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Application by Oceanis Pty. Ltd. to amend the list to include Grey Nurse Shark for live import.

Terms of Reference for the Impact of Importing Grey Nurse Shark

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Terms of Reference for the Impact of Importing Grey Nurse Shark

Chapter 1. Summary of proposed activity.

Grey Nurse Sharks *Carcharias taurus* (Rafinsque, 1810) have been captured and held in aquariums worldwide since the late 1800's. There are reports that the New York Aquarium held a "sand tiger" (*C. taurus*) for many years (32years) between 1896 and 1928 (Koob, 1997). Since this time the Grey nurse shark has remained a popular aquarium shark, well suited to the managed environment. They survive very well in captivity (Govender *et al.*, 1991) and as in the case of the New York Aquarium; they can live for more than 31 years in captivity (Mohan, 2001) which is close to the maximum wild lifespan of 30 to 40 years (Goldman 2002) for them.

Oceanis's purpose to importing Grey Nurse Sharks is for educational public display as well as to assist the current dwindling numbers of captive Grey Nurse Shark held in their aquaria. Wild populations are protected off Australian waters and no animals can be collected. East coast Grey nurse shark populations of Australia are currently listed as critically endangered under the Environment Protection and Biodiversity Conservation Act of 1999. Oceanis Pty, Ltd. Consists of two large public Aquaria in Australia namely Melbourne Aquarium and Underwater World – Sunshine Coast. Oceanis Australia Pty. Ltd. currently also has aquaria in Thailand, South Korea and China.

Public Aquariums have provided public the best means to identify with this species to aid in education, conservation and protection. To lose this species from Australian public aquariums will have a negative effect on public awareness to identify with their plight. All imported Grey nurse shark will be recorded with the Australasian Regional Association of Zoos, Parks and Aquaria's (ARAZPA) Australian Species Management Program (ASMP) species co-ordinator. It is envisaged that all Grey Nurse shark will fall under a managed captive population program.

With current husbandry research in aquaria in Australia, significant steps are underway to fully understanding captive reproduction and to developing techniques to promote this. Importing grey nurse sharks will aid in further developments in captive reproduction techniques.

Oceanis Pty, Ltd. would like to import a total number of 12 Grey nurse shark (8 females and 4 males) into Australia to use in both Melbourne Aquarium and Underwater World – Sunshine Coast.

Grey nurse sharks will be obtained from other public Aquaria such as Siam Oceanworld (Bangkok, Thailand) and Busan Aquarium (South Korea) which also belongs to Oceanis Pty. Ltd aquariums group. Were possible captive bred animals will be sought in favour of wild caught but at this stage none are available. Table below outlines the contacts and addresses for source of Grey nurse sharks.

Table 1: List of contacts for Aquariums to obtain sharks from.

Aquarium	Name:	Position:	Email:	Phone:	Address:
Oceanis Group	Jeff Archer	Group Curator	jarcher@oceanisgroup.net	ph +971 50 640 5627	Oceanis Head Office, Flinders Street, Melbourne, Australia
Dubai Aquarium	Paul Hamilton	Curator	Mcustudio@emaar.ae	Ph +971507881372	Dubai Aquarium, Dubai Mall, Burj Dubai, Dubai, UAE
Shanghai Chang Feng Ocean World	Hunter Chen	Curator of Fishes	hunter@oceanworld.com	Ph +8613916359866	Shanghai Cheng Feng Ocean World, #839 Zao Yang Road, Pu Tuo District, Shanghai
Siam Ocean World (Bangkok)	Ross Werner	Curator	rwerner@siamoceanworld.com	Ph: +66 84 088 1608	Siam Oceanworld, B1-B2 Siam Paragon, Rama 1, Pathumwan, Bangkok
Busan Aquarium	Jini Kim	Head Curator	kim@busanaquarium.com	Ph +82-51-740-1736	Busan Aquarium, #1411-4, Jung 1-dong, Haeundae-gu, Busan, SOUTH KOREA (612-846)

Chapter 2. Transportation, housing and disposition.

a. Transportation

Grey nurse sharks have been transported globally by land, sea and air for many decades and are common and accepted practises within public aquariums and associated organisations. A variety of acceptable methods exist to transport Grey nurse sharks depending upon size and distance that they have to be transported.

