Australian Government

Department of the Environment

Non-Detriment Finding for the export of shark species listed in the Convention on the International Trade in Endangered Species of Flora and Fauna (CITES) and harvested from Australian waters:

Sphyrna lewini **- scalloped hammerhead shark**

Sphyrna mokarran **- great hammerhead shark**

Sphyrna zygaena **- smooth hammerhead shark**

Lamna nasus **- porbeagle shark**

Carcharhinus longimanus **- oceanic whitetip shark**

2014

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Executive Summary

On 14 September 2014 the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II listing of five shark and two manta ray species will take effect. The CITES Scientific Authority of Australia has worked with Commonwealth, state and territory fishery management agencies to ensure that Australia's legislated CITES obligations will be met for these species. This document, the non-detriment finding (NDF), forms part of those CITES requirements, and is made for a period of three years from 14 September 2014 unless reviewed earlier, and applies to harvest from approved commercial Australian fisheries that interact with the species. The listed species are:

Sphyrna lewini - scalloped hammerhead shark

Sphyrna mokarran - great hammerhead shark

Sphyrna zygaena - smooth hammerhead shark

Lamna nasus - porbeagle shark

Carcharhinus longimanus - oceanic whitetip shark

*Manta birostris** – giant oceanic manta ray

*Manta alfredi** – reef manta ray

*Currently there is no catch or export of *M. birostris* and *M. alfredi* from Australian fisheries. *M. birostris* is listed as a protected migratory species under the Part 13 provisions of the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), as a consequence of its listing on Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). Under this provision, export is not allowed. There is no data available at this time to suggest that these two species have been retained in Australian fisheries, or that they are caught with any frequency therefore no assessment of these species is included within this NDF.

Additionally, *L. nasus* is also as a protected migratory species under the Part 13 provisions of the EPBC Act, as a consequence of its listing on Appendix II of CMS however, the fishery management arrangements for Australian commercial fisheries which may encounter *L. nasus* are accredited under Part 13, meaning it is not an offence to take the species. Since the time of the Part 13 listing, the catch of *L. nasus* from all Australian fisheries has averaged less than one tonne per annum, with the majority of the take being from the Commonwealth Eastern Tuna and Billfish Fishery therefore, a positive NDF could be made where there is limited interaction as implemented under current management practices where live specimens caught are returned with as little harm as possible.

Obligations under CITES are given effect domestically by the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*. The EPBC Act requires that, *inter alia*, an export permit for a CITES Appendix II listed species may only be issued by the Minister for the Environment if satisfied that the export will not be detrimental to, or contribute to trade which is detrimental to, the survival or recovery of the species or a relevant ecosystem. This assessment is known as an NDF and underpins the assessment and approval of wildlife trade operations (WTO) for Australian fisheries harvesting and interacting with the CITES Appendix II listed species. There are state and Commonwealth legislation that provide for fishery management arrangements to be implemented. NSW is the only state to have *Sphyrna lewini and S. mokarran* listed as threatened species, prohibiting commercial harvest in NSW state waters.

This NDF has been made based on the current and available information including each species' range, population structure, status and stock assessments in Australian waters; an analysis of Australian commercial fisheries interacting with the listed species, including an assessment of existing management measures; and consideration of regional and global management measures, threats, stocks and harvests.

The current management arrangements in place in Australian managed fisheries meet the majority of the requirements that the CITES Scientific Authority of Australia is required to consider in the making of this NDF. Improvements over time in the management arrangements will be incorporated as part of the ongoing export approval process.

Current information on the population distribution and status of hammerhead species in Australia is relatively limited as identification to species level is uncommon in fisheries logbooks, making it somewhat difficult to ascertain definitive trends in catch history (Koopman and Knuckey, 2014). Although also limited in extent, more detailed information is available for *L. nasus* and *C. longimanus* sharks allowing more detailed analysis to be undertaken for the making of this NDF.

While data is limited with regards to global stock sizes of these shark species, the findings and harvest levels in this NDF have been determined using the best available scientific information, by analysing current Australian harvest against global harvest and by assessing the risks associated with the management arrangements currently in place in Australian fisheries.

The total global catch of hammerhead species is estimated between 2000 and 6000 tonnes (t) over the past decade and continues to rise. Australia is a range State for each of the listed shark species which are commercially harvested in some Australian fisheries in small numbers compared to global harvest. The scientific evidence available suggests Australia shares some of these stocks with other countries in the region (Simpfendorfer, 2014).

Therefore, national harvest levels for the listed shark species, with the exception of *C. longimanus* (any harvest of this species would be considered detrimental to its survival), are:

Harvest levels:

Scalloped hammerhead (*Sphyrna lewini*) – 200 tonnes per year.

Great hammerhead (*Sphyrna mokarran*) – 100 tonnes per year

Smooth hammerhead (*Sphyrna zygaena*) – 70 tonnes per year

Porbeagle (*Lamna nasus*) – Up to historic levels (2.5 tonnes per year) allowed to be landed domestically. No export allowed as this species is listed under Part 13 of the EPBC Act, and is excluded from approved wildlife trade operation declarations for Australian commercial fisheries

Oceanic whitetip (*Carcharhinus longimanus*) – no harvest permitted

Subsequently, if further information on individual species abundance, distribution and harvest becomes available through a review of trade data, ecological risk assessment or through research projects, the harvest levels contained in this NDF may be reviewed. Through the improvement of reporting (down to species level) and research, the information basis for future NDFs will improve over time.

The CITES Scientific Authority of Australia will continue to liaise with other CITES Parties in the development and sharing of NDFs where shared stocks information can be incorporated, in turn, to improve currency and to ensure rigorous data underpins future harvest levels.

Management recommendations to fisheries agencies:

- Species level reporting in log books
- Further measures to reduce incidental capture and post release mortality as practically appropriate to specific fisheries and gear types
- Landing of sharks with fins naturally attached
- Mandatory discard reporting to species level
- Maximum size limits
- Trip limits
- An improved understanding and management focus on illegal, unreported and unregulated harvest (IUU)

Introduction from the sea (IFS)

This NDF provides a basis for IFS certificates to be produced for a minimal harvest of the listed shark species from the high seas zones of the Eastern Tuna and Billfish Fishery (ETBF) and the Western Tuna and Billfish Fishery (WTBF). These two fisheries operate close to the Australian economic zone and interact with stocks assessed in this NDF. However, a positive NDF for the Australian High Seas Fishery (AHSF) that operates further from the Australian economic zone was not possible. Due to the lack of information required to underpin a robust NDF, including stock assessments, trends, conservation management measures and harvests by other Parties, the CITES Scientific Authority of Australia was unable to determine sustainable harvest levels for any catch of the listed shark species taken in the high seas outside of the Eastern Tuna and Billfish Fishery and Western Tuna and Billfish Fishery.

Monitoring of information

The harvest levels contained in this NDF will be monitored annually by the CITES Scientific Authority of Australia, through CITES permit acquittals and catch data. Catch data is provided annually by fishery management agencies as a requirement of the wildlife trade operation accreditation. Any changes to harvest levels or improvements to management measures for the listed species will be implemented in conjunction with the wildlife trade operation review and approvals process.

Conclusion

This NDF finding is based on many sources of information available for the five CITES Appendix II listed shark species including the Simpfendorfer scientific assessment (2014) and the Koopman and Knuckey analysis of Australian fisheries (2014). The Australian CITES Scientific Authority has determined that the aforementioned annual harvest levels for a period of three years from 14 September 2014 are sustainable and unlikely to be detrimental to the species.

The CITES Scientific Authority will continue to communicate with fisheries management agencies and industry bodies in determining future management arrangements for these species, in the context of the implementation by other CITES Parties.

Introduction

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES is an international agreement between governments that aims 'to ensure that the international trade in specimens of wild animals and plants does not threaten their survival' (CITES, 2014)

Sphyrna lewini (scalloped hammerhead shark), *S. mokarran* (great hammerhead shark), *S. zygaena* (smooth hammerhead shark), *Lamna nasus* (porbeagle shark) and *Carcharhinus longimanus* (oceanic whitetip shark) are listed on Appendix II of CITES. These listings come into effect on 14 September 2014. Appendix II includes species not necessarily threatened with extinction, but for which trade must be controlled in order to avoid utilisation incompatible with their survival. The listing on Appendix II of manta rays *Manta birostris* and *M. alfredi* also come into effect on 14 September but these species are not included in this NDF as there is currently no Australian commercial catch.

Before a species listed in Appendix II may be exported, the CITES Scientific Authority of the State of export must determine that the proposed export will not be detrimental to the survival of the species. This is called a non-detriment finding (NDF) which is based in part on resource assessment methodologies which include management measures, threats and population structure, status, harvests and trends nationally and internationally. A NDF for harvest of a species can be made when the sum of all harvests of the species is sustainable, in that it does not result in unplanned range reduction, or long-term population decline, or otherwise change the population in a way that might be expected to lead to the species' decline. This NDF has been guided in its development by:

- CITES Resolution Conf. 16.7 Non-detriment finding
- CITES Non-Detriment Findings Guidance for Shark Species: a Framework to assist Authorities in making Non-detriment Findings (NDFs) for species listed in CITES Appendix II
- Guidance for CITES Scientific Authorities: Checklist to assist in making non-detriment findings for Appendix II exports
- CITES Resolution Conf. 14.6 – Introduction from the Sea; and
- Two independent commissioned reports by Simpfendorfer (2014) and Koopman and Knuckey (2014) (among other documents) on the catch and harvest and species assessments.

Scope

The scope of this NDF takes into account the biology, distribution, threats and all known harvest of *S. lewini*, *S. mokarran*, *S. zygaena*, *L. nasus* and *C. longimanus* as well as the management arrangements currently in place in Australian fisheries that take these sharks. This NDF also provides recommendations to Australian fisheries agencies which would aid in the ongoing management of these sharks and provide further data to be considered for the future review of harvest levels. The harvest levels for all species take into account the low level of take (and limited effort) in the high seas area of the Australian tropical tuna fisheries. The catch of these species is likely to be from the same stocks accounted for in this NDF due to the close proximity of the areas in which the species are taken to the Australian Exclusive Economic Zone (Simpfendorfer, 2014).

The minimal catch of *L. nasus* by Australian vessels on the high seas immediately adjacent to the Australian Fishing Zone (AFZ) requires an IFS certificate to allow the catch to be landed in Australia. This NDF takes into account those catches in its harvest levels for domestic purposes. It does not include consideration of the Australian High Seas Fishery (AHSF) that operates further from the Australian economic zone, due to the paucity of information required to adequately inform an NDF.

The findings in this NDF have taken into account information on the recreational importance of the five shark species. More details on this are included in the Harvest section of this document.

Currently there is no catch or export of *M. birostris* and *M. alfredi* from Australian fisheries. *M. birostris* is listed as a protected migratory species under the Part 13 provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), as a consequence of its listing on Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). Under this provision, export is not allowed. Moreover, there is no data available at this time to suggest that these two species have been retained in Australian fisheries, or that they are caught with any frequency therefore no assessment of these species is included within this NDF.

Legislation

Commonwealth legislation

The EPBC Act gives effect to CITES requirements domestically. Under section 303CA of the Act, the Environment Minister must establish a list of CITES species, which enables domestic application of CITES requirements. Under certain circumstances, the Minister may grant permits for the export and import of species on this list.

The EPBC Act, in paragraph 303CG(3)(a), provides that the Minister must not issue a permit for the export or import of a CITES specimen unless satisfied that:

a) the action or actions specified in the permit will not be detrimental to, or contribute to trade which is detrimental to:

i) the survival of any taxon[1] to which the specimen belongs; or

ii) the recovery in nature of any taxon to which the specimen belongs; or

iii) any relevant ecosystem (for example, detriment to habitat or biodiversity).

This assessment has been developed to inform the Minister's consideration of this matter in his decision regarding whether to declare fisheries as approved wildlife trade operations and also to inform individual decisions on whether to grant export permits for the five species of sharks harvested within approved Australian fisheries. Any Commonwealth or State managed fishery where CITES listed species are caught and exported requires a wildlife trade operation to be in place before the catch takes place. A wildlife trade operation is considered to be an 'approved source'.

The Australian Government *Fisheries Management Act 1991 (FMA)*, which is administered by the Australian Fisheries Management Authority (AFMA), allows for plans of management to be made for each Commonwealth managed fishery. Each individual management plan prescribes the marine species that may or may not be taken lawfully and any mitigation measures that must be used whilst carrying out fishing operations.

State Legislation

Queensland

Fisheries that fall under Queensland jurisdiction are managed under the Queensland *Fisheries Act 1994*, the Queensland Fisheries Regulation 2008 and the respective management plans for some fisheries. The Queensland *Nature Conservation Act 1992* provides for the legislative protection of flora and fauna that are threatened within Queensland. Currently none of the species of sharks contained in this NDF are listed as threatened species in Queensland.

Northern Territory

Fisheries that fall under Northern Territory jurisdiction are managed under the Northern Territory *Fisheries Act 1988*, the Northern Territory Fisheries Regulations 1995 and the respective management plans for some fisheries. The *Territory Parks and Wildlife Conservation Act 2000*

[1] Under section 528 of the EPBC Act, Taxon "means any taxonomic category (for example, a species or a genus), and includes a particular population".

provides for the legislative protection of flora and fauna that are threatened within the Northern Territory. Currently none of the species of sharks contained in this NDF are listed as threatened species in Northern Territory.

