southern Ocean between South Africa and Australia, while females within these two regions apparently remain faithful to continental breeding sites[18]. However, this same genetic study and at least one tag-return indicate that both male and female White Sharks cross the open ocean (Tasman Sea) between Australia and New Zealand and thus comprise a single breeding stock.

3. Threats

The following threats to White Shark populations were identified (not all apply in all regions):

- Commercial fisheries
- Recreational fisheries
- Subsistence/artisanal fisheries
- Bather protection programmes
- Ecotourism
- Habitat deterioration and loss (including depletion of prey species)

Commercial and recreational fisheries may target White Sharks or capture them accidentally while fishing for other species (incidental or bycatch). Unmonitored artisanal fisheries (which catch and utilise a very wide range of species) also occasionally capture White Sharks. Where levels of bycatch have been estimated, the rarity of the species means that these tend to be numbered only in the low to mid 100s of individuals/year, even within regions with important White Shark populations[2,19]. About 40% of White Shark bycatch is released alive in Australia[20]. Post-release mortality has not been researched, but 10-30% of free-swimming sharks sighted during a study in South Australia carried remnants of fishing gear or showed signs of damage from capture[14]. The proportion of sharks escaping or being released from fishing gear without obvious damage is unknown. White Sharks caught on hook and line and removed from the water for the installation of satellite tags in South Africa under veterinary supervision all survived for long periods[21].

The very high value of White Shark teeth, jaws and fins (see section 6)[22] mean that bycatch of this species is very likely to be utilised unless regulations prevent it, require live release of bycatch, and are enforced. Where recreational fishing is concerned, the White Shark has a special status among some sport anglers who

seek to capture individuals for the record or experience. The sharks may be released alive or retained for photography with the jaws extracted and kept as a trophy.

Capture in Australian and South African beach meshing programmes (protecting bathing beaches) is smaller (averaging 10-50 sharks per annum[19,20,23]) than capture in commercial or recreational fisheries. No White Sharks have been captured in New Zealand's beach meshing programme in the last ten years[24].

The effects of disturbance from ecotourism operations, habitat damage or loss, and prey species depletion on White Shark populations are unknown, but these factors may be affecting some important White Shark aggregations and habitats.

4. Population trends and conservation status

The natural rarity of White Sharks means that catch records are scarce. This makes it more difficult to identify statistically significant trends from most data sets than is the case for other more commonly-recorded large shark species, which are certainly declining in some regions[2,25,26,27,28]. Even so, the majority of data sets identified demonstrate significant declining trends in White Shark catch per unit effort or catch data over relatively short time scales[2,29,30]. Even data sets from areas where the species is legally protected show either a declining trend, or apparent stability, but no recovery[23,31]. No data set has been identified that demonstrates an increasing population trend.

Available data, particularly decline data, led to the listing of the global population of the White Shark as Vulnerable on IUCN's Red List of Threatened Species in 2000. Some Regional Red List assessments are currently in preparation and are expected to result in a few regional populations being assessed as Endangered or Critically Endangered in the 2004 Red List. The species also appears on some national threatened species lists.

5. Legal and management status

International and regional fisheries instruments and organisations

UNCLOS and Fish Stocks Agreement

The White Shark is one of five species within 'Family Isurida' (correctly named Family Lamnidae) listed on Annex 1 (Highly Migratory Species) of the UN Convention on the Law of the Sea (UNCLOS). This agreement recognizes that coordinated management and assessment of shared migratory populations would promote an understanding of the cumulative impacts of fishing effort on the status of shared populations. Implementation of management of Annex I species should be facilitated by the Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks (Fish Stocks Agreement) that came into force in December 2001. Progress towards implementation is slow and inadequate.

UN FAO International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks)

Adopted in 1999, progress towards implementation of the IPOA-Sharks has been slow and disappointing[32]. The Working Group did not identify any specific progress with implementation of White Shark conservation or management as a result of the IPOA-Sharks.

RFMO Management measures

None are known.