Any method used must take into account the following water parameters:

a. Temperature
b. pH
c. particulates and organics
d. Nitrogenous wastes
e. Oxygen

These methods are outlined in the Elasmobranch Husbandry manual. For grey nurse shark the following methods of transport have been used successfully: sealed bag and box, free swimming and the restrained method particularly if the animal is large (Smith et al., 2004). One of these methods where appropriate will be used for transportation of Grey nurse shark if the application to import were successful.

Once the animal reaches the destination it will have to acclimatise and be allowed to recover. This is usually done by replacing the transport water with that of the quarantine facility water. Once healthy the shark can be given prophylactic treatments such as antihelminthic baths and antibiotic injections. Any facility importing grey nurse shark must have quarantine facilities large enough to support such an animal. The Elasmobranch Husbandry Manual outlines requirements for sizes of quarantine and temporary holding areas. Any imported grey nurse sharks will have to undergo the quarantine periods and procedures as stipulated by Biosecurity Australia.

b. Housing

There are currently no Australian or international standards for the containment and management of Grey nurse sharks. Best practise can be obtained through the Elasmobranch Husbandry Manual by Smith et al. 2004. Grey nurse sharks are usually kept in large public aquarium facilities and require a certain minimum number of parameters to thrive. These parameters are:

a. Spatial requirements
b. Depth
c. Water current and flow
d. Water quality
e. Water temperature

Grey nurse shark are pelagic non-obligate ram ventilators which basically means that they do not have to continuously swim to obtain oxygen through their gills. They can remain motionless and actively pump water through their gills. This means that they can thrive in smaller exhibits and have been kept successfully in tanks with volumes of 400 000l and upwards. These exhibits are usually over 2m in depth and

rectangular, circular or oval in shape (Smith et al., 2004). Majority of exhibits today are in excess of 2 million litres. Both Melbourne Aquarium and Underwater World – Sunshine Coast are over 2.2 million litres in volume and over 3m in depth.

In Australia there are currently five public aquaria that keep Grey nurse shark in their collections (*Fischer). They are AQWA, Manley OceanWorld, Melbourne Aquarium, Sydney Aquarium and Underwater World – Sunshine Coast (*Fischer). In all these aquaria there is a mix of sexes usually with a ratio of more females to males. The best practise is to ensure a higher ratio of females to males. During mating season females can be mated with very vigorously which usually always results in many mating scars (pers. obser.). Having too many males can result in severe mating injury to the females. The recommendation is therefore to ensure more females to males to alleviate mating pressure amongst the other females.

Table 2. Holdings of Grey Nurse Shark in Australian Aquaria up to January 2007 (Data from the ARAZPA Grey nurse shark studbook). *data through pers. comm.

	Current Holdings (01-01-2007)		
Institution	**Male**	**Female**	**Unknown**
*AQWA	1	5	0
Manley OceanWorld	4	5	1
Melbourne Aquarium	1	2	0
Sydney Aquarium	2	3	0
Underwater World	3	2	0
TOTAL	**11**	**17**	**1**

Although no standards exist for this species in Aquaria in Australia and the rest of the world, suitable exhibits for this species must include gentle currents and long stretches of open areas between artificial reefs/rocks (Smith et al., 2004) in which they can glide or swim in. Exhibits must be wide enough for gradual turns and low interference in glide patterns. Each Aquarium follow their own individual standards based on best practise.

There exist two main methods for the acquiring and filtering of seawater in large public aquaria.

a. In semi open system seawater is pumped in from the ocean and usually undergoes some treatment for sterilisation and filtration. Excess water is then usually returned back into the ocean through overflow grids or by backwashing.
b. In a closed system the entire aquarium is reliant on a recirculation system that undergoes extensive sterilisation and filtration. Seawater may be artificially

made up or brought in by truck to ensure a certain percentage of new seawater is topped up.

In either case, sharks such as the Grey nurse cannot physically escape from these systems. As they give birth to live young only (90cm to 120cm) and do not release eggs it is not physically possible for offspring to be accidently released.