Western Australia

Fisheries that fall under Western Australian jurisdiction are managed under the Western Australian *Fish Resources Management Act 1994*, the Western Australian Fish Resources Management Regulations 1995 and the respective management plans for some fisheries. The Western Australian *Fish Resources Management Act 1994* also provides for the legislative protection of listed threatened species within Western Australia. Currently none of the species of sharks contained in this NDF are listed as threatened species in Western Australia.

New South Wales

Fisheries that fall under New South Wales jurisdiction are managed under the New South Wales *Fisheries Management Act 1994*, the New South Wales Fisheries Management (General) Regulation 2010 and the respective management strategies for some fisheries. The New South Wales *Fisheries Management Act 1994* also provides for the legislative protection of listed threatened species within New South Wales. Currently, *S. lewini* is listed as endangered and *S. mokarran* is listed as vulnerable in New South Wales.

Victoria

Fisheries that fall under Victorian jurisdiction are managed under the Victorian *Fisheries Act 1995*, the Victorian Fisheries Regulation 2009 and the respective management plans for some fisheries. The Victorian *Wildlife Act 1975*, the Victorian *Flora and Fauna Guarantee Act 1988* and the Victorian *Fisheries Act 1995* provide for the legislative protection of listed threatened species within Victoria. Currently none of the species of sharks contained in this NDF are listed as threatened species in Victoria.

South Australia

Fisheries that fall under South Australian jurisdiction are managed under the South Australian *Fisheries Management Act 2007*, the South Australian Fisheries Management (General) Regulations 2007 and the respective management plans for some fisheries. The South Australian *National Parks and Wildlife Act 1972* also provides for the legislative protection of listed threatened species within South Australia. Currently none of the species of sharks contained in this NDF are listed as threatened species in South Australia.

Tasmania

Fisheries that fall under Tasmanian jurisdiction are managed under the Tasmanian *Living Marine Resources Management Act 1995*, the Tasmanian Fisheries (General and Fees) Regulations 2006 and the respective rules and management plans for some fisheries. The Tasmanian *Living Marine Resources Management Act 1995* provides for the legislative protection of listed threatened species within Tasmania. Currently none of the species of sharks contained in this NDF are listed as threatened species in Tasmania.

Biology

Hammerhead sharks (genus Sphyrna)

Hammerhead sharks are a small but common genus of sharks in the family Sphyrnidae. Their heads have laterally expanded blades, in the shape of "a double-bitted axe in profile" (Compagno, 1984). This unique head shape is thought to increase manoeuvring capabilities and/or sensory capacity or to help them hunt (Compagno, 1984). Hammerheads are plain grey or brown on top and white underneath, reproduce viviparously (embryos fed by a yolk sac placenta and develop in-utero) and are obligate ram ventilators (i.e. they need to swim to get oxygen from the water) (Compagno, 1984). A number of publications to aid in identifying these species can be found on the CITES website at http://www.cites.org/eng/prog/shark/resources.php.

Growth

Sphyrna lewini is a large (>3m) and long lived (20-30 years) species of hammerhead shark that is late maturing. Reports of maximum size and age vary worldwide (see Table 1), as do estimates of size and age at maturity (see Table 1). While data from Australian waters are sparse, it appears that age and size of females at maturity are smaller than global averages, which is congruent with measurements taken elsewhere in the world. The smallest mature male found in a study of sharks on the eastern coast of Australia, however, was found to be smaller than any other estimate worldwide (*Harry et al.,* 2011a). The study also found that Australian populations mature at a smaller length.

Sphyrna mokarran is the largest of the hammerhead sharks (>6m) and is long lived (>30 years) and late to reach maturity (see Table 1). As has been seen for male *S. lewini,* both male and female *S. mokarran* appear to mature at a smaller size in Australian waters than populations elsewhere in the world (Stevens and Lyle, 1989; Harry *et al.,* 2011a).

Sphyrna zygaena is a large, long lived species that matures at a late stage (see Table 1). Unlike *S. lewini* and *S. mokarran,* studies on the east coast of Australia have found males and females are maturing at larger sizes than elsewhere in the world (Stevens, 1984; Patterson and Tudman 2009). No estimates can be found of age at maturity; however, given its size at maturity is similar to *S. mokarran,* it is possible that its age at maturity is also similar, around 10 years*.*

Reproduction

S. lewini is thought to reproduce annually, mating from September to December (Stevens and Lyle, 1989). Estimates of gestation period vary between 9 and 12 months, with birthing is thought to occur in spring and summer in Australia (October to January) (Baum *et al.,* 2007; White *et al.,* 2008; Harry et al. 2011a). The reproductive period, however, may be only partially seasonal as neonates (newborn sharks) have been observed throughout the year in Australian waters (White *et al.,* 2008; Harry *et al.,* 2011a).

Females travel close inshore to birth their pups, often using near-shore nurseries (Duncan *et al.,* 2006). There have been suggestions that *S. lewini* exhibit natal philopatry; however, recent mtDNA evidence does not support this, suggesting instead that they stray between proximal nursery areas (Duncan *et al.,* 2006). As a result of this, recolonisation of areas following overfishing is likely to be via reproduction, not immigration of adults from other populations (Duncan *et al.,* 2006). Compared to other large, placentally viviparous carchariniform sharks, *S. lewini* is relatively fecund, although this is still low compared to fishes in general (see Table 1). The sex ratio of embryos has been found to be 1:1 and several studies have found a positive correlation between female body size and number of embryos, i.e. the larger the female, the more embryos she produces (White *et al.,* 2008; Noriega *et al.,* 2011).

After birth, neonate and juvenile *S. lewini* remain close inshore, often in large schools and in confined coastal pupping areas, for several years prior to moving into the adult habitat (Compagno, 1984; Holland *et al.,* 1993; Baum *et al.,* 2007; Rowling *et al.,* 2010; Speed *et al.,* 2010). Studies in the waters off southern Brazil found a horizontal pattern of distribution for these sharks, with juveniles inhabiting deeper waters than neonates (CITES, 2013). The age at which juveniles leave these inshore waters is not known for certain; estimates range from one to five years of age (Duncan and Holland, 2006; Baum *et al.,* 2007). Nursery locations are well understood in some parts of the world such as Hawaii (Holland *et al.,* 1993; Duncan and Holland, 2006). In Australia it is unknown whether these discrete nursery areas exist or whether all coastal regions are potential pupping habitat. Litter sizes are quite large (1-41 pups per breeding cycle - Baum *et al.,* 2007) and there appears to be a significant relationship between maternal length and litter size and the sex ratio is 1:1 (Stevens and Lyle, 1989).

Neonate *S. lewini* have been observed in shallow regions (<3 m) of Moreton bay (Taylor, 2008), caught in Rockingham, Halifax, Cleveland, Bowling Green Bay and Repulse Bays in Queensland

(Simpfendorfer *et al.,* 2012) and caught in several inshore fisheries (Stevens and Lyle, 1989; Harry *et al.,* 2011b).

Little information on the reproductive behaviour of *S. mokarran* exists, particularly in Australian waters. Females appear to give birth once every two years, producing between 6 and 42 pups per breeding cycle (Compagno, 1984; Stevens and Lyle, 1989; Denham *et al.,* 2007; Harry *et al.,* 2011a). Size at birth is larger than *S. lewini* (Table 1).
Birthing occurs in late spring and summer around the world, occurring between October and November on the east coast of Australia and December and January off northern Australia (Compagno, 1984; Stevens and Lyle, 1989; Harry *et al.,* 2011a). Estimates of gestation period vary between 7 and 11 months (Compagno, 1984; Stevens and Lyle, 1989; Denham *et al.,* 2007). It is unknown whether females use discrete nursery areas close to the coast or if birthing occurs out to sea. In studies in eastern Australian waters, small numbers of juveniles were found in Cleveland, Bowling Green Bay, Upstart, Edgecumbe and Repulse Bays (Simpfendorfer *et al.,* 2012).

S. zygaena is thought to breed every two years and have a 10-11 month gestation period (Casper *et al.,* 2005; Rowling *et al.,* 2010). Studies in NSW suggest it gives birth between January and March (Stevens, 1984; Krogh, 1994; Casper *et al.,* 2005). Litter sizes are relatively large (20-49 pups per breeding cycle- Stevens, 1975) and have an embryonic sex ratio of 1:1. Pup sizes are similar to *S. mokarran* (Table 1).
Little information on the use of nursery habitats is available for this species. The IUCN states that they use smooth sandy substrate in shallow waters, but the location of these areas in Australia is unknown (Casper *et al.,* 2005). All shallow waters in New Zealand are potential pupping grounds (CITES, 2013).

Diet

All three hammerhead species are high trophic level predators in coastal and open ocean ecosystems (CITES, 2013). They eat a large range of food, including bony fish, elasmobranchs, cephalopods and crustaceans (Compagno, 1984; Branstetter, 1987; Stevens and Lyle, 1989; Casper *et al.,* 2005; Denham *et al.,* 2007; Noriega *et al.,* 2011). Juvenile *S. lewini* eat a similar diet consisting of benthic reef fish, demersal fish and crustaceans (Baum *et al.,* 2007).

Porbeagle sharks (*Lamna nasus*)

L. nasus is a small and uncommon species of shark in the family Lamnidae. They are commonly known as mackerel sharks and are grey or bluish grey to black on top and white underneath that reproduce oviphagously (embryos eat other eggs within the uterus). *L. nasus* have conical snouts with very stout bodies and a crescent shaped caudal (tail) fin (Gomon *et al.,* 2008). *L. nasus*, like hammerheads, are obligate ram ventilators that need to constantly swim to obtain oxygen from the water (Compagno, 1984).

Growth

L. nasus is a large (~3 m), relatively long lived species, that matures late in life (8-10 years for males, 15-18 years for females) (see Table 2) (Koopman and Knuckey, 2014). Estimates of age at maturity is around four to five years of age with longevity being around 22 years (Koopman and Knuckey, 2014).

Reproduction

L. nasus reproduce viviparously, are thought to reproduce annually and generally have an 8-9 month gestation period (Francis and Stevens, 2000). In the northern Atlantic Ocean, *L. nasus* is believed to give birth in spring-summer; however, in southern waters they are believed to give birth in winter (Francis and Stevens, 2000), Litter sizes are relatively small (1-5 pups) and embryonic sex ratios have not been determined to date. Pup sizes at birth are between 68 and 78cm total length (Francis and Stevens, 2000).

Diet

L. nasus are high trophic level predators that mostly feed on demersal and pelagic bony fish, as well as cephalopods, other invertebrates, plant matter and on occasion are known to eat seabirds (Stevens *et al.,* 2006).

Oceanic whitetip shark (*Carcharhinus longimanus*)

C. longimanus are a diverse species of shark from the family Carcharinidae. They are commonly known as whaler sharks, with a streamlined, general cylindrical shape with tapered edges. *C. longimanus* are bronzy-grey on top and paler underneath and reproduce viviparously (bearing live young, not eggs). *C. longimanus* have a short snout and a long torpedo shaped torso (Gomon *et al.,* 2008).

Growth

C. longimanus is a large (~3 m), long lived species that matures late in life (Table 2) (Koopman and Knuckey, 2014). Estimates of age at maturity is ~13 years of age with longevity being greater than 26 years in the North Atlantic Ocean (Koopman and Knuckey, 2014). Estimates of longevity in southern waters are largely unknown due to declining catches and lack of research (Francis *et al.,* 2008).

Reproduction

C. longimanus reproduces viviparously, are thought to reproduce annually and generally have a 12 month gestation period. In northern Atlantic Ocean and southern Indian Ocean waters, *C. longimanus* mate in summer; however, embryos have been found in females in the Pacific Ocean at all times of the year suggesting mating may occur for longer there. *C. longimanus* have from one to 15 pups and reach sexual maturity when males are 1.75 m and females are 2 m (Baum *et al.,* 2006).

Diet

C. longimanus are high trophic level predators that mostly feed on demersal and pelagic bony fish, as well as cephalopods, other invertebrates, plant matter and on occasion are known to eat seabirds (Baum *et al.,* 2006).

Table 1: Measures of maximum size, age, size at maturity and age at maturity, study location and study reference for males and females of three species of hammerhead shark. (Note: TL = total length)

		Sphyrna lewini			*Sphyrna mokarran*			*Sphyrna zygaena*		
		Measure (cm TL)	**Location**	**Ref***	**Measure (cm TL)**	**Location**	**Ref***	**Measure (cm TL)**	**Location**	**Ref***
Max size	F	346 TL	Nth Aus.	1	550-610+	Global	3	370-400 cm TL	Global	3
	M	321	SW Atlantic	2	550-610+	Global	3	370-400 cm TL	Global	3
		370-420	Global	3						
		301 TL	Nth Aus.	1						
Size at maturity	F	240	SW Atlantic	2	250-300	Global	3	210-240 cm TL	Global	3
		212	Global	3	210-258	Nth Aus.	1	265 cm TL	E Aus.	10
		250	Gulf of Mexico	4	212-242 TL	E Aus.	6			
		220-240	Indo.	7						
		200	Nth Aus.	1						
	M	180-200	SW Atlantic	2	234-269	Global	3	210-240 cm TL	Global	3
		140-165	Global	3	225 cm	Nth Aus.	1	250-260 cm TL	E Aus.	10
		180	Gulf of Mexico	4	227-242	E Aus.	6			
		170-190	Indo.	7						
		135-161	Nth Aus.	1						
		129-199	E Aus.	6						
		Measure (years)	**Location**	**Ref***	**Measure (years)**	**Location**	**Ref***	**Measure (years)**	**Location**	**Ref***
Max age	F	35	Gulf of Mexico	4	39.1	E Aus.	6	20 +	World	11
		38.5	Atlantic /Gulf of Mexico	5						
		21	E Aus.	6						
	M	22-30	Gulf of Mexico	4	31.7	E Aus.	6	20 +	World	11
		26.6	Atlantic /Gulf of Mexico	5						
		15	E Aus.	6						
Age at maturity	F	15	Gulf of Mexico	1	6.7-7.6	E Aus.	6			
	M	9-10	Gulf of Mexico	1	8.6-9.8	E Aus.	6			
		3-9	E Aus.	6						

***References:** 1= Stevens and Lyle, 1989; 2=Hazin *et al.,* 2001; 3=Compagno, 1984; 4=Branstetter, 1987; 5=Piercy *et al.,* 2007; 6= Macbeth *et al.,* 2011; 7=White *et al.,* 2008; 8=Noriega *et al.,* 2011; 9=Baum *et al.,* 2007; 10=Stevens, 1984; 11=Casper *et al.,* 2005

Table 2: Reproductive traits of three species of hammerhead shark.