International and regional wildlife conservation instruments

Convention for the Conservation of Migratory Species

In 2002, Australia successfully proposed the White Shark for listing on both **Appendix I** (endangered migratory species requiring strict protection measures and **Appendix II** (species with an unfavourable conservation status that would benefit from the implementation of international co-operative Agreements for their conservation and management). While this listing may, in due course, result in improved conservation and management of the species, the listing of the Whale Shark *Rhincodon typus* in 1999, which was intended

to lead to cooperative management agreements in 2000-2002, indicates that progress may be slow. Relatively few White Shark range states are Party to CMS.

CITES Appendix III
Australia listed White Shark on Appendix III in 2001. Some trade data are now available as a result of this listing (see section 6).

Mediterranean and European Conventions
The White Shark is listed on Annex II (Endangered or Threatened species) of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean of the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean. This should result in full legal protection for the species when the Convention is ratified. It is also listed on Appendix II (animal species requiring strict protection) of the Bern Convention on the Conservation of European Wildlife and Natural Habitats, meaning that it should, in due course, be included under the European Habitats Directive. Only one Party (Malta, see below) has implemented these listings by providing national protection for the species.

National fisheries regulation

Fisheries legislation in South Africa and Namibia prohibits commercial and recreational fisheries for the White Shark. Similar legislation in New Zealand prohibits target commercial fisheries and limits recreational catches of the species. Fisheries legislation protects White Sharks in Australian state and territory waters. The Atlantic Highly Migratory Species Fishery Management Plan confers legal protection on the species in East Atlantic federal waters of the United States of America, and state law protects the species off California. These measures are based on concern that the White Shark is not sufficiently productive to support target fisheries. There is no known species-specific management of target or bycatch fisheries for White Sharks.

National wildlife regulation

White Sharks are listed under Australia's Environment Protection and Biodiversity Conservation Act (1999) as a vulnerable species and therefore protected under wildlife legislation in federal waters. Wildlife legislation also protects the species in Malta (the only Mediterranean state that has ratified the regional conventions listing the species) and in state waters of Florida, USA.

6. Products in international trade

Some White Shark products enter international trade: teeth, jaws and fins. An identification guide already exists for these products[33]. Jaws and teeth are easily identifiable, fins slightly less so. There is now a low-cost DNA test for White Shark products that enables them to be identified unequivocally[34,35]. Jaws, teeth and fins are high value, low volume products that are in considerable international demand in several parts of the world as trophies or curios (the jaws and teeth are readily available through internet sites for up to US$425/tooth and US$12,500/jaw set[22]) or for the shark fin market. A lack of species-specific customs codes means that it is difficult to assess overall volumes involved. Australia's CITES Appendix III listing for the White Shark has resulted in five international trade records for 2002[36]. There is also evidence of illegal trade in these products[37,38].

Other products (meat, leather, cartilage, liver oil) are higher volume and lower value. They probably enter international trade only rarely, if at all, although they may be used nationally.

7. Economic importance

White Sharks are of economic value for consumptive commercial and recreational fisheries, non-consumptive sports angling (release fisheries), and ecotourism (boat watching, aerial observations and cage diving). White Shark ecotourism, in particular, is a relatively recent but rapidly expanding industry that is likely to continue to spread to new centres of White Shark abundance and has the potential to increase coastal community income significantly. A recent socio-economic study of the value of the White Shark to a

small fishing community in South Africa identified sale of tickets for White Shark watching at sea as the single largest source of income to the community from marine-based tourism (larger than whale watching, recreational fishing, accommodation, or restaurant turnover)[39].

The workshop concluded that the direct income from living White Sharks at a tourist site over a period of several years is significantly greater than the one-off income from sales of their products. It is important to manage this new industry and to regulate competing consumptive uses in order to protect White Shark populations and ensure that ecotourism is sustainable.