Grey nurse shark can survive a very broad range of temperatures and have been kept successfully in temperatures varying from 12^{O}C to 29^{O}C (personal recorded observation as a former Curator and over1o years of Aquarium industry experience).

Water quality parameters are listed in more detail in table 2 below.

Table 3: Recommended basic water quality parameters for sharks (adapted from the Elasmobranch husbandry manual, 2004).

Parameter	Range	Units
Salinity	25.0 – 35.0	$^{0}/_{00}$
pH	7.7 – 8.4	
DO (Dissolved oxygen)	85 - 98	% saturation
ORP	250 – 380	mV
Ammonia	<0.3	mg/l
Nitrites	<0.1	mg/l
Nitrates (as nitrate nitrogen)	<70	mg/l
Total coliform	<1000	CFU/100ml

c. Disposition

Neither imported Grey nurse sharks nor their progeny will leave the public aquaria except with consent of state or commonwealth authorities. It is however acceptable to relocate excess specimens for captive management and in consideration with the ARAZPA ASMP.

Any deceased Grey nurse shark would be kept frozen and held for disposition under direction of AQIS and state authorities. It would be anticipated that specimens and parts would be made available for research through Universities as required.

Chapter 3. Taxonomy

Class: Chondrichthyes (Cartilaginous fishes)

Order: Lamniformes (Mackeral shark)

Family: Odontaspididae

Genus: *Carcharias*

Species: *taurus* (Rafinsque, 1810)

Common Names: Grey Nurse Shark (Australia), Spotted Ragged Tooth Shark (South Africa), Sand Tiger Shark (United States of America and Europe).

Carcharias taurus (Rafinsque, 1810) is one of only four species of the family Odontaspididae.

Although it is the same species (no sub species either) in all the listed countries above, there exists between populations of South Africa, Western Australia and the East coast of Australia a difference in the amount of genetic variation between the populations (Stow et al., 2006). There is also no immigration in Australian grey nurse shark and there is also no movement between East and Western Australian grey nurse shark. South African grey nurse shark showed the most genetic variation where as the East coast Australian grey nurse shark showed the least (Stow et al., 2006). The isolation of Australian grey nurse shark has implications for conservation management of this species since there is no replenishment between the critically endangered East coast and vulnerable west coast populations and is unlikely to be achieved by natural migration from more numerous populations (of higher genetic variation) elsewhere (Stow et .al., 2006). It is said therefore that current declines in East coast grey nurse shark numbers and negligible migration between Australian populations and South African populations, extinction will be imminent in East Coast Australia populations (Stow et. al., 2006).

Chapter 4. Cites Status

IUCN Status: Vulnerable (VU) (A1ab+2d), 30-Jun-2000

CITES Listing: **Not Listed**

Other relevant listings:

Mediterranean:

Possible extinction (Fergusson et al. 2002).

East Coast of North America:

Declining (Musick et. al. 2000).

East Coast of South America:

Critically Endangered (Dicken, 2006).

South Africa:

Near threatened (Dicken, 2006)

East Asian Coast:

No reliable records (Dicken, 2006).

Australian Commonwealth:

East coast population - Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999.*

West Coast population – Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999.*

State:

NSW: Endangered (NSW Fisheries Management Act 1994)
QLD: Endangered (Nature Conservation Act 1992)
QLD: Protected (Fisheries Act 1994)
VIC: Protected (Fisheries Act 1995)
VIC: Threatened (Flora and Fauna Guarantee Act 1988)
TAS: Protected (Fisheries Regulations 1996)
WA: Protected (Wildlife Conservation Act 1950)

Chapter 5. Ecology of the Grey nurse shark

a. Natural Geographic Range

Carcharias taurus (Rafinsque, 1810) is a wide-ranging species in warm-temperate and tropical coastal waters of the Atlantic Ocean, Mediterranean Sea and Indo-West Pacific Ocean. It is found in and around sandy or boulder filled gutters and caves around rocky reefs in coastal waters. It is absent from the Central Pacific and Eastern Pacific Oceans (Dickens 2006).

Off Australia they are known on the east coast of Australia as well as off the Western coast of Australia in temperate and sub tropical waters (Last & Stevens 1994).