	Sphyrna lewini			*Sphyrna mokarran*			*Sphyrna zygaena*		
	Measure (# of pups)	**Location**	**Ref***	**Measure (# of pups)**	**Location**	**Ref***	**Measure (# of pups)**	**Location**	**Ref***
Litter size	2-21	SW Atlantic	2	6-42	Global	3	29-37	Global	3
	1-25	East coast Australia	8				20-49	E Aus.	Stevens 1975
	12-41	World	9	6-33	Nth Aus.	1			
	15-31	World	3						
	14-41	Indonesia	7						
	13-23	Nth Aus.	1						
	Measure (cm TL)	**Location**	**Ref***	**Measure (cm TL)**	**Location**	**Ref***	**Measure (cm TL)**	**Location**	**Ref***
Size at birth	45-55	E Aus.	8	50-70	Global	3	50-61	Global	3
	42-55	Global	3						
	45-50	Nth Aus.	1	65	Nth Aus.	1			
	39-57	Indonesia	7						

***References:** 1= Stevens and Lyle, 1989; 2=Hazin *et al.,* 2001; 3=Compagno, 1984; 4=Branstetter, 1987; 5=Piercy *et al.,* 2007; 6= Macbeth *et al.,* 2011; 7=White *et al.,* 2008; 8=Noriega *et al.,* 2011; 9=Baum *et al.,* 2007; 10=Stevens, 1984; 11=Casper *et al.,* 2005

Distribution and Status

Global and Australian distribution and status

Hammerhead sharks

Evidence suggests that hammerhead sharks have undergone varying levels of reduction in abundance worldwide (Casper *et al.,* 2005; Baum *et al.,* 2007; Denham *et al.,* 2007; CITES, 2012). There are currently no global or regional stock assessments for hammerhead sharks due to the aggregation of catch data for all hammerhead species, i.e. they are usually only identified to genus level in log books. This aggregation of data makes stock assessments of the separate species difficult; however, some analysis of un-standardised catch rates within Australian waters has been completed (Simpfendorfer, 2014). Current evidence suggests that the Australian populations of hammerhead species are shared stocks with neighbouring countries such as Indonesia and New Zealand (Simpfendorfer, 2014).

Scalloped hammerhead – global distribution

S. lewini is circumglobally distributed in warm temperate and tropical waters. It is a coastal-pelagic and semi-oceanic species, found over continental and insular shelves and the deep water adjacent to them, as well as close inshore (Compagno, 1984; Baum *et al.,* 2007; Rowling *et al.,* 2010). Depths inhabited are from the intertidal zone to at least 275 m in depth (Compagno, 1984), possibly as deep as 1000 m (CITES, 2013). *S. lewini* was historically abundant along continental margins and tagging data has shown that they occasionally make long distance trips into offshore oceanic habitat (Kohler and Turner, 2001). Some adult populations are known to form large schools around sea mounts and sometimes undertake migrations, often to warmer water (Compagno, 1984; Baum *et al.,* 2007; Speed *et al.,* 2010; Noriega *et al.,* 2011). Both juvenile and adult *S. lewini* appear to range widely at night time and are more constrained during the day (Duncan and Holland, 2006; Speed *et al.,* 2010).

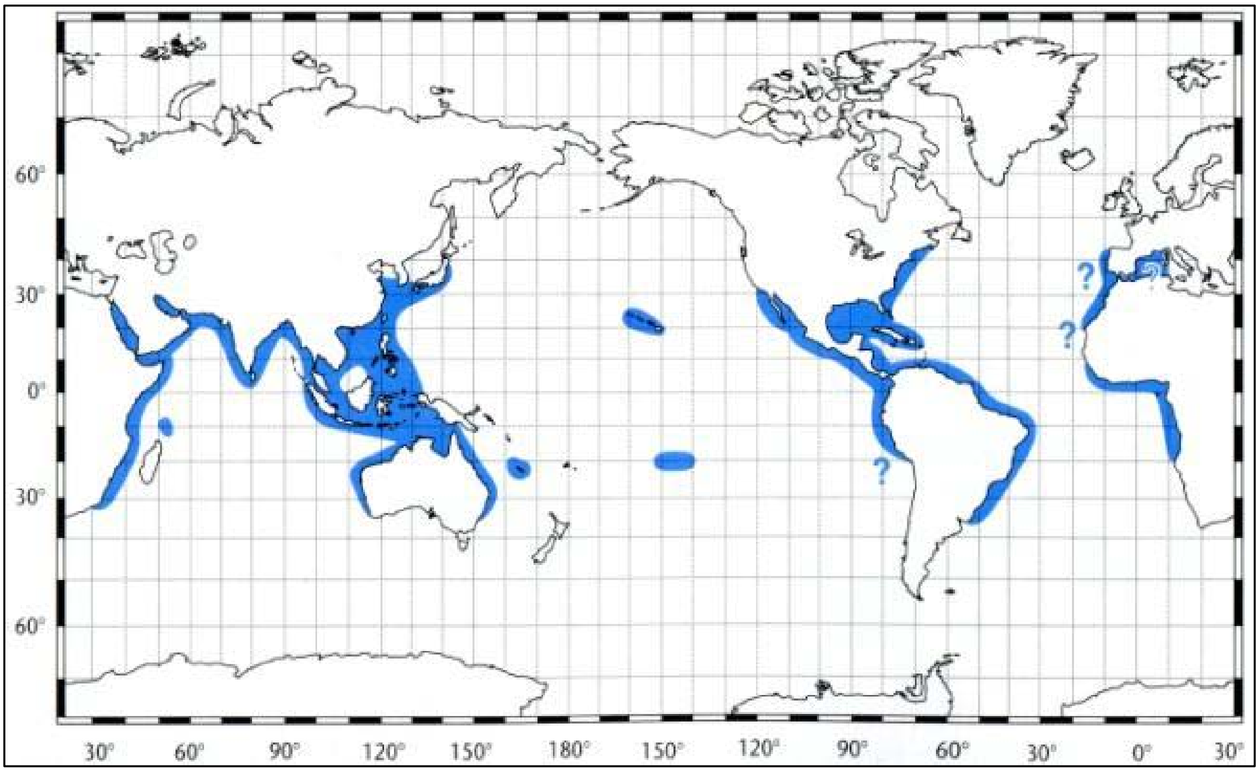


Figure 1. Global distribution of the Scalloped hammerhead (*S. lewini*). (Source: Last and Stevens, 2009)

Scalloped hammerhead - Australian distribution

S. lewini is found in northern Australian waters, down to approximately 34 degrees south (Sydney on the east coast and Geographe Bay on the west coast; (Rowling *et al.,* 2010). The IUCN's regional assessment on conservation status considers *S. lewini* to be 'data deficient' in Australia (Baum *et al.,* 2007).

Scalloped hammerhead - status

S. lewini is listed as 'endangered' on the International Union for the Conservation of Nature (IUCN)'s Red List (Baum *et al.,* 2007). While there is no global stock assessment currently in place for *S. lewini*, Simpfendorfer (2011) has produced the largest data set of catch and effort data from fisheries and shark control programs along the eastern Australian coast, where some data has been collected since 1965. Based on the data analysed, Simpfendorfer (2014) concluded that the population of *S. lewini* has declined to between 16.5 and 33.4 per cent of its original pre-exploitation levels.

An analysis of un-standardised catch rates in the Western Australian North Coast Shark Fishery (WANCSF) and the Joint Authority Northern Shark Fishery (JANSF), which are now closed to fishing, had seen a decline in catch rates to between 24 and 42 per cent of their original levels over a 5 year period suggesting a moderate decline in numbers (Heupel and McAuley, 2007).

It should be noted however, that as the catch was not recorded down to species level, it is assumed that the catch was made up of *S. lewini* and *S. mokarran* due to their tropical distributions (Simpfendorfer, 2014).

Great hammerhead - global distribution

S. mokarran is also a circum-global species found in tropical and warm temperate waters around the world, from 40 degrees north to 35 degrees south (Compagno, 1984; Denham *et al.,* 2007; Rowling *et al.,* 2010). It is coastal-pelagic and semi-oceanic, occurring both close inshore and offshore over the continental shelves, as well as the deep water adjacent to the shelf and from depths of 1 m down to at least 80 m (Compagno, 1984; Denham *et al.,* 2007; Rowling *et al.,* 2010). These species are thought to be partially migratory (Compagno, 1984; Denham *et al.,* 2007), with satellite tagging conducted in Australian waters suggesting the northern Australian population is connected with the Oceania population (Simpfendorfer, 2014). A recent study by Hammerschlag *et al.,* (2011) concluded that *S. mokarran* in the Northern Hemisphere are known to travel large distances in short timeframes which suggests they are nomadic and highly migratory.

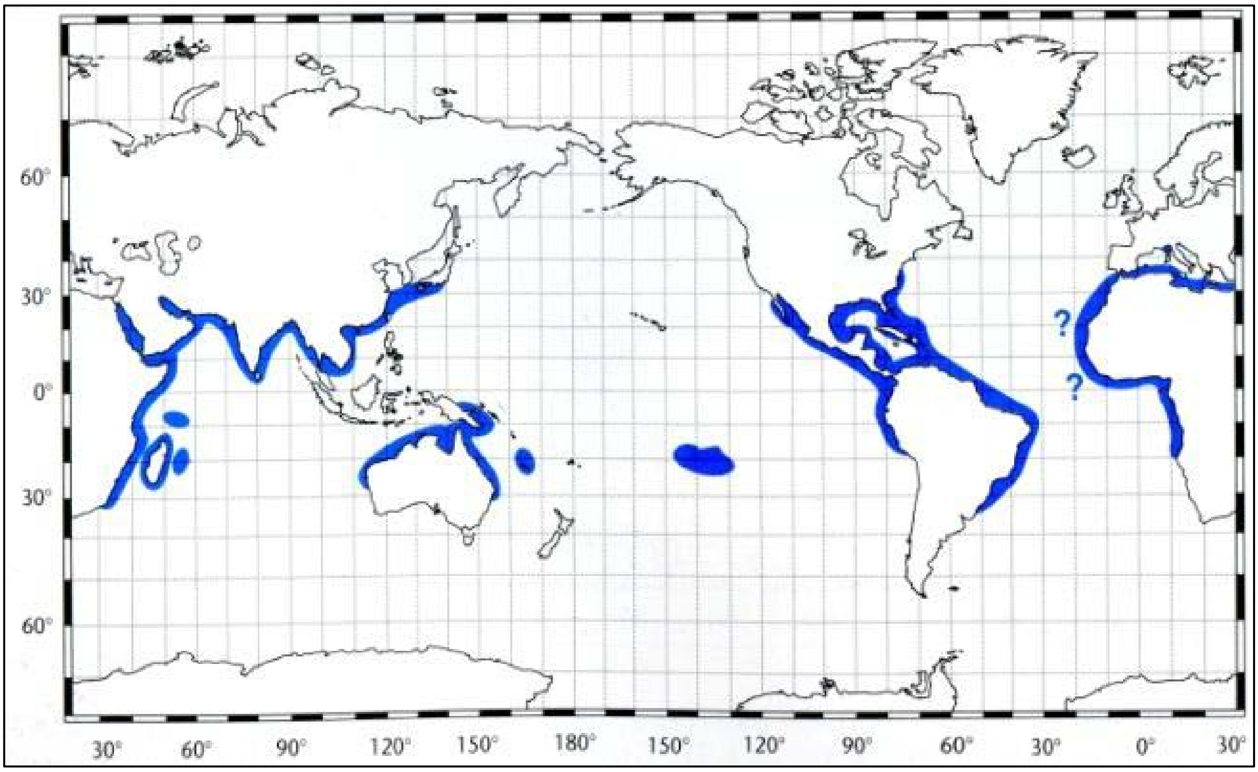


Figure 2. Global distribution of the Great hammerhead (*S. mokarran*). (Source: Last and Stevens, 2009).

Great hammerhead - Australian distribution

S. mokarran inhabits waters across the northern coast of Australia and as far south as Sydney on the east coast (Stevens and Lyle, 1989; Denham *et al.,* 2007; Rowling *et al.,* 2010). The southern limit on the western coast of Australia is unknown. The IUCN has listed *S. mokarran* as 'data deficient' within Australia (Denham *et al.,* 2007).