8. Management challenges

The few range states managing White Shark populations are using both fisheries and wildlife legislation (together or singly) to manage their White Shark populations. The main management focus is to prohibit or to severely restrict fisheries because of concern that consumptive use is unlikely to be sustainable. Workshop participants agreed that it is highly unlikely that this species is sufficiently productive to sustain a target fishery; indeed, CPUE data from the northwest Atlantic indicate that even bycatch is unsustainable[2]. Technical measures need to be developed to avoid White Shark bycatch and promote their live release.

Persecution of the species by some water users occurs because of their damage to fish farm stock and equipment, and occasional attacks on swimmers, surfers and divers. Such persecution may continue when the species is protected. Public attitudes are still influenced by 40 years' promotion of the White Shark's 'man-eater' status and occasional sensational shark attack stories appearing in the media. This may influence the development of management policies for the species.

National management measures suffer from shortcomings in monitoring, control and surveillance. This species is not captured in large-scale directed single-species fisheries, where catches and landings may be monitored and controlled, but as bycatch or in multi-species shark fisheries. The high value of its products, however, certainly encourages targeting of individuals or small aggregations by both commercial fishers and trophy hunters. The White Shark's habit of returning periodically to well-known locations where it aggregates makes it particularly vulnerable to such target fishing, including poaching.

A particular challenge when managing White Shark populations is that this species is highly migratory, moving rapidly between national and international waters, and between the waters of adjacent states before returning to its major aggregation sites. Domestic management and enforcement measures may not, therefore, be sufficient to ensure that the population is not affected by fishery impacts in other parts of its range, and it can be difficult to determine whether White Sharks have been caught in protected areas or territorial waters or in areas outside national jurisdiction where no management exists. White Shark stocks therefore need to be managed cooperatively throughout their range, not just in parts of it.

While recent research indicates that large adults are mainly pelagic in international waters (at least for the one stock that has been studied), the species may be most vulnerable to direct disturbance and overexploitation where it aggregates in coastal waters, particularly if targeted there. The most important portion of the population for the survival of a stock is likely to be the large, mature females. The late maturity of this species, small litter size and likely low number of litters produced (females of closely related shark species have a short reproductive lifespan) makes the protection of this portion of the population essential. Unfortunately, the largest animals are also the most sought-after by trophy hunters and for their high value teeth and jaws.

Despite the relatively large number of international fishery and wildlife agreements for the White Shark and the very large numbers of Parties to these agreements, only a few range states and no regional fisheries management organisations have implemented any kind of management measures for White Sharks. National management measures, while highly desirable, are of limited effectiveness for a species that regularly crosses national borders and spends a significant part of its life cycle on the high seas, where unregulated and unmonitored fisheries bycatch could have a significant impact on large adults. International management measures are, therefore, also essential for this highly vulnerable species.

References

1. Springer, S. 1963. Field observation on large sharks of the Florida-Caribbean region. Pp. 95-113 in: Gilbert, P.W. (ed.) *Sharks and Survival*. D.C. Heath and Co., Boston.

2. Baum, J. K., R. A. Myers, D. G. Kehler, B. Worm, S. J. Harley, and P. A. Doherty. 2003. Collapse and conservation of shark populations in the Northwest Atlantic. *Science* 299: 389-392.

3. Cailliet, G.M., Natanson, L.J., Weldon, B.A., and Ebert, D.A. 1985. Preliminary studies on the age and growth of the white shark *Carcharodon carcharias*, using vertebral bands. *South. Calif. Acad. Sci.*, Memoirs 9: 49-60.

4. Compagno, L.J.V. 2001. *Sharks of the World. An annotated and illustrated catalogue of the shark species known to date. Volume 2. Bullhead, mackerel and carpet sharks (Heterodontiformes, Lamniformes and Orectolobiformes). FAO Species Catalogue for Fisheries Purposes* No. 1, Vol. 2. Rome, FAO. 269pp.