It is absent all along the west coast of North and South America.

b. Habitat requirements

Grey nurse shark are a marine (saltwater) species known to inhabit the continental shelf down to depths of 190 m, but is most commonly found at depths between 10m and 40m in sandy-bottomed gutters or gullies, and in rocky caves in the vicinity of inshore reefs and islands (Otway and Parker 2000, Compagno 2001, Smale 2002).

Being a marine species, water quality parameters for Grey nurse shark are no different to marine bony fish species. With a few notable differences sharks are more sensitive to therapeutic copper, organophosphates, and low salinity (Smith et al., 2004).

c. Diet

Grey nurse shark are regarded as opportunistic feeders, consuming a wide variety of bony fish as well as smaller shark and ray species. They also occasionally consume invertebrates such as squid, crabs and lobsters (Bass *et al.* 1975, Compagno 2001, Smale 2005) and are considered to be ambush predators. Observations also suggest that this species feeds co-operatively by forming packs and concentrating prey prior to attack (Ireland 1984, Smale 2005).

In South African waters, Grey nurse sharks feed on a wide range of bony fish including: herrings (Family Clupeidae), croakers (Family Sciaenidae), bluefishes (Family Pomatomidae), mackerels (Family Scombridae), butterfishes (Family Odacidae), snappers (Family Lutjanidae), eels (Family Muraenidae), wrasses (Family Labridae), mullets (Family Mugilidae), sea basses (Family Serranidae), flatfishes

(Families Platycephalidae & Bothidae), jacks (Family Carangidae), and likely many others, as well as small and juvenile sharks (especially those of the Families Carcharhinidae and Triakidae), eagle rays (Family Myliobatidae), squid and, on rare occasions, crabs and lobsters (Bass et al. 1975).

In Australian waters, it is likely that the diet consists of pilchards, jewfish, tailor, bonito, morays, blue groper, sea mullet, flatheads, yellowtail kingfish, small and juvenile sharks, squid and possibly some crustaceans (Last and Stevens 1994, Otway and Parker 1999). This will need to be verified by gut content analysis of incidentally caught and killed grey nurse sharks. It is important to note that many of the species that comprise the sharks' diet are also harvested by commercial and recreational fishers.

d. Behaviour

Grey nurse shark are a pelagic non-obligatory ram ventilators. This enables them to remain motionless in the water while actively pumping water over their gills. Whilst gliding or active swimming they can switch to ram ventilation reducing energy required for respiration. Grey nurse sharks are able to maintain neutral buoyancy by swallowing air at the surface and holding it in their stomachs (Bass 1972), and are often found hovering motionless just above the seabed either alone or in groups of up to eighty individuals.

Grey nurse sharks are a migratory species that can travel large distances for breeding and pupping. This has been well documented in South Africa (Dickens 2006). Females and males congregate during spring off warmer waters and will actively mate. Once pregnant, females migrate thousands of kilometres to cooler waters in which they will give birth to pups the following spring.

As the Grey nurse shark is primarily a fish eater and has teeth adapted to catch and hold fish it will not attack humans unprovoked (Lane, King and O' Hearn 2006). To date there is no substantiated evidence that grey nurse sharks have attacked unprovoked and in many cases where this was thought so, may have been mistaken identification.

Chapter 6. Reproductive biology

Grey nurse shark have distinct sexes with female Grey nurse shark being ovoviviparous with no placental connection. Juveniles exhibit intra-uterine

cannibalism as well as developing embryos obtaining nutrition through oophagy (Dicken 2006).

Sexes are easy to distinguish with males possessing a pair of claspers joined onto the base of the anal fins. These are absent in females and is used for sexual reproduction.

Grey Nurse sharks mature at around 6 to 9 years (190cm to 230cm in length) however there is variation in maturity in age between sexes, lengths as well as geographical populations (Dicken 2006). Females usually mature at a later age than males and are usually larger than as well (Dicken 2006).

Females produce two pups every two years only. However according to Gilmore (1993) and Gordon (1993) they hypothesised that *C. taurus* reproduces annually whereas Bransetter and Musick (1994) presented evidence supporting a two-year reproductive cycle with a resting stage in between. The latter has been confirmed to date with females at UnderWater World – Sunshine Coast. Juvenile Grey Nurse Shark show evidence of cyclic annual movement to and from summer nursery areas and adults have far more extensive migratory movements associated primarily with reproduction (Dicken 2006).