Great hammerhead - status

The IUCN has listed *S. mokarran* as 'endangered' on its Red List (Denham *et al.,* 2007). While there is no global stock assessment currently in place for *S. mokarran*, Simpfendorfer (2011) has conducted an analysis of trends using standardized catch data from shark control programs along the eastern Australian coast. The analysis concluded that the population had declined to between 16.5 and 33.4 per cent of their original levels since 1965 (Simpfendorfer, 2014). Similarly, an analysis of un-standardised catch data from the WANSCF and JANSF concluded that catch rates had declined to between 24 and 42 per cent of original levels over a five year period (Huepel and McAuley, 2007; Simpfendorfer, 2014).

Smooth hammerhead - global distribution

S. zygaena is a coastal-pelagic and semi-oceanic species occurring in amphitemperate waters (occurs in temperate waters of the northern and southern hemispheres but is absent in tropical waters). As with other large hammerheads, it can be found both very close inshore in shallow water and out over the continental and insular shelves to adjacent deep water (Compagno, 1984; Casper *et al.,* 2005; Rowling *et al.,* 2010). *S. zygaena* is listed as 'vulnerable' on the IUCN Red List (Casper *et al.,* 2005).

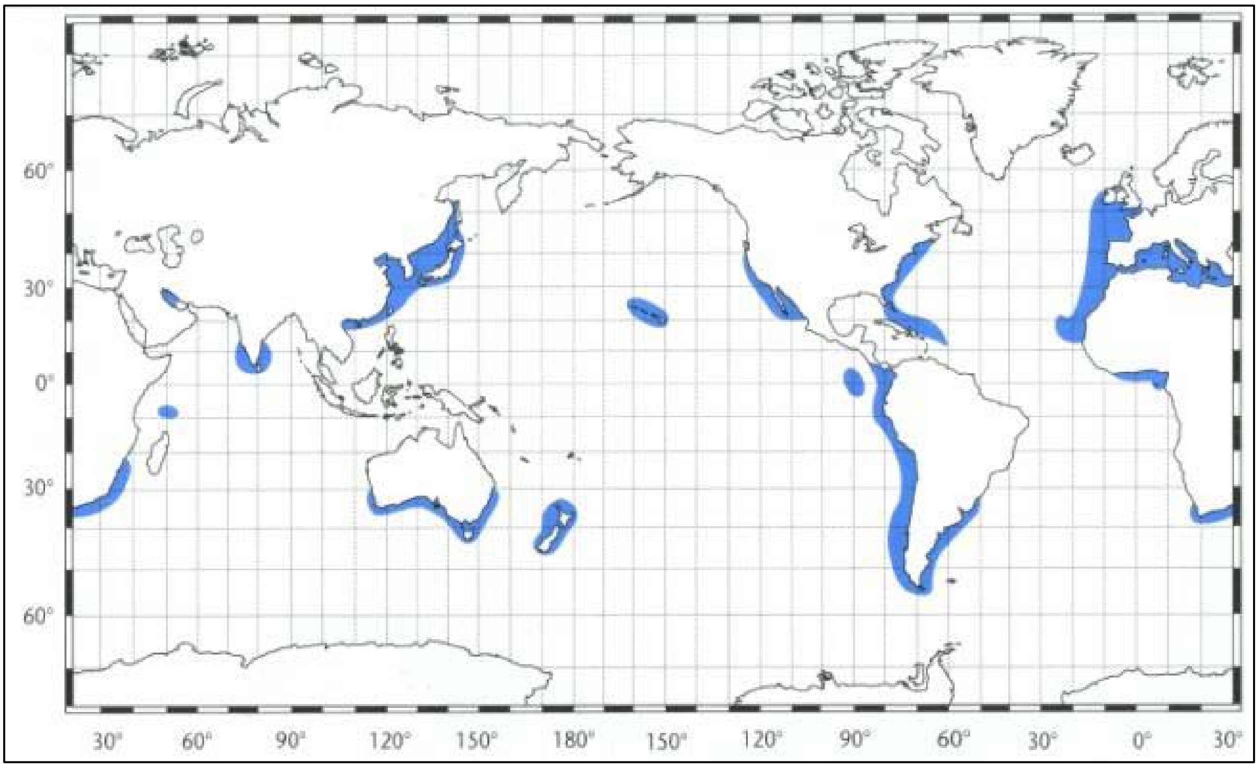


Figure 3. Global distribution of the Smooth hammerhead (*S. zygaena*). (Source: Last and Stevens, 2009).

Smooth hammerhead - Australian distribution

Of the three hammerhead species, *S. zygaena* has been least studied and there is a serious paucity of information, particularly in regards to Australian populations (Simpfendorfer, 2014). In Australia, it occupies waters off Western Australia, South Australia, Victoria, Tasmania and New South Wales (Casper *et al.,* 2005). Its northern limit on the east coast is Coffs Harbour and on the west coast Jurien Bay (Patterson and Tudman, 2009; Rowling *et al.,* 2010). It is generally found in waters down to 20 m, although its depth range has been reported to 200 m (Compagno, 1984; Casper *et al.,* 2005; Patterson and Tudman, 2009; Rowling *et al.,* 2010; CITES, 2013).

Smooth hammerhead - status

There is currently no assessment of *S. zygaena* populations in Australian waters; however, an analysis of catch per unit of effort (CPUE) data from the Joint Authority Southern Demersal Gillnet and Demersal Longline Fishery (JASDGDLF) and the West Coast Demersal Gillnet and Demersal Longline Fishery (WCDGDLF) from 1989/90 showed that CPUE had increased steadily over time (Simpfendorfer, 2014). This rise in CPUE may be attributed to catch being identified to species level rather than an increase in species abundance. The data does suggest moreover, that the abundance of *S. zygaena* had not significantly declined over time (Simpfendorfer, 2014). A study using data from 1994 to 1999, suggests that fishing was not conducted at a level that would lead to a decline in populations due to those relatively low catch levels continuing over time. This supports the above analysis that a major decline in population had not occurred (McAuley and Simpfendorfer, 2003).

Porbeagle sharks – global distribution

L. nasus is circum-globally distributed in temperate and cold temperate waters. It is a coastal and oceanic species, found over continental shelves and insular shelves and the deep water adjacent to them, as well as close inshore (Compagno, 2001; Stevens *et al.,* 2006). They are found in depths ranging from the intertidal zone out to 370 m (Campagno, 2001). Tagging studies from the United States have shown that *L. nasus* travel short to moderate distances (up to 1,500 km) along continental shelves (cited in Stevens *et al.,* 2006); although 90 per cent of tagged *L. nasus* moved less than 950 km from their original tagging position (Kohler *et al.,* 2002). Previous studies suggested mixing of *L. nasus* populations throughout their range in the north-east Atlantic due to some sharks recording movements of some 4,260 km from their original tagging position (Stevens, 1976, 1990). *L. nasus* is listed as ‘vulnerable’ on the IUCN red list (Stevens *et al.,* 2006).

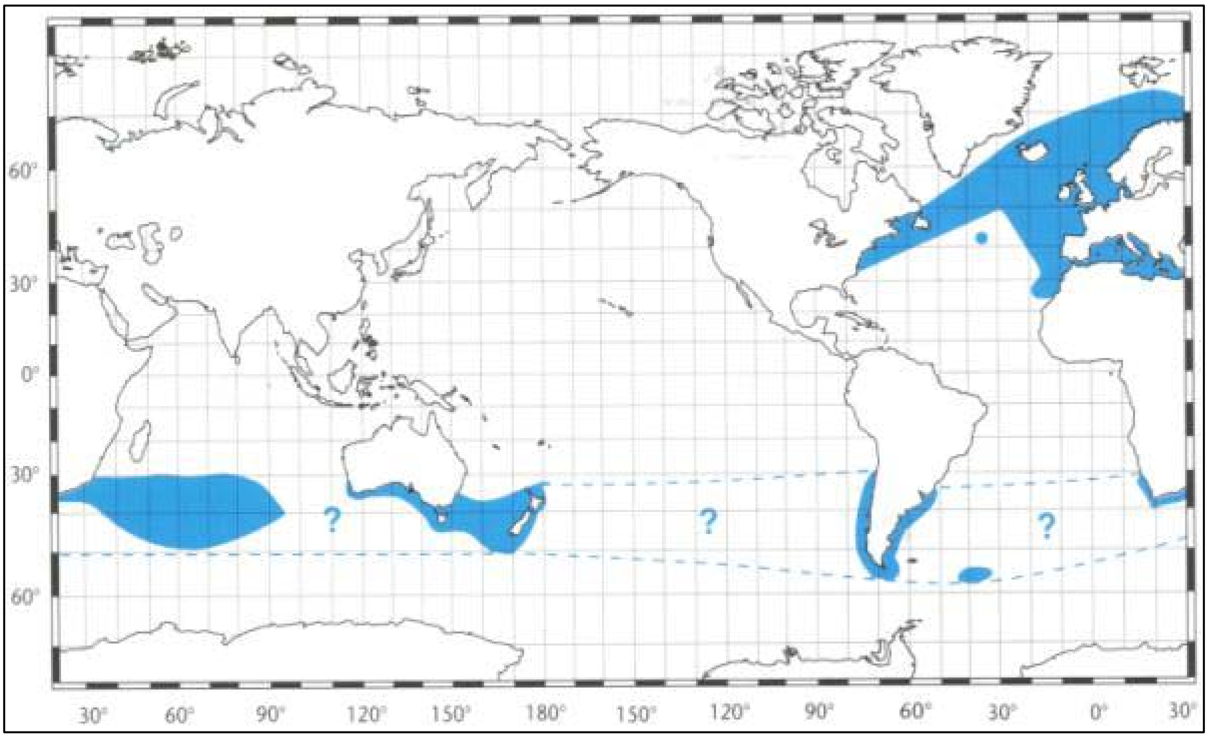


Figure 4. Global distribution of the porbeagle shark (*L. nasus*). (Source: Last and Stevens, 2009).

Porbeagle sharks - Australian distribution

While there are few recorded reports of *L. nasus* in southern Australian waters, it is accepted that they inhabit coastal surface waters out to approximately 370 m in depth, in southern waters from southern New South Wales in the east to southern Western Australia in the west. They also inhabit subantarctic waters (Compagno, 2001; Last and Stevens, 2009).

Porbeagle sharks - status

There is currently no assessment of *L. nasus* populations in Australian (or Southern Ocean) waters; however, New Zealand initiated discussions of a stock assessment through the Commission for the Conservation of Southern Bluefin Tuna in 2013 – 2014. This process has been suspended and without a stock assessment in place, knowledge gaps around sustainable levels of take for this species will remain for some time (Simpfendorfer, 2014)

Oceanic whitetip sharks – global distribution

C. longimanus is circum-globally distributed, spanning across entire oceans in tropical and subtropical waters. It is an oceanic shark found offshore in epipelagic waters sometimes down to 200 m; however, it is typically found in surface waters (Baum *et al.,* 2006). *C. longimanus*, along with the silky shark (*C. falciformis*) was considered one of the three most abundant species of oceanic sharks worldwide; however, recent evidence suggests these sharks are now seldom recorded (Baum and Myers, 2004; Domingo, 2004- cited in Baum, 2006). Tagging studies suggest that *C. longimanus* can travel over thousands of kilometres, although most satellite tracked individuals travel between 1500 and 2000 km (Simpfendorfer, 2014). The same tagging studies suggest *C. longimanus* show a high level of philopatry, returning to the area where they were released (Simpfendorfer, 2014). *C. longimanus* is listed as ‘vulnerable’ on the IUCN red list (Baum *et al.,* 2006).

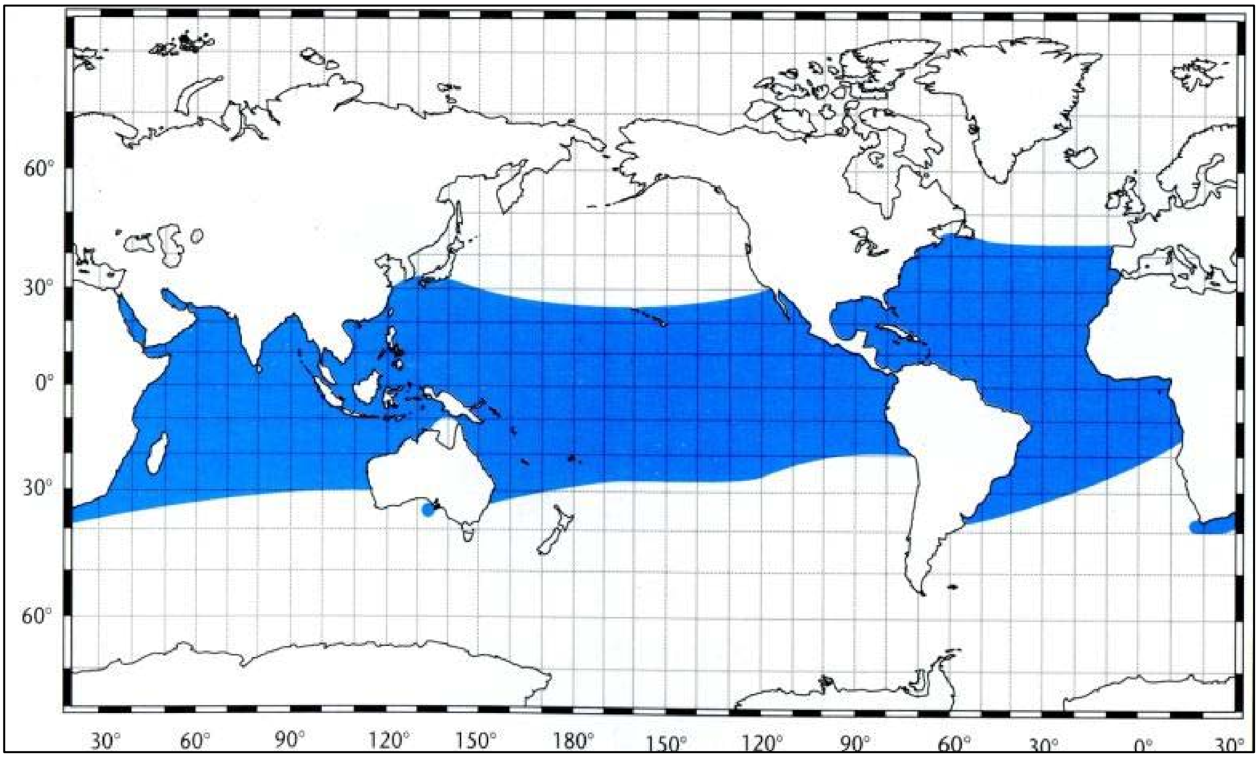


Figure 5. Global distribution of the oceanic whitetip shark (*C. longimanus*). (Source: Last and Stevens, 2009).