5. Fergusson, I.K., Compagno, L.J.V., and Marks, M. In press. White Shark *Carcharodon carcharias*. *In*: Fowler, S.L., Camhi, M., Burgess, G.H., Cailliet, G.M., Fordham, S.V, Cavanagh, R.D., Simpfendorfer, C.A. and Musick, J.A. In press. *Sharks, rays and chimaeras: the status of the chondrichthyan fishes.* IUCN SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

6. Francis, M. 1996. Observations on a pregnant white shark with a review of reproductive biology. pp. 157-172 *In*: A.P. Klimley & D.G. Ainley (eds). *Great White Sharks: The Biology of Carcharodon carcharias*. San Diego: Academic Press.

7. Pratt, H.L. Jr. 1996. Reproduction in the male white shark (*Carcharodon carcharias*). In: Klimley, A.P. and Ainley, D.G. (eds), *Great white sharks: Ecology and Behaviour.* Academic Press, Orlando.

8. Smith, S. E., Au, D. W. and Show, C. 1998. Intrinsic rebound potentials of 26 species of Pacific sharks. *Marine and Freshwater Research* 49(7): 663-678.

9. Bruce, B. and Stevens, J. 2004. Movement patterns and behaviour of white sharks in Australia. Abstract of paper presented at White Shark workshop, New York, January 2004.

10. Bonfil, R., O'Brien, S., Meyer, M., Scholl, M., Johnson, R., Oosthuizen, H., and Dudley, S. 2004. Long-range spatial dynamics of the great white shark (*Carcharodon carcharias*) in South Africa using satellite tags. Abstract of paper presented at White Shark workshop, New York, January 2004.

11. Boustany, A., Weng, K., Block, B., Pyle, P., and Anderson, S. 2004. Movement patterns and habitat preference of adult white sharks electronically tagged off the central California coast. Abstract of paper presented at White Shark workshop, New York, January 2004.

12. Domeier, M.L. 2004. Summary of great white shark research activities at Isla Guadalupe, Mexico. Abstract of paper presented at White Shark workshop, New York, January 2004.

13. Klimley, A.P. and Anderson, S.D. 1996. Residency Patterns of White Sharks at the South Farallon Islands, California. Pp 365-373 *in:* Klimley, A.P. and Ainley, D.G. (eds). *Great White Sharks: The biology of Carcharodon carcharias*. Academic Press Inc., California.

14. Strong, W.R. Jr., Nelson, D.R., Bruce, B.D. and Murphy, R.D. (1996). Population Dynamics of White Sharks in Spencer Gulf, South Australia. Pp 401-414 *in*: Klimley, A.P. and Ainley, D.G. Eds. *Great White Sharks: The biology of Carcharodon carcharias*. Academic Press Inc., California.

15. Scholl, M.C. 2004. Long-term individual photographic identification methodology and population structure of great white sharks (*Carcharodon carcharias*) at Dyer Island, South Africa. Abstract of paper presented at White Shark workshop, New York, January 2004.

16. Anderson, S.D. and K.Goldman. (1996) Photographic evidence of white shark movements in California waters. *California Fish and Game* 82:182-186.

17. Boustany, A.M., S.F. Davis, P. Pyle, S.D. Anderson, B.J. Le Boeuf & B.A. Block. 2002. Expanded niche for white sharks. *Nature* 415: 35-36.

18. Pardini, A.T., C.S. Jones, L.R. Noble, B. Kreiser, H. Malcolm, B.D. Bruce, J.D. Stevens, G. Cliff, M. Scholl, M. Francis, C.A.J. Duffy & A.P. Martin. 2001. Sex-biased dispersal of great white sharks. *Nature* 412, 12 July 2001:139-140.

19. Environment Australia. 2002. White Shark (*Carcharodon carcharias*) Recovery Plan. Environment Australia, Canberra, New Zealand. http://www.ea.gov.au/coasts/species/sharks/index.html

20. Bruce, B.D., Malcolm, H., and Stevens, J.D. 2001. A review of the biology and status of White Sharks in Australian Waters. CSIRO Marine Research, Hobart, Tasmania, Australia.