Females move to temperate water (12^{O}C to 18 ^{O}C) for pupping and usually migrate to sub tropical waters (18^{O}C to 25^{O}C) after this for mating. Water temperature seems to play a vital role in triggering mating behaviour and it is the change from cold to warm during seasonal changes (spring) and or migration to warmer waters that sparks mating behaviour. Adults seem to live for 30 to 40 years (Goldman 2002) and can reach a size of 320cm and weigh just over 200kg.

They have very low, minimum population doubling time more than 14 years (Fec=2; K=0.14-0.17; T_{max}=17) in the wild (http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=747&genusname=Carcharias&speciesname=taurus

Reproductive cycle:	In southern hemisphere peak breeding season is September, October or November. In northern hemisphere this is in March, April or May. Strong correlation to temperature and season.
Sexual maturity:	Mature at around 6 to 9 years (190cm to 230cm in total length)
Gestation Period:	9 to 12 months.
Social Structure:	Mixed in captivity. Complex migratory patterns in the wild (Dicken 2006).

Mating behaviour	Males highly aggressive and females submissive.
Litter:	2 pups every two years (live birth).
Size at birth:	90cm to 120cm

Grey nurse shark breeding has been observed in captivity with a small number of aquariums around the world having had pups born (Marineland - Florida; SeaWorld – Orlando). It cannot be confirmed however if actual conception occurred within the aquarium for these.

Majority of pups however have been still born or short lived and only three aquariums SeaWorld – Durban in South Africa and Underwater World – Sunshine Coast and Manly Oceanworld in Australia, have had live born pups that have grown and stayed alive. Conception in these instances occurred within the aquariums. Sex ratios of those Aquariums that have had success showed some similar ratios (with the exception of Seaworld – Durban which had a ratio of 1:1) with ratios of 3 males to 4 females.

In Australia Grey nurse shark holdings are all voluntarily submitted to the Australian species management program (ASMP) of the Australasian Regional Association of Zoos, Parks and Aquaria (ARAZPA) and fall under a voluntary regional studbook. This studbook is managed under the Aquatic TAG (Taxon Advisory Group) of ARAZPA. All data on animals that will be imported will be given to the regional studbook.

Hybridisation, (the interbreeding of individuals from genetically distinct taxa (Allendorf et al., 2001)), is defined as the act of mixing different species or varieties of animals or plants and thus to produce hybrids. For animals, only the rank of subspecies is officially regulated by the Zoological Code (ICZN). There is no subspecies for Grey nurse shark. To date no hybridisation has occurred between this species and any other species in the wild and in captivity. As the reproductive method is fairly unique to this species it is very unlikely that this will occur.

Intraspecific hybridisation can occur between imported and Australian grey nurse sharks but can be a controlled practise in captivity where parents and progeny will be added to the ARAZPA ASMP studbook.

Chapter 7. Establishment of feral populations

There are no known feral populations of Grey nurse sharks. This species occurs naturally in warm-temperate and tropical waters around continental land masses and appears only to be absent on the eastern Pacific Ocean off North and South America (Dicken 2006).

As this species occurs naturally in areas as listed above and as there is no sub species of grey nurse shark, there must have in geological times, been periods when this species was able to migrate between various global regions. Due to climatic and ocean current variability populations have become isolated to some extent. This is evident in the East Coast Australian grey nurse sharks which show very low genetic variation (Stow et al., 2006) in comparison to the South African populations. This is due to the population being isolated for a much longer period and in-breeding within a smaller population size. In any case the question would be whether a grey nurse shark brought in and released could be considered as feral seeing that it does occur here naturally? If conditions become right there could be natural migration occurring as it has in the past. Although it is not in the realms of this import application, it can be argued that bringing in and releasing grey nurse shark with greater genetic variation will aid the dwindling East coast Australian populations by increasing genetic variability.