Oceanic whitetip sharks - Australian distribution

C. longimanus inhabit the pelagic and oceanic waters of Australia ranging in depths from surface waters down to approximately 170 m (Koopman and Knuckey, 2014). It is distributed from southern New South Wales in the east, north and around to Perth in the West; however, it is not generally found around Torres Strait, the Gulf of Carpentaria and the Arafura Sea (Koopman and Knuckey, 2014).

Oceanic whitetip sharks - Australian status

Recent assessments of stock size of *C. longimanus* were conducted by the Indian Ocean Tuna Commission (IOTC) and the Western and Central Pacific Fisheries Commission (WCPFC) within their boundaries under the convention. While the IOTC assessment was based on a risk framework, the WCPFC assessment was based on an age-structured model (Simpfendorfer, 2014). The WCPFC assessment concluded that the population of C*. longimanus* had declined by approximately 86 per cent from 1995 to 2009 and to achieve maximum sustainable yield, fishing mortality would have to have been reduced by up to six times (Simpfendorfer, 2014). The assessment further concluded that 'the approximate remaining biomass of *C. longimanus* is between 3 and 19 per cent of pre-exploitation levels and most likely around 7 per cent'.

The IOTC assessment concluded that not enough information was available to determine a status for the population within the area of the IOTC convention; however, it is most likely that the population suffered a substantial decrease from pre-exploitation levels. Currently there remains considerable uncertainty of stock structure of this species and while it remains unclear if separate stocks exist off Australia's coasts, it is prudent to expect a similar fate of this species has occurred in the Oceania region as it has elsewhere (Simpfendorfer, 2014).

Population structure

Scalloped hammerhead – population structure

Genetic studies of *S. lewini* indicate strong genetic traits that distinguish regional populations (CITES, 2013). There appears to be high population structure at a global scale across ocean basins in the maternal line, with mitochondrial DNA (mtDNA) lineages that appear to have been isolated within ocean basins for extensive periods of time (Duncan *et al.,* 2006; Quattro *et al.,* 2006). There is some contemporary genetic connectivity occurring, which could be the result of male mediated dispersal and gene flow (Daly-Engel *et al.,* 2012). There is little genetic structure among populations that are connected by coastlines (Duncan *et al.,* 2006), possibly the result of females showing levels of fidelity to certain coastlines for reproductive purposes, while males disperse longer distances (Daly-Engel *et al.,* 2012). Little information is known however, about such long distance dispersal events (Kohler and Turner, 2001). Recent studies have uncovered the presence of a cryptic hammerhead species morphologically resembling *S. lewini* in the western Atlantic Ocean (Quattro *et al.,* 2006; Pinhal *et al.,* 2012). The presence of this cryptic species could have influenced previous population assessments and is likely to have entered trade (CITES, 2013).

Studies including *S. lewini* in Australian waters have found little or no genetic subdivision between samples taken from across the Indo-Pacific region, including from east and west Australia and Indonesia (Ovenden *et al.,* 2009, 2011). Therefore Australia is most likely sharing a fishery stock with Indonesia, where fishing pressure is high (CITES, 2013).

Scalloped hammerhead - sexual segregation

Genetic evidence suggests that male and female *S. lewini* behave differently and probably spend large amounts of their lives in different habitats. Sexual segregation in *S. lewini* has been noted in catch data of some fisheries when particular age and size classes are missing. Klimley (1987) studied *S. lewini* off the coast of California and noted that females appeared to move offshore at a smaller size to males, with females being caught in significantly deeper water on average than males of the same length. Females appeared in offshore schools around lengths of 100 cm, whereas males were absent until 160 cm (Klimley, 1987). Mature females dominate catches in Indonesian waters where the ratio of females to males larger than 110 cm was almost five to one (White *et al.,* 2008). In a Brazilian catch there were proportionally more females of a certain size category than males (Hazin *et al.,* 2001).

Harry *et al.,* (2011a) found on the Australian east coast that females were almost completely missing from tropical inshore fisheries. They found most females had left shallow waters by three years of age and 100 cm length, whereas males remained for up to 10 years of age and 200 cm length. Juvenile females and large adult males were found predominantly in deeper temperate eastern Australian waters, with large adult females still missing (Harry *et al.,* 2011a). Catches off northern Australia comprised of neonates and juveniles of both sexes and small adult males (Stevens and Lyle, 1989). In their review of the Queensland shark control program, however, Noriega *et al.,* (2011) found evidence of sexual segregation at only one of their 10 study sites, Cairns (90% males).

Great hammerhead – population structure

Very little information exists as to *S. mokarran's* population and genetic structure. Early data on population structure was an analysis of samples from several areas around the world, which found two distinct groupings, one from Atlantic populations and a second group from samples in Australia and Borneo, suggesting some level of shared stock between Australia and south-east Asia, similar to *S. lewini* (Naylor *et al.,* 2012).

Great hammerhead – sexual segregation

Harry *et al.,* (2011a) found that there was a bias towards catching females in inshore fisheries in tropical Queensland, an opposing trend to *S. lewini.* Fisheries in temperate waters were mainly capturing larger males (Harry *et al.,* 2011a). After their northern Australian study, Stevens and Lyle (1989) concluded that *S. mokarran* had the lowest levels of sexual segregation of the hammerhead sharks.

Smooth hammerhead – population structure and sexual segregation

Little differences within some populations were found in a study from California, Senegal, Asia and the North Atlantic. No Australian samples, however, were included in this study (Naylor *et al.,* 2012). In a study of recreational fishing off NSW, Stevens (1984) found that mature males were absent in the catches and that species shorter than 120cm were also absent, although this could be a result of gear selectivity. There is no information currently available on the level of sexual segregation in *S. zygaena*.

Porbeagle – population structure

Recent research has concluded there are two genetically distinct populations of *L. nasus*, a northern hemisphere population and a southern hemisphere population (Testerman, 2014). The same study determined there is one single stock in the southern hemisphere through the examination of genetic samples from five locations; the Falkland Islands, Chile, South Africa, Tasmania and New Zealand (Testerman, 2014). Although tag-recapture data shows *L. nasus* move long distances along continental margins and seldom across ocean basins, pop-up satellite tags have revealed that adult *L. nasus* move away from continental margins and move vast distances to warmer pupping grounds (Campana *et al.,* 2010).

Porbeagle – sexual segregation

There is currently no information on the level of sexual segregation in the southern hemisphere population of *L. nasus* however, there is some evidence that the North Atlantic and Mediterranean stocks are segregated by sex and also size (Stevens *et al.,* 2006). While very few adult animals are captured in the Mediterranean, it is still considered to be a nursery ground (Stevens *et al.,* 2006). There is no evidence to determine the ratio of males to females during segregation.

Oceanic whitetip – population structure

At present, there is little evidence to suggest any stock structuring of *C. longimanus* (Simpfendorfer, 2014); however, tag-recapture data collected through the US cooperative Shark Tagging Project in the Atlantic Ocean has verified that *C. longimanus* can move hundreds to thousands of kilometres (Kohler *et al.,* 1998). More recent satellite tagging data collected from the Atlantic Ocean confirms that *C. longimanus* regularly move between 1000 and 2000 km and tagged individuals displayed a high level of philopatry (return to the same area they were released) (Howey-Jordan *et al.,* 2013). This data may also be the best way of determining population structure in the Oceania Region by using extrapolation (Simpfendorfer, 2014). The vast distances travelled by the tagged animals suggests that stocks would mix between the eastern Indian Ocean and the western Pacific; however, mixing would only occur if animals move through the Indonesian Archipelago (Simpfendorfer, 2014). Based on the tagging data, it is highly likely that Australia shares these stocks with its regional neighbours (Simpfendorfer, 2014). Further research into population structure is required for *C. longimanus* to determine relationships between the Indian Ocean and western Pacific stocks (Simpfendorfer, 2014).

Oceanic Whitetip – sexual segregation

There is currently no information on the level of sexual segregation in the Eastern Indian Ocean or Western Pacific populations of *C. longimanus;* however, Coehlo *et al.,* (2009) provides evidence of sexual segregation in the Western Atlantic population where a sample size of 104 sharks showed a large number (80.7 per cent of males and 89.4 per cent of females) were immature and resulting in a sex ratio of 1.2:1 (male:female). The study also showed differences in maturation sizes compared to Indian Ocean sharks in a study by Bass *et al.,* (1973) in which it was suggested that males mature between 185 and 198 cm total length (TL) and females between 180 and 190 cm TL. Coehlo *et al.,* (2009) suggests males in the Western Atlantic stock mature between 160 and 196 cm TL and females between 181 and 203 cm TL.

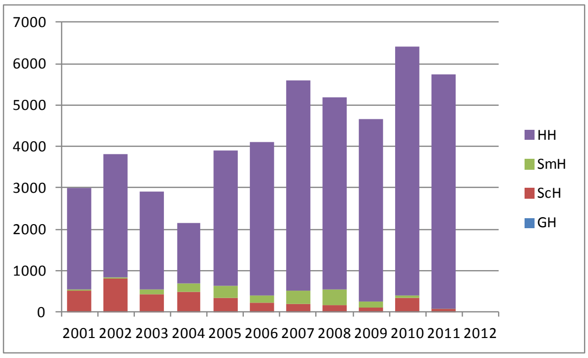
Global and domestic harvest

Hammerhead shark harvest

Generally, in global fisheries, hammerhead species are not reported down to species level. This is evident as there were no records of great hammerheads in global catches (Koopman and Knuckey, 2014). The lack of species specific identification makes it inherently difficult to compare Australia's catch with global catches; however, comparing catches on a generic level, using species distribution was completed by Koopman and Knuckey, (2013).

Total global catches of hammerhead species ranged between 2000 and 6000 tonnes (t) over the past decade (Figure 6a) and continues to rise where Australia's catch has ranged between 200 and 600 t and has been declining since 2004 (Figure 6b). This represents approximately 8.5 per cent of global catches in the period 2001 through 2011 (Koopman and Knuckey, 2014).

a)



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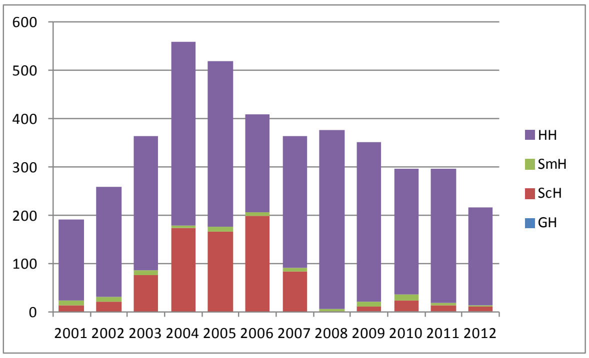

Figure 6. Annual catches (t) of hammerheads a) globally and b) Australian. Scalloped Hammerhead (ScH), Smooth Hammerhead (SmH), Great Hammerhead (GH) and unspecified hammerhead (HH). Data Source: FAO FishStat and Australian fishery logbook data. Figure Source: Koopman and Knuckey, (2013).

Four Australian fisheries account for approximately 90 per cent of the Australian hammerhead catch: the Northern Territory's Ocean Net and Line Fishery (ONLF), Queensland's East Coast Inshore Finfish Fishery (ECIFFF), and Western Australia's Temperate Demersal Gillnet and Demersal Longline Fishery (TDGLF) and Northern Shark Fishery (NSF) (Koopman and Knuckey, 2014). The remaining 10 per cent of catch is taken in a number of other State and Commonwealth managed fisheries (Koopman and Knuckey, 2014).

The largest declines in catches (approximately 40 per cent between 2003 - 2012) were seen in the ONLF, ECIFF and NSF (Koopman and Knuckey, 2014); however, effort had also decreased by approximately 56 per cent in that same time frame. A number of management arrangements in fisheries that interact with these sharks have also changed over time, such as the introduction of shark fin ratios, the targeting of other species of teleosts (bony fish) where interactions with sharks are minimised (grey mackerel in ONLF) (Northern Territory Government, 2012 cited in Koopman and Knuckey, 2014) and the introduction of effort caps for longlining (Koopman and Knuckey, 2014). The implementation of a total allowable commercial catch in the ECIFFF during 2009-2010 has been attributed to lower shark catches in the fishery rather than a decline in numbers (Koopman and Knuckey, 2014). There has been no reported effort in the NSF, which has not been an approved wildlife trade operation, since 2008–09 (Fletcher and Santoro, 2012).