21. Personal communications, White Shark Workshop participants, January 2004.

22. Duffy, C. 2004. International trade in white shark (*Carcharodon carcharias*) goods from New Zealand: fisheries and trade monitoring, international implications and recent policy developments. Abstract of paper presented at White Shark workshop, New York, January 2004.

23. Dudley, S.F.J. 2003. Shark Catch Trends and Effort Reduction in the Beach Protection Program, KwaZulu-Natal, South Africa. Proceedings of Scientific Symposium, 2002. North Atlantic Fisheries Organization SCR Doc. 02/124.

24. Duffy, C. Personal Communication 2004. White Shark Workshop, New York, January 2004.

25. Camhi, M., Fowler, S., Musick, J., Bräutigam, A., and Fordham, S. (1998). *Sharks and their relatives. Ecology and Conservation. Occasional Paper* 20 of the IUCN Species Survival Commission.

26. IUCN. 2003. IUCN Red List of Threatened Species. www.redlist.org

27. Fowler, S.L., Camhi, M., Burgess, G.H., Cailliet, G.M., Fordham, S.V, Cavanagh, R.D., Simpfendorfer, C.A. and Musick, J.A. In press. *Sharks, rays and chimaeras: the status of the chondrichthyan fishes*. IUCN SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

28. Stevens, J.D., Bonfil, R., Dulvy, N.K., and Walker, P.A. 2000. The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems. *ICES Journal of Marine Science*, 57: 476–494.

29. Casey, J.G. and Pratt, H.L.Jr. (1985). Distribution of the white shark, *Carcharodon carcharia*s, in the western North Atlantic. *South. Calif. Acad. Sci., Mem.* 9: 2-14.

30. Soldo, A., and I. Jardas. 2002b. Occurrence of great white shark, *Carcharodon carcharias* (Linnaeus, 1758) and basking shark, *Cetorhinus maximus* (Gunnerus, 1765) in the Eastern Adriatic and their protection. *Periodicum Biologorum* 104 (2): 195-201.

31. Cliff, G., Dudley, S.F.J. and Jury M.R. (1996). Catches of White Sharks in KwaZulu-Natal, South Africa and Environmental Influences. Pp 351-362 i*n "Great White Sharks: The biology of Carcharodon carcharias*" (Klimley, A.P. and Ainley, D.G. Eds.). Academic Press Inc., California.

32. CITES 2002. Notification to the Parties No. 2002/042 of 24 June 2002, transmitting *The Role of CITES in the Conservation and Management of Sharks* (a revised and updated version of document AC18 Doc. 19.2 – *Report on Implementation of the International Plan of Action for Sharks*, prepared by the IUCN Species Survival Commission's Shark Specialist Group and TRAFFIC).

33. http://www.deh.gov.au/coasts/species/sharks/greatwhite/manual.html

34. Chapman, D.D., Abercrombie, D.L., Douady, C.J., Pikitch, E.K., Stanhope, M.J. , and Shivji, M.S. 2003. A streamlined, bi-organelle, multiplex PCR approach to species identification: Application to global conservation and trade monitoring of the great white shark, *Carcharodon carcharias*. *Conservation Genetics* **4:** 415–425.

35. Shivji, M.S., Chapman, D.D., and Pikitch, E.K. 2004. Applying new DNA forensic methods to monitor trade in shark products with special reference to great white sharks. Abstract of paper presented at White Shark workshop, New York, January 2004.

36. World Conservation Monitoring Centre database. UNEP. Cambridge, UK.

37. Gosling, M. 2003. Great White Sharks under attack by curio pirates. *Cape Times*, October 16 2003, South Africa.

38. Personal communication from Sara Williams, Department of Environment and Heritage, Australia, to Clinton Duffy, concerning illegal trade in White Shark teeth from Australia to New Zealand. 7 November 2003.

39. Hara, M., Maharaj, I., and Pithers, L. 2003. Marine-based Tourism in Gansbaai: A Socio-economic Study. Department of Environmental Affairs, Internal report. South Africa.