If correct conditions are met as in Chapter 10 then yes imported Grey nurse shark could mingle and breed with Australian grey nurse shark. There are no plans in this application to pursue or recommend the release of imported GNS into the wild environment. It will not be possible for accidental release to occur due to the size nature and logistics of moving live sharks and containment standards of Australian public aquaria.

Chapter 8. Results of any other previous risk assessments

There have to the best of our knowledge, been no previous risk assessments done on this species or any other shark species in general.

Chapter 9. Legislative controls of this species

This species is controlled in each state under the listed table below as well as there exists two distinct populations which are listed under the Australia commonwealth below.

Australian Commonwealth:

East coast population - Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999.*

West Coast population – Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999.*

State:

NSW: Endangered (NSW Fisheries Management Act 1994)
QLD: Endangered (Nature Conservation Act 1992)
QLD: Protected (Fisheries Act 1994)
VIC: Protected (Fisheries Act 1995)
VIC: Threatened (Flora and Fauna Guarantee Act 1988)
TAS: Protected (Fisheries Regulations 1996)
WA: Protected (Wildlife Conservation Act 1950)

Chapter 10. Factors affecting the potential to establish and become a pest

a. Likelihood of release

Although physical barriers cannot alone be proof against release from natural disasters, vandalism, terrorism, civil war/unrest or wilful release (Bomford 2003). It is extremely unlikely that Grey nurse shark can escape from their holding facility or exhibit. Unlike a terrestrial species grey nurse shark cannot escape and Exhibits and holding facilities in large public aquaria usually consist of two types which refer to how they obtain or recycle the seawater.

c. In semi open system seawater is pumped in from the ocean and usually undergoes some treatment for sterilisation and filtration. Excess water is then usually returned back into the ocean.
d. In a closed system the entire aquarium is reliant on a recirculation system that undergoes extensive sterilisation and filtration. Seawater may be artificially made up or brought in by truck to ensure a certain percentage of new seawater is topped up.

In either case, sharks such as the Grey nurse cannot physically escape from these systems. As they give birth to live young (90cm to 120cm) and do not release eggs it is not possible for escape of fertile eggs.

It is also extremely unlikely that a Grey nurse shark can be stolen and released as the requirements for catching out and placing into a transport container makes it unfeasible. Moving live sharks is a skill intensive, labour intensive, time intensive and monetary intensive operation. Public aquariums are also extremely secure sites so this too would eliminate any risk.

The only instance a Grey nurse shark would be able to find its way into the wild would be through an unlawful release from the aquarium by its operators. This too would be extremely unlikely due to the high cost of purchasing and transporting this species.

In the event of natural disasters and the even that a public aquarium is destroyed the outcome would usually lead to the death of the species. This is due to the fact that if water was to escape from the exhibit the sharks would succumb.

b. Likelihood of establishment

It must be noted that Grey nurse shark already occur off Australian water naturally and therefore has habitats already suited to them.

There are a number of factors that will determine whether a species will succeed in establishing a free living population. It is usually a combination and not necessarily individual factors that will lead to feral populations becoming established. These are (Bomford 2003):

1. Introduction effort:
   The more grey nurse shark released at different times and places the greater the chance of successful establishment.
2. Climate match:
   For feral populations to occur they must be released in areas that have very similar climates as those where they occur naturally. In the case of the grey nurse shark the areas that already have grey nurse shark would be a climate match. On the East Coast from North East Victorian coastline to Southern Queensland (Last & Stevens 1994) and on the West Coast of Australia from Augusta to Exmouth (Last & Stevens 1994).
3. Overseas geographic range: As this species is very widespread geographically and occurs in nearly all the major oceans it will establish in regions as listed in climate match. However Grey nurse shark do not have a limited known range and are not known to be endemic to a specific area (Carlson et al 2009).
4. History of establishing exotic populations elsewhere:
   There is no history of establishing exotic populations for this species.
5. Taxonomic group:

Certain taxonomic groups such as mammals generally have double the success rate than birds for establishing exotic populations. This would require a more conservative approach to the import and keeping of mammals.
As Grey nurse shark have an extremely low reproductive rate and population doubling time it must be assumed that establishment risk would be low.