Recent research by Bradshaw et al., 2013 and Field et al., 2012 suggests some level of recovery of *S. mokarran* and *S. lewini* in northern Australian waters since Taiwanese gillnet fishing ceased in the mid 1980's. Currently there are also no indications to suggest that the population of *S. zygaena* is at a level where the current harvest would be detrimental to the species (Simpfendorfer, 2014). However, large catches of hammerhead sharks in neighbouring countries that share stocks with Australia could lead to more rapid declines of stocks, requiring reassessment of sustainable harvest levels (Simpfendorfer, 2014).

Porbeagle shark harvest

Global catches of *L. nasus* have declined significantly over the past decade with catches now in the range of approximately 200 t which is down from approximately 1200 t a decade ago. Australian catches have remained at less than 2.5 t per year over the same time frame with one Commonwealth managed fishery accounting for 75 per cent of the take within the high seas area of the Eastern Tuna and Billfish Fishery (ETBF) (Koopman and Knuckey, 2014) (Figure 7). *L. nasus* was listed as a migratory species under the Part 13 (protected species) provisions of the EPBC Act in 2010, as a consequence of its listing on Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). Under the EPBC Act, the fishery management arrangements for Australian commercial fisheries which may encounter *L. nasus* are accredited under Part 13, meaning it is not an offence to take the species. The accreditation is based on management arrangements requiring fishers to take all reasonable steps to avoid *L. nasus*, and for live specimens caught to be released unharmed. Since the time of the Part 13 listing, the catch of *L. nasus* from all Australian fisheries has averaged less than one t per annum, with the majority of the take being from the Commonwealth Eastern Tuna and Billfish Fishery (Koopman and Knuckey, 2014).

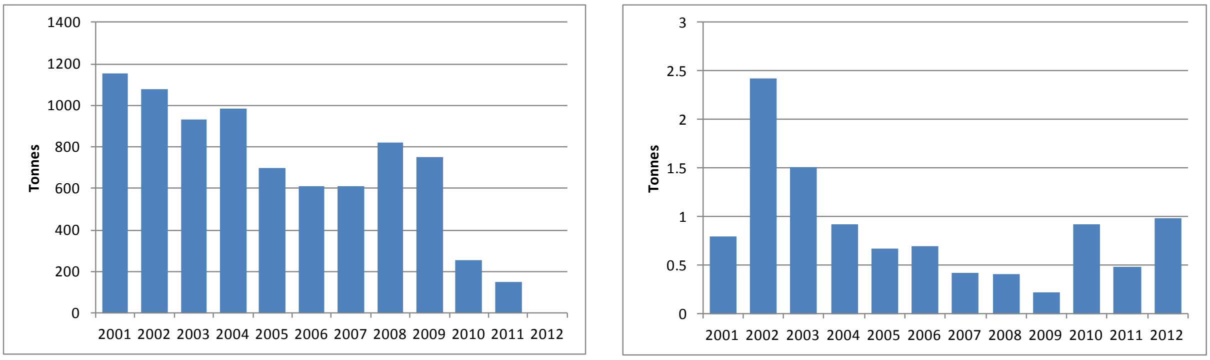

Figure 7: Annual catches (t) of Porbeagle Shark a) globally and b) Australian. Source FAO FishStat and Australian fishery logbook data (Source: Koopman and Knuckey, 2014).

Oceanic whitetip shark harvest

Global catches of oceanic whitetip sharks have varied over the past decade with catches ranging between 200 t and 1800 t. Australian catches have seen a decline from over 25 t in 2002 to less than 5 t in 2012 (Figure 8). This decline in catch has been attributed to the implementation of stricter management arrangements (ban on wire traces, trip/trigger limits, ban on shark finning, carriage of line cutters) and a decrease in effort in the ETBF and the Western Tuna and Billfish Fishery (WTBF) (Koopman and Knuckey, 2014). In line with conservation and management measures agreed by the Western and Central Pacific Fisheries Commission and the Indian Ocean Tuna Commission, retention of oceanic whitetip shark is prohibited in the Commonwealth ETBF and WTBF, the two fisheries most likely to encounter the oceanic whitetip shark. Small numbers of oceanic whitetip shark are possibly caught in state managed fisheries operating far offshore. The total Australian catch of oceanic whitetip shark is estimated to be less than 5 t per annum.

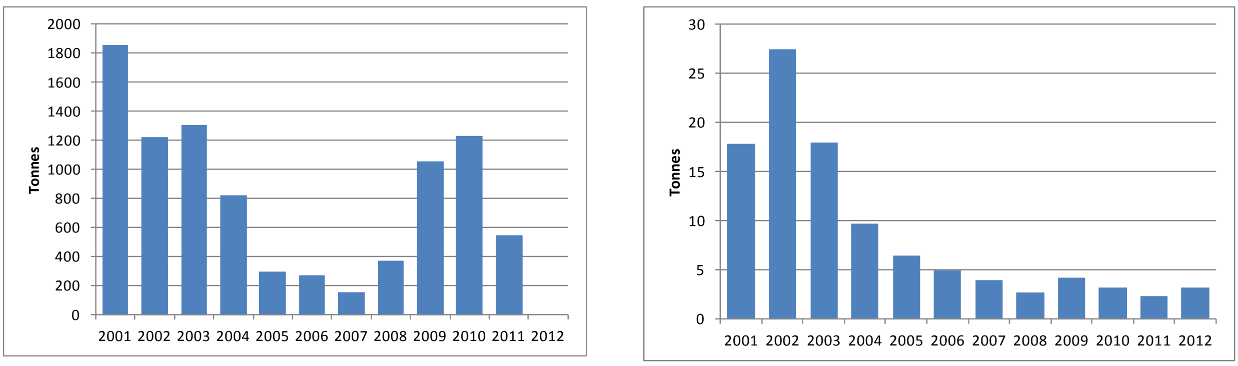

Figure 8. Annual catches (t) of Ocean Whitetip Shark a) globally and b) Australian. Source FAO FishStat and Australian fishery logbook data (Source: Koopman and Knuckey, 2014).

Recreational harvest

S. zygaena and *S. lewini* as well as *C. longimanus* rank highly among recreational fishers as popular game fish (Cheshire *et al.,* 2013). *L. nasus* are taken occasionally however, not in large numbers. Minimum size limits are in place for recreational fishing of sharks and since 2007, there has been an increase in catch and release of sharks during game fishing tournaments (*ibid*). The tag and release of hammerheads increased to approximately 88 per cent between 1993 and 2005 (Park, 2007). While there is no data on the number of sharks retained or the total number released, the large number of sharks that are tagged and released provides jurisdictions with basic biological and migration information. Recreationally caught sharks in Australia are also unable to be sold or exported (Cheshire *et al.,* 2013).

Threats and Mortality

Risk of capture and overfishing

Hammerhead sharks – risk of capture

All three hammerhead species are caught in fisheries around the world. They are captured as both target species and bycatch in a wide variety of fisheries, including trawls, bottom and offshore pelagic longlines, purse-seines, gillnets, handlines and inshore artisanal fisheries, which are often amalgamated as catches of Sphyrna spp. (Compagno, 1984; Stevens and Lyle, 1989; Casper *et al.,* 2005; Baum *et al.,* 2007; Denham *et al.,* 2007; CITES, 2013). Hammerheads are used for a variety of purposes such as fresh, frozen, dried and smoked meat for consumption, fins for shark-fin soup, skin for leather and livers for oil (Compagno, 1984). These three hammerhead species, *S. lewini, S. mokarran* and *S. zygaena* have morphologically similar fins and are used predominantly for the fin market, as their fins are highly valued due to their large size and high fin ray count (Casper *et al.,* 2005; Baum *et al.,* 2007; Denham *et al.,* 2007; CITES, 2013). A recent report by Whitcraft *et al.,* (2014), however, concluded that there has been a significant decline (approximately 50-70 per cent) in shark fin demand throughout China.

Several traits increase the hammerheads susceptibility to capture, including increased risk due to their unique head shape, which can easily become tangled in nets (Harry *et al.,* 2011b; Noriega *et al.,* 2011). An Australian study showed that unlike most shark species, hammerhead sharks of any size can become tangled in small mesh gill nets due to their unique head morphology and quickly die if not freed. These nets would normally exclude sharks of a larger size (Harry *et al.,* 2011b). Being obligate ram ventilators, like most sharks, requires them to maintain constant movement to obtain oxygen and this can mean asphyxiation for bycaught sharks (Compagno, 1984).

Juvenile hammerhead sharks can also be caught in different fishing gear including gillnets, trawls and hand lines (Compagno, 1984; Casper *et al.,* 2005; White *et al.,* 2008). *S. lewini* juveniles are particularly at risk due to their presence in large numbers in near shore nursery habitats; in their IUCN listing, it is noted that large numbers of juvenile *S. lewini* are caught by nearshore artisanal shark fisheries throughout the world, as well as commercial bottom trawls (Baum *et al.,* 2007). In New Zealand, juveniles and neonates are a common bycatch species in commercial gillnet fisheries (Casper *et al.,* 2005). The lack of information regarding the location of pupping grounds for both *S. mokarran* and *S. zygaena* raises some serious concerns about the risk posed to these juvenile life stages as large fishing effort around such nursery areas could significantly affect recruitment and survival at these crucial life stages (Simpfendorfer, 2014).

The aggregating behaviour displayed by both adults (around sea mounts and during small migrations) and juveniles (in nursery areas) increases their risk of capture in fisheries (Baum *et al.,* 2007). This behaviour increases the risk of disproportionately impacting on either juvenile life stages or pregnant females and thus seriously reducing population success.

Hammerhead sharks - post-catch mortality

Post catch mortality is also a serious issue as it can make a species highly vulnerable to fishing pressure, regardless of whether it is a targeted or bycatch species. Evidence and data about post-catch mortality are sparse for the three hammerhead species; however, as obligate ram ventilators (i.e. they need to swim to obtain oxygen from the water) it would be expected that post catch mortality rates would be high, particularly in gillnets. Estimates of post catch survivorship range from 10% (Denham *et al.,* 2007; CITES 2013), to 17% (Cortés *et al.,* 2010). Compagno (1984) notes that some of the larger hammerheads tend to expire faster than other species after being caught but does not supply any explanation. Data from New Zealand shows that juveniles commonly caught in trawlers and gillnet fisheries are usually dead before they are discarded (Casper *et al.,* 2005). Data from Atlantic pelagic longline fisheries show that *S. lewini* and *S. zygaena* both have low survivorship and are usually dead before being discarded (Cortés *et al.,* 2010). In a study of NSW populations it was noted that pups were often aborted during the process of capture (Stevens, 1984).

Hammerheads – risk of overfishing

Like many shark species, the three hammerhead sharks are highly susceptible to human pressures as a result of their biological characteristics. They are long lived, slow growing and late maturing species with relatively low fecundity (in comparison with other fishes). *S. mokarran* and *S. zygaena* only reproduce every second year, which adds to this vulnerability. Although biological data for *S. zygaena* is sparse worldwide, Casper *et al.,* (2005) note that it is presumably at least as biologically vulnerable as *S. lewini*. Complex migration pattern and spatial use (e.g. sexual segregation and site fidelity) can further increase vulnerability to overfishing. The Food and Agriculture Organisation (FAO) of the United Nations considers *S. lewini* to fall within the low productivity category (r<0.14) as a result of its low population growth rate (CITES, 2013).

There is also a risk from illegal, unregulated and unreported (IUU) fishing. There was a reported increase in this IUU fishing in northern Australia, of which *S. lewini* and *S. mokarran* are known to feature (Baum *et al.,* 2007; Denham *et al.,* 2007). However, recent observation by AFMA indicates less IUU due to increased compliance and enforcement activities – including surveillance and intercepts by the Australian Customs and Border Protection Service (Department of Agriculture, 2014).

Hammerhead sharks – other risks

Predation on neonate and juvenile *S. lewini* by other predatory sharks is high and is likely to be a significant source of natural mortality on the population (Baum *et al.,* 2007). In a study of juvenile *S. lewini* in Hawaii, mortality (both natural and fishing) as a fraction of neonate population size was estimated to be 0.85 to 0.93 during the first year of life (Duncan and Holland, 2006). The authors conclude that weight loss as a result of food competition was a significant factor contributing to this attrition rate.

Porbeagle shark – risk of capture

L. nasus are caught in both commercial and recreational fisheries worldwide. They are captured as target species and bycatch in a wide variety of fisheries, including trawls, bottom and offshore pelagic longlines, purse-seines, gillnets, handlines and inshore artisanal fisheries (Anonymous, 2004 cited in Stevens *et al.,* 2006). *L. nasus* are also a highly valued target species in big game recreational fisheries (Stevens *et al.,* 2006). Globally, *L. nasus* are primarily caught for their high value meat and fins; however, in high seas longline fisheries, where freezer space is limited, carcasses of *L. nasus* are seldom kept, only the fins are retained (Stevens *et al.,* 2006). In Australia, though, shark finning (retention of fins and discard of the body of the shark) is prohibited. While *L. nasus* aren't known to aggregate in large numbers, both juveniles and mature adults are retained due to the high value of the meat which can, in some cases, increase the fishing effort and thus risk of capture where known populations are located (Stevens *et al.,* 2006). In Australia though, there is little fishing effort where porbeagles occur, which reduces the risk of capture. Being obligate ram ventilators, like most sharks, requires them to maintain constant movement to obtain oxygen and this can mean asphyxiation for bycaught sharks (Compagno, 1984).

Porbeagle shark - post catch mortality

Data from Atlantic pelagic longline fisheries suggests that post capture mortality is likely to be lower than both *S. lewini* and *S. zygaena* due to being less susceptible to capture by surface longline gear and having a smaller distribution in areas of fishing effort in the Atlantic (Cortés *et al.,* 2010).

Porbeagle shark – risk of overfishing

The biological characteristics of *L. nasus* (long lived, slow growing, late maturation and low fecundity), along with little mixing of neighbouring extant populations, make them highly susceptible to human pressures (Stevens *et al.,* 2006). Female *L. nasus* breed on a yearly cycle and produce on average four pups per cycle, which can add to its vulnerability (Baum *et al.,* 2007; Stevens *et al.,* 2006)

There is also a risk from IUU fishing. While a number of countries operate fisheries for Patagonian toothfish (*Dissostichus eleginoides*) and tuna and billfish in the Southern Hemisphere where porbeagles are possible bycatch, only New Zealand reports their catches to the FAO. It is likely that a large amount of *L. nasus* was caught historically; however, research between 1990 and 2002 saw catch rates significantly reduced from 110 kg per 1000 hooks to 1 kg per 1000 hooks (Stevens *et al.,* 2006). Since the tuna catching effort of foreign vessels in New Zealand's Exclusive Economic Zone has reduced since the early 1990's, research suggests the New Zealand stock of *L. nasus* is in a recovering state (pers.com. Robertson, 2014).

Oceanic whitetip shark – risk of capture

C. longimanus are caught mainly in commercial pelagic longline, handline and most likely in pelagic gillnet, trawl and bottom trawl fisheries (Baum *et al.,* 2006). These sharks are often caught in large numbers as bycatch during fishing operations in oceanic waters where only the valuable fins are retained (Baum *et al.,* 2006). These sharks are seldom caught in recreational fisheries due to their distribution being mainly offshore (Baum *et al.,* 2006).

Oceanic whitetip shark – post-catch mortality

C. longimanus that are caught as bycatch in tuna longline fisheries are often either finned and discarded or treated poorly which often results in the discarded sharks having high post catch mortality (Bromhead *et al.,* 2012). While *C. longimanus* are likely to be caught in trawl and gillnet fisheries globally, there are no data to suggest what volume those catches may be (Baum *et al.,* 2006). The major differences in post capture survivorship in trawl and gillnet fisheries is related to the morphology and physiology of the sharks and the interactions with the fishing gear (Kaiser and Spencer, 1995). Some sharks are known to have a relatively high survivorship (as high as 95%) such as the bottom dwelling lesser-spotted dogfish, *Scyliorhinus canicula* (Kaiser and Spencer, 1995) whereas pelagic sharks such as the thresher shark, *Alopias vulpinus,* have a relatively low survivorship (Braccini *et al.,* 2012). A recent study by Musyl *et al.,* (2011), found that out of 18 *C. longimanus* caught in shallow set longlines in a Hawaiian based longline fishery, only one of those was not located via pop up archival tag which suggests the other 17 animals had high post capture survival. Also, being obligate ram ventilators, like most sharks, requires *C. longimanus* to maintain constant movement to obtain oxygen and this can mean asphyxiation for bycaught sharks (Compagno, 1984).

Oceanic whitetip shark – risk of overfishing

Efforts are currently underway through Regional Fisheries Management Organisation's (RFMO) to attempt to control the large catches of *C. longimanus* in tuna longline fisheries (Bromhead *et al.,* 2012). Like most sharks, the biological characteristics of *C. longimanus* (slow growing, long living, late maturation and lower fecundity) make these sharks inherently vulnerable to overfishing (Baum, 2006; Cortés *et al.,* 2010). In addition, the large fins of *C. longimanus*, which are highly valued in Asian markets, expose them to greater risk of being targeted and overfished (Baum, 2006).

Fishery management issues and recommendations

There are a number of other mechanisms that may trigger specific fisheries management arrangements for the species contained in this NDF. Some of these mechanisms are:

- The Australian Government Threatened Species Scientific Committee (TSSC) provides conservation advice to the Minister for the Environment on whether a species should be considered for listing under the EPBC Act as a threatened species. *S. lewini* is currently being considered for listing under the EPBC Act which, if listed, may require strict management arrangements to be imposed on fisheries that interact with the species. *S. zygaena* and *S. mokarran* are proposed for similar listing as look alike species to *S. lewini.*
- The Convention on Migratory Species of Wild Animals (CMS or Bonn Convention) 'provides for a global platform for the conservation and sustainable use of migratory animals and their habitats' (CMS, 2014). The CMS makes decisions on whether to list marine species as migratory, which may trigger management responses under the EPBC Act. *S. lewini* and *S. mokarran* are currently being considered for listing under the CMS which, if listed, would require both species to be listed as migratory species under the EPBC Act. This would impact on fisheries by no longer allowing export of these species if retained.
- Australia's second National Plan of Action for the Conservation and Management of Sharks (Shark-plan 2) was released in July 2012. Shark-plan 2 identifies how Australia will manage and conserve sharks, and ensure that Australia meets international conservation and management obligations. The plan identifies research and management actions across Australia for the long-term sustainability of sharks, including actions to help minimise fishing impacts. Shark-plan 2 was developed in conjunction with state, Northern Territory and Australian Government agencies, and has been endorsed by the Shark-plan Implementation and Review Committee and the Australian Fisheries Management Forum.
- Wildlife trade operation (WTO) approvals under the EPBC Act are operations taking specimens that meet legal requirements, such as a market testing operation, a small-scale operation, a developmental operation, a commercial fishery, a provisional operation or an existing stocks operation. As each WTO is renewed, CITES issues and listings are considered under the assessment process. The Minister for the Environment may specify the period, the circumstances or the conditions under which the operation will be subject, in the declaration (Australian Department of the Environment, 2014).

Wildlife trade operations are considered to be an ‘approved source’ so that CITES species may be exported while ever a NDF for the take of those species is in place and an export permit has been issued.

While the above mechanisms may impact on management arrangements in the future, for the CITES Scientific Authority of Australia to make this NDF, only the current management arrangements and catch information has been assessed. The harvest levels contained in this NDF will be monitored annually by the CITES Scientific Authority of Australia, through CITES permit acquittals and catch data. Catch data is provided annually by fishery management agencies as a requirement of the wildlife trade operation accreditation. For future NDF’s to be made, other management arrangements as mentioned below, if implemented, will aid in ensuring a robust finding is made. Implementation of these recommendations will be sought through the WTO assessment and approvals process for each fishery, including the provision of annual catch data of the CITES listed shark species.

Issues

The Commonwealth and State fisheries that interact with the species contained in this NDF have a range of management measures in place such as:

- a limited number of licences
- catch and/or effort limits
- restrictions on the fishing gear that can be used
- compulsory reporting of catch in logbooks
- some fisheries have ongoing observer programmes, either electronic or human
- prohibition on the retention of sharks in most non-shark targeted fisheries

These measures may help to reduce the number of these sharks being caught; however, there remain a number of areas where management measures may be improved to further reduce the catch. Some measures are common to most, if not all fisheries that interact with these sharks to differing degrees (Koopman and Knuckey, 2014).

Recommendations for management

Determining the extent of Illegal, Unregulated and Unreported (IUU) catch

IUU catch and composition down to species level has been estimated (Marshall, 2011); however, the estimation was completed for the whole of Northern Australia which makes it difficult to attribute the catch to any particular fishery (Koopman and Knuckey, 2014). While it may be possible to disaggregate this data to attribute to specific fisheries, the data is almost 10 years old and may not be relevant to current management practices (Koopman and Knuckey, 2014). Closing the knowledge gaps with regards to IUU catch and species level composition would improve the basis on which an NDF is made.

Species specific reporting with lengths and sex

The current reporting of shark catches differs between fisheries and between jurisdictions. One example of this is the grouping of all 'hammerheads' in some fisheries, rather than being attributed to individual species. While the fishing industry is generally able to identify hammerheads to species level, the logsheets completed by fishermen are hard coded with generic 'hammerhead' only and provide no space to enter the sex of the animal or its total length. (Koopman and Knuckey, 2014). It is recommended for all fisheries that take the shark species in this NDF that some level of species specific reporting is implemented as WTO's are reviewed. Fisheries that target shark species (and catch these sharks as bycatch/byproduct) should also consider implementing the recording of sex and total lengths once trigger points are reached (Koopman and Knuckey, 2014). The recording of this information would improve the confidence in the data and in turn increase confidence in the making of an NDF (Koopman and Knuckey, 2014). In addition to the recording of catch to species level, identification down to species level would also be required for exporting businesses to ensure the correct species are being exported.

Recording of bycatch, discards and health status

Currently there is very little or no recording of any discarded sharks due to trip limits, the 'no take' of some species and the lack of recording space in logsheets (Koopman and Knuckey, 2014). It is important that the capacity to record discards (and the health status of those discards) of these shark species is incorporated over time and as WTO's are reviewed into the logbooks; however, it is noted that phasing in health status recording may be a more feasible option in the future. The gathering of this information will help to arrive at future NDFs with more certainty (Koopman and Knuckey, 2014).

Species specific catch/trip limits with maximum size limits to protect mature animals depending on post capture mortality

A large number of Australian commercial fisheries have in place catch triggers for byproduct groups such as sharks in general; however, it is very rare to find trigger limits for individual species. To reduce the risk of increased fishing pressure or increased potential to target these shark species, individual catch limits should be implemented for each of the listed species (Koopman and Knuckey, 2014). Further to this, a limit on the maximum size of sharks that can be retained could also be implemented to ensure stricter protection of a portion of the mature shark population. Where bycatch exceeds trip limits, further measures to protect sharks such as banning of wire traces and safe handling practices, would aid in improving the sustainable management of these sharks and improve the basis for positive NDFs in the future (Koopman and Knuckey, 2014)

While most of the measures described above can be implemented with minor changes to management arrangements, it is noted that some measures may require consultation with the fishing industry and conservation organisations as well as require legislative amendments before they can be implemented. We recommend that fisheries agencies ensure that adequate data reporting on catches of CITES listed species is collected, to further inform future NDFs WTOs or State initiated reviews.

Summary of recommendations

Management measures to improve information and enhance the sustainable management of these species are required for fisheries that interact or are likely to interact with these species. These measures include:

- Species level reporting in log books
- Further measures to reduce incidental capture and post release mortality as practically appropriate to specific fisheries and gear types
- Landing of sharks with fins naturally attached
- Reporting of discards to species level
- Maximum size limits
- Trip limits
- An improved understanding and management focus on IUU

Any management change or data improvements should be practical, effective and efficient. Logbook data is currently improving markedly, and complex or impractical management changes that may compromise this are not recommended at this stage. In fisheries that have negligible interactions, simple changes that ensure species level reporting of all retained and discarded catches will contribute to information needed for future NDF requirements. It may be appropriate to institute additional practical management measures in fisheries with more significant impact on these species to improve sustainability. Table 3 lists the main fisheries that are likely to interact with the shark species in this NDF and the recommended management arrangements that could be implemented to improve the sustainability of shark catch. These are recommended management measures to arrive at sustainable outcomes for the fisheries. Management agencies may use other measures to arrive at the same outcomes.

Table 3. Summary of recommended improvements to the management and data requirements of each Australian fishery that has confirmed catches or interactions with any of the five listed shark species (Source: Koopman and Knuckey, 2014). ***N.B. Recommendations in this table are drawn from Rosser and Haywood (2002). Numbers here refer to a list of possible recommendations from Table 2 in the same document (ibid.). This table includes fisheries that may have changed name or ceased operating.***

WA – Kimberley gillnet and barramundi fishery (KGBF)	
Recommendations	2.10 An estimate of the annual IUU catch of Great Hammerhead, Scalloped Hammerhead and Ocean Whitetip Shark within the boundary of this fishery is required. 2.14 Implement trip limits for the five shark species of interest. 2.19 Provide facility to report discards in commercial logbook data. 2.20 Collect more recent observer data to describe species composition of the catch and discards. Ensure any catch of the five species of interest is reported at species level in the logbooks. 2.26 Implement trip limits for the five shark species of interest, as well as maximum size limits.
WA – Northern shark fishery (NSF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.14 Implement trigger limits for the five shark species of interest. 2.19 Remove generic shark references in logbooks and improve species identification in logbook data. 2.20 Collect more recent observer data to describe species composition..
WA – Pilbara fish trawl fishery (PFTF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.19 Allow for reporting of discarded shark in the logbooks and/or use observer program to estimate total annual discard of sharks of interest.
WA – Temperate demersal gillnet and demersal longline fisheries (TDGDLF)	
Recommendations	2.14 Implement trip limits for the five listed shark species. 2.19 Remove generic shark references in logbooks and provide facility to report discards in commercial logbooks. 2.20 Collect more recent observer data to describe species composition of the catch and quantify discards. Ensure any catch of the five species of interest is reported at species level in the logbooks. 2.26 Implement trip limits for the five listed shark species, and potentially implement maximum size limits to ensure stricter protection of a portion of the mature shark population.
NSW – Ocean Trawl Fishery (OTF)	
Recommendations	2.14 Implement trip limits for the listed shark species other than Scalloped and Great Hammerhead 2.19 Provide facility to report discards in commercial logbooks. 2.20 Collect more recent observer data to describe species composition of the catch and quantify discards. Ensure any catch of the five species of interest is reported at species level in the logbooks. 2.26 Implement trip limits for the listed shark species other Scalloped and Great Hammerhead, and potentially implement maximum size limits to ensure stricter protection of a portion of the mature shark population.
NSW – Ocean Hauling Fishery (OHF)	
Recommendations	2.14 Quotas are not appropriate for infrequently caught byproduct/ bycatch species, but trip limits or catch triggers could be implemented for the listed shark species other Scalloped and Great Hammerhead. 2.19 Provide facility to report discards in commercial logbooks. 2.20 Collect more recent observer data to describe species composition of the catch and quantify discards. Ensure any catch of the five species of interest is reported at species level in the logbooks. 2.26 Implement trip limits for the listed shark species other Scalloped and Great Hammerhead, and potentially implement maximum size limits to ensure stricter protection of a portion of the mature shark population.
NSW – Ocean Trap & Line Fishery (OTLF)	
Recommendations	2.14 There are reasonably strong controls on shark captures in this fishery. If they were to be strengthened at all, separate trip limits and maximum size limits for the listed shark species other Scalloped and Great Hammerhead could be introduced. 2.19 Provide facility to report discards in commercial logbooks.