6. Body mass:
   Body mass can only be used to compare related species introduced in similar circumstances and is if no significance to Grey nurse shark.
7. Rate of population increase:
   Grey nurse shark have a very low, minimum population doubling time of more than 14 years (Fec=2; K=0.14-0.17; T_{max}=17) in the wild (http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=747&genusname=Carcharias&speciesname=taurus. This is due to the low numbers of pups produced and the ability for females to produce only two pups every two years (Bransetter and Musick 1994) as well as the only achieving maturity at around 6 to 9 years (Dicken 2006). Because of the low number of pups produced per season therefore this variable can be considered a low risk.
8. Migratory behaviour:
   It has been found that non-migratory behaviour is a significant predictor of establishment success for birds and mammals in New Zealand and Australia (Bomford 2003). Grey nurse shark are a migratory species moving seasonally for reproductive purposes (Dicken 2006).
9. Diet:
   A generalist diet increases the probability of establishment success (Bomford 2003) and as Grey nurse shark have a generalist diet this variable could be considered as a possible risk to establishment success.
10. Ability to live in human disturbed habitats:
    Many ecologists consider an ability to live in human disturbed habitats increases the probability of establishment, and because most successful established exotic vertebrates are human commensals (Bomford 2003). Grey nurse shark occur only in non human disturbed habitats in the ocean.
11. Source of animals:
    In general wild caught animals are more successful at establishing wild populations than their captive counterpart. It is therefore desirable to restrict the import of wild caught animals if possible (Bomford 2003). To date however there is no captive bred Grey nurse shark available and all available Grey nurse shark originated from the wild.

12. Suitable site:
    If Grey nurse sharks are released near a habitat that meets their physiological and ecological needs then there would be a risk of establishment under this variable. Low occurrences of predators, parasites, disease or competitors are often suggested to favour establishment (Bomford 2003).
13. Timing of release:
    If Grey nurse shark are released when environmental conditions are favourable to survival and breeding then there may be an increase in probability to establishment. As they occur naturally off Australia on the east coast as well as off the Western coast in temperate and sub tropical waters (Last & Stevens 1994) then it must be assumed that conditions are favourable for the risk of establishment under this variable.
14. Genotypic and phenotypic variability and behavioural flexibility:
    Williamson (1996) suggests that genetics currently have little to offer for the prediction of likelihood of establishment (Bomford 2003).
15. Flocking or herding:
    According to Bomford (2003) flocking or herding behaviour probably has little value for predicting establishment success.
16. Dispersal ability:
17. According to Bomford (2003) based on current evidence, dispersal behaviour has little value for predicting establishment success.
18. Fertilised female able to colonise alone:
    Due to lack of evidence to support this theory and lack of ecological knowledge about species under this variable it is unlikely to be used for managing risk for new species establishing (Bomford 2003).
19. Individuals age and health:
    Given that releases of Grey nurse shark are likely to be unintentional, managers are likely to have little opportunity to affect age or health of released animals and therefore these variables are unlikely to be of use in managing the risk of establishment in this species (Bomford 2003).
20. Public and government attitude and actions:
    It is uncertain if dedicated assistance can help to establish populations. Attempts to capture or destroy released animals and their progeny can help reduce chances of establishment.

However, as this species is already a natural native to Australian waters and occurs naturally on the East coast and West Coast of Australia, if released into suitable sites it may be likely that they will establish with native Grey nurse shark (if some of the above factors can be met). Should Grey nurse shark be released into the wild their impact should be no greater than that of the current declining natural population.

Chapter 11. Impact Assessment

Grey nurse shark is a species that occurs throughout the world including Australia from the continental shelf down to depths of 190 m. Grey nurse shark are predominantly a fish and invertebrate feeding species and in the extreme unlikely event that a Grey nurse shark had to escape into the wild, it would be expected that they would consume the same species of fish and invertebrates as native Grey Nurse shark. This would include but not be limited to pilchards, jewfish, tailor, bonito, morays, blue groper, sea mullet, flatheads, yellowtail kingfish, small and juvenile sharks, squid and possibly some crabs and lobsters (Bass et al. 1975, Gray & Otway 1994, Otway et al. 1996).