Queensland – River and Inshore Beam Trawl Fishery (RIBTF)	
Recommendations	2.10 Estimate IUU catch 2.19 Provide facility to report discards in commercial logbooks. 2.20 Improve species identification of observers. Required estimation of weight in observer records.
Queensland – Gulf of Carpentaria Inshore Fin Fish Fishery (GOCIFFF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.14 Quotas are not appropriate for infrequently caught byproduct/ bycatch species, but trip limits or catch triggers for the five listed shark species could be implemented. 2.19 Provide facility to report discards in commercial logbooks. 2.20 Improve reporting of shark weight in observer records.
Queensland – Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (GCDFFTF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.20 Improve reporting of shark weight in observer records.
Queensland – Fin Fish (Stout Whiting) Trawl Fishery (FFTF) Gulf of Carpentaria Developmental Fin Fish Trawl Fishery	
Recommendations	2.19 Provide facility to report discards in commercial logbooks. 2.20 Improve reporting of shark weight in observer records.
Queensland – East Coast Spanish Mackerel Fishery (ECSMF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.14 Quotas are not appropriate for infrequently caught byproduct/ bycatch species, but trip limits or catch triggers for the five listed shark species could be implemented. 2.19 Provide facility to report shark species and discards in commercial logbooks.
Queensland – East Coast Otter Trawl Fishery (ECOTF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.19 Provide facility to report discards in commercial logbooks. 2.20 Improve reporting of shark weight in observer records
Queensland – East Coast Inshore Fin Fish Fishery (ECIFFF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.14 Implement trip limits for the listed shark species by licence with an S symbol. 2.19 Improve reporting to species level and provide facility to report discards in commercial logbooks. 2.20 Improve reporting of shark weight in observer records
Queensland – Coral Reef Fin Fish Fishery (CRFFF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.14 Quotas are not appropriate for infrequently caught byproduct/ bycatch species, but trip limits or catch triggers for the five listed shark species could be implemented. 2.19 Improve reporting to species level and provide facility to report discards in commercial logbooks. 2.20 Improve reporting of shark to species level and shark weight in observer records. 2.26 Implement trip limits for the listed shark species and potentially implement maximum size limits to ensure stricter protection of a portion of the mature shark population.
Northern Territory – Barramundi Fishery (BF)	
Recommendations	2.19 Improve reporting to species level in commercial logbooks and include discard weights. 2.20 Improve reporting of shark to species level and shark weight in observer records. 2.26 Potentially implement maximum size limit for Smooth Hammerhead, Oceanic Whitetip Shark or Porbeagle Shark. Required estimation of weight in observer records.
Northern Territory – Demersal Fishery (DF) – multi sector that now includes the original Finfish Trawl and Demersal Fisheries	
Recommendations	2.10 Estimate IUU catch 2.20 Improve reporting to species level in both logbooks and by observers.
Northern Territory – Offshore Net and Line Fishery (ONLF)	
Recommendations	Develop performance measures for Hammerheads. 2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery

	level. 2.14 and 2.18 Implement trip limits for the listed shark species 2.18 Require landing with of sharks with fins naturally attached 2.19 Remove generic group reference and improve reporting to species level in commercial logbooks. 2.20 Improve reporting of shark to species level and shark weight in observer records. 2.26 Implement trip limits for the listed shark species. and potentially implement maximum size limits to ensure stricter protection of a portion of the mature shark population.
Commonwealth – Western Tuna and Billfish Fishery (WTBF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.19 Only slight improve needed in reporting to species level in commercial logbooks. 2.20 Improve reporting of shark to species level and shark weight in observer records.
Commonwealth – Western Deepwater Trawl Fishery (WDTF)	
Recommendations	2.14 Implement trigger limits for the five shark species of interest. 2.26 Implement catch limits or trip limits for the listed shark species and potentially implement maximum size limits to ensure stricter protection of a portion of the mature shark population.
Commonwealth – North West Slope Trawl Fishery (NWSTF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.14 Implement trigger limits for the five shark species of interest. 2.20 Improve reporting of shark to species level in observer records. 2.26 Implement catch limits or trip limits for the listed shark species and potentially implement maximum size limits to ensure stricter protection of a portion of the mature shark population.
Commonwealth – Torres Strait Prawn Fishery (TSPF)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.20 Improve reporting of shark to species level in observer records, and require reporting of discards of sharks in commercial logbooks.
Commonwealth – Southern and Eastern Scalefish and Shark Fishery (multiple sectors)	
Recommendations	2.14 Implement catch or trip limits for the five shark species of interest. 2.20 Improve reporting of shark to species level in observer records. Check on the correct identification of shark species in commercial logbook data 2.26 Implement catch limits or trip limits for the listed shark species and potentially implement maximum size limits to ensure stricter protection of a portion of the mature shark population.
Commonwealth – Northern Prawn Fishery	
Recommendations	2.10 An estimate of the annual IUU catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but may require a specific project to identify species (mostly by fins) on seized vessels. 2.20 Improve reporting of shark to species level in observer records, and require reporting of discards of sharks in commercial logbooks.
Commonwealth – Eastern Tuna and Billfish Fishery	
Recommendations	2.20 Improve reporting of hammerhead shark to species level in observer records.
Commonwealth – Coral Sea (multi-sector)	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. This was done across all of northern Australia (Marshall 2011) but needs to be disaggregated to fishery level. 2.14 Quotas are not appropriate for infrequently caught byproduct/ bycatch species, but trip limits or catch triggers for the five listed shark species could be implemented. 2.20 Observer data on retained and discarded shark species should be identified down the species level. Commercial logbook data is generally identified to species level for hammerheads but whalers and weasel sharks are often grouped but any Oceanic Whitetip Sharks should be specifically identified (there was none apparent in the observer data). 2.26 A maximum size limit could be implemented to ensure stricter protection of a portion of the mature population.
Commonwealth – Australian High Seas Fisheries	
Recommendations	2.10 An estimate of the annual catch of each of the five species of interest by IUU fishing is required. 2.14 Quotas are not appropriate for infrequently caught byproduct/ bycatch species, but trip limits or catch triggers for the five listed shark species could be implemented. 2.26 A maximum size limit could be implemented for the non-trawl sector to ensure stricter protection of a portion of the mature population.
South Australia – Marine Scalefish Fishery (MSF)	
Recommendations	2.14 Quotas are not appropriate for infrequently caught byproduct/ bycatch species, but trip limits or catch triggers for Smooth Hammerhead and Porbeagle Shark could be implemented.

	2.19 Improve reporting of sharks to species level in commercial logbooks and record any discards. 2.26 A maximum size limit could be implemented to ensure stricter protection of a portion of the mature population.
Victorian – Ocean Access Fishery (OAF)	
Recommendations	2.14 Quotas are not appropriate for infrequently caught byproduct/ bycatch species, but trip limits or catch triggers for Smooth Hammerhead and Porbeagle Shark could be implemented. 2.19 Improve identification of shark catches in commercial logbooks. 2.20 An observer program should be implemented and data on retained and discarded shark species should be identified down the species level. 2.26 A maximum size limit could be implemented to ensure stricter protection of a portion of the mature shark population.
Tasmanian – Scalefish Fishery (SF)	
Recommendations	2.19 Improve identification of shark catches in commercial logbooks. 2.20 An observer program should be implemented and data on retained and discarded shark species should be identified down the species level. 2.26 A maximum size limit could be implemented to ensure stricter protection of a portion of the mature shark population.

Conclusions: NDF harvest levels

Scalloped hammerhead

On the basis of the information available on the population of *S. lewini* within Australian waters and within the Oceania region, and the threats posed to the species, the CITES Scientific Authority of Australia has found that current levels of catch for *S. lewini* are unlikely to be detrimental to the species. The current catch level accepted as non detrimental to *S. lewini* is **200 tonnes per year** for Australian fisheries. This conclusion is arrived at on the basis of: *S. lewini* being listed as endangered under the NSW *Fisheries Management Act 1994* which restricts the capture of this species, management arrangements in place in all fisheries to protect sharks in general, the Western Australian Northern Shark Fishery currently being closed, a marked decrease in shark fishing in northern Western Australia over the past 5-8 years and evidence of other more heavily exploited species of sharks in northern Australia (*Carcharhinus tilstoni* and *C. sorrah*) showing positive signs of recovery since being heavily fished by the Taiwanese gillnet fishery in the 1970's and 1980's (Bradshaw *et al.,* 2013; Field *et al.,* 2012). This research may also suggest a recovery of *S. lewini* in the same area.

Great hammerhead

On the basis of the information available on the population of *S. mokarran* within Australian waters and within the Oceania region, and the threats posed to the species, the CITES Scientific Authority of Australia has found that current levels of catch of *S. mokarran* is unlikely to be detrimental to the species. The current catch level accepted as non detrimental to *S. mokarran* is 100 tonnes per year. This conclusion is arrived at on the basis of: *S. mokarran* being listed as vulnerable under the NSW Fisheries Management Act 1994 which restricts the capture of this species, management arrangements in place in all fisheries to protect sharks in general, the Western Australian Northern

Shark Fishery being closed and that recent research by Bradshaw et al., 2013 and Field et al., 2012 suggesting some level of recovery of *S. mokarran* in northern Australian waters since Taiwanese gillnet fishing ceased in the mid 1980's.

Smooth hammerhead

On the basis of the information available on the population of *S. zygaena* within Australian waters and within the Oceania region, and the threats posed to the species, the CITES Scientific Authority of Australia has found that current levels of catch of *S. zygaena* is unlikely to be detrimental to the species. The current catch level accepted as non detrimental to *S. zygaena* is **70 tonnes per year**. This conclusion is arrived at on the basis that currently there are no indications to suggest that the population is at a level where the current harvest would be detrimental to the species (Simpfendorfer, 2014).

Hammerheads – general comments

It should be noted that the positive NDF findings for the three hammerhead species are subject to:

- no further increase in the average annual catch of the species
- there is no carryover of catch levels from year to year, and
- Australian State and Commonwealth management agencies seeking to implement improved management arrangements (see **Recommendations for Management** above) to minimise the ongoing catch of these species.

As the catch of *S. lewini* and *S. mokarran* in the Commonwealth tropical tuna fisheries is mostly taken in the high seas area of those fisheries, due to the distribution of these populations, the minimal catch by these fisheries and the close proximity to the AFZ where these fisheries operate, it is likely these catches are taken from the same stock that inhabits Australian waters, therefore this NDF has taken into account these catches and they have been included in the above catch levels.

Porbeagle sharks

A positive NDF could be made for the porbeagle shark where there is limited interaction as implemented under current management practices where live specimens caught are returned with as little harm as possible. However, all species listed under Part 13 of the EPBC Act, including porbeagle shark, are excluded from approved wildlife trade operation declarations for Australian commercial fisheries. Hence, the current situation, whereby legal export of porbeagle shark from Australian commercial fisheries is not possible, remains unchanged. Harvest for domestic purposes, up to historical levels of 2.5 t per year, is considered unlikely to be detrimental to the species (Simpfendorfer, 2014)

Oceanic whitetip sharks

On the basis of the information available on the population of *C. longimanus* within Australian waters and within the Oceania region, and the threats posed to the species, the CITES Scientific Authority of Australia has found that any catch of *C. longimanus* is likely to be detrimental to the species. Therefore, no NDF can be made for this species at this time. This conclusion is arrived at on the basis of assessments by the WCPFC and IOTC indicating the species is currently overfished and overfishing is continuing (Simpfendorfer, 2014).

Management and review of harvest levels

The harvest levels detailed in this NDF are developed on the available harvest information and a precautionary approach has been taken to set these levels. However, levels can be reviewed if new information becomes available from trade and fishery data, ecological risk assessments or potential research projects. The sustainable harvest levels will be managed by State and Territory fishery agencies and improvements over time in the management arrangements will be incorporated as part of the ongoing export approval process.

Therefore, the CITES Scientific Authority of Australia has taken a precautionary approach and considers the short term annual harvest levels contained in this NDF to be sustainable. If further information of individual species abundance, distribution and harvest becomes available harvest levels of these species can be reassessed.

Introduction from the Sea

The close proximity of the Australian tropical tuna fisheries to the AFZ, the minimal catch of hammerheads and *L. nasus* and the distribution of hammerhead and *L. nasus* populations allows for these species to be introduced into Australia from the high seas via an IFS certificate. However, a positive NDF for the Australian High Seas Fishery that operates further from the Australian economic zone was not possible. Due to the lack of information required to underpin a robust NDF, including stock assessments, trends, conservation management measures and harvests by other Parties, the Australian CITES Scientific Authority was unable to determine sustainable harvest levels for any catch of the listed shark species taken in the high seas outside of the Australian tropical tuna fisheries.

Note: Catches of hammerheads and *L. nasus* on the high seas are bycatch only under current management practices and not targeted specifically.

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