Although the Grey nurse shark is a large species growing to over 3.2m in length, contrary to many beliefs is not an aggressive 'man-eater'(Lane, King and O' Hearn 2006). It is generally slow-moving and timid unless provoked and its teeth are adapted to feed on fish and smaller items of prey.

a. Disease

Grey nurse shark would be expected to suffer from and potentially carry a number of the ubiquitous disease agents that effect fish around the world. These include parasites such as parasitic Copepods (Oldewage and Smale 1993) and marine leeches (Solo 2003). As these disease agents already occur in Australian waters there should be no major impact as what there is already.

In a preliminary literature search we were not able to identify any specific disease agent concerns associated with the importation of Grey nurse shark that could not be covered by the existing conditions for live fish importation.

All imported Grey nurse sharks must go through strict quarantine. Quarantine protocols developed by Biosecurity Australia (BA) and the Australian Quarantine and Inspection Service (AQIS) would eliminate any risk of disease.

b. Similar niche species

Grey nurse shark already exist as a native species and their impact would be expected to be no greater than what exists already. Therefore no disruptions to the ecosystem would be expected.

As there is no sub species of grey nurse shark, there must have in geological times, been periods when this species was able to migrate between various global regions. Due to climatic and ocean current variability populations have become isolated to

some extent. This is evident in the East Coast Australian grey nurse sharks which show very low genetic variation (Stow et al., 2006) in comparison to the South African populations. This is due to the population being isolated for a much longer period and in-breeding within a smaller population size. In any case the question would be whether a grey nurse shark brought in and released could be considered as feral seeing that it does occur here naturally? If conditions become right there could be natural migration occurring as it has in the past.

Although it is not in the realms of this import application, it can be argued that bringing in and releasing grey nurse shark with greater genetic variation will aid the dwindling East coast Australian populations by increasing genetic variability.

Chapter 12. Conditions or restrictions required

Grey nurse shark imported into Australia should only be allowed to be done for those institutes or organisations that can show that they can meet the requirements to house and keep the sharks. As there are no standards for this species the Elasmobranch husbandry manual can be used as a guideline.

Import proposal does not call for imported Grey nurse sharks to be released from effective human control.

Facilities intending on keeping Grey nurse shark should have security systems in place. These can be in the form of surveillance and alarm system on site to ensure that animals are not at risk. Additional security guards after hours when there are no more staff around is important for animal security as well. The ARAZPA guidelines for facility security can be used to meet these conditions.

For anyone importing these animals, the aim and understanding should be that these animals are registered and placed in a Studbook. All imported sharks should also each receive a unique transponder tag implant using the ISO transponder chip, inserted on the right hand side of the base of the dorsal fin. This will aid in future identification when required.

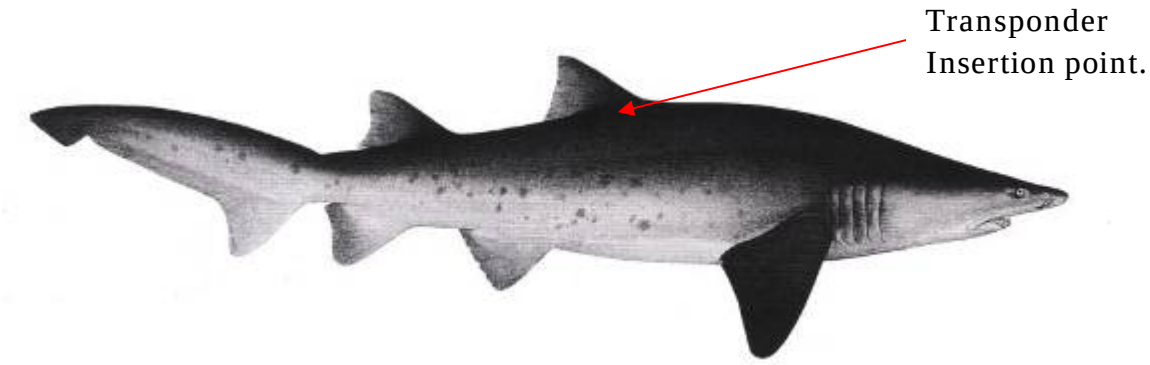

Figure 1: Grey Nurse Shark transponder insertion point (adapted from Last & Stevens 1994).